Abstract Book

IAU SYMPOSIUM 340

Long Term Datasets for the Understanding of Solar and Stellar Magnetic Cycles

19 – 24 February 2018

B. M. Birla Auditorium, Jaipur, India

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Monday, 19th February 2018

Session 1: Velocity Fields in the Convective Zone [Chair: Siraj Hasan]

IAUS340_324	Aaron Birch	Invited

Authors: Aaron C. Birch Max Planck Institute for Solar System Research

Title: Data and Methods for Helioseismology

Abstract: Helioseismology is a set of methods for inferring subsurface physical conditions from surface observations of solar oscillations. Helioseismology methods are typically applied to observations of Doppler velocity. The most widely used data sets for helioseismology come from SOHO/MDI, GONG, and SDO/HMI. Global helioseismology methods are based on measuring the resonance frequencies of the global acoustic and surface-gravity modes of the Sun. These mode frequencies contain information about the north-south and azimuthal averages of solar structure and rotation rate. Local helioseismology methods (e.g., time-distance helioseismology, ring-diagram analysis, helioseismic holography) are based on measuring the correlations or local power spectra of the surface wavefield. Local methods can be used to infer a three-dimensional picture of flows and structure in the solar interior.

IAUS340_316	Shravan Hanasoge	Invited

Authors: Shravan Hanasoge, TIFR

Title: New constraints on interior convection from measurements of normal-mode coupling

Abstract: Convection is believed to play a central role in determining the large-scale dynamics of the Sun. Measuring its properties is therefore a problem of fundamental importance. Convection couples global modes of oscillation and measuring this subtle effect allows for inferring the details of the underlying flows. I will present analyses from 20 years of solar oscillation data (MDI and HMI) that place new constraints on the amplitudes of convective velocities in the solar interior.

IAUS340_135	Chia-Hsien Lin	Oral

Authors: Chia-Hsien Lin (National Central University, Taiwan) Dean-Yi Chou (National Tsing-Hua University, Taiwan)

Title: Probing solar-cycle variations of magnetic fields in the convective zone using meridional flows

Abstract: Solar meridional flows are axisymmetric flows on meridional planes. Here we study their solar-cycle variations in the convective zone using SOHO/MDI helioseismic data from 1996 to 2010, which includes two solar minima and one maximum. The travel time difference between northward and southward waves is measured with the time-distance method as a function of travel distance, latitude, and time. An inversion method is applied to invert the travel time difference to obtain meridional flows at the minimum and the maximum. At the minimum, the flow has a three-layer pattern: poleward in the layer above 0.86R, equatorward between 0.74 and 0.86R, and poleward below 0.74R. The flow pattern changes significantly from the minimum to the maximum. The change above 0.9R indicates two phenomena: first, the flow speed is reduced at the maximum; second, a convergent flow centered at the active latitudes is generated at the maximum. These two phenomena are consistent with the surface meridional flows measured with surface tracers in the previous study. The flow change extends all the way down to 0.68R, and the pattern is more complicated. However, it is clear that the active latitudes play a role in the flow change. This suggests that magnetic fields are responsible for the flow change, which could be used to probe the solar cycle variations of magnetic fields in the deep convection zone.

IAUS340_271	Robert Cameron	Invited

Authors: Robert Cameron

Title: Small-scale flows and the solar dynamo

Abstract: Small-scale flows play a key role in many of the processes which generate the Sun's large-scale magnetic field. In this talk I will focus on some key areas where synoptic observations can lead to progress in our understanding.

IAUS340_192	Sarbani Basu	Invited

Authors: Sarbani Basu, Yale University

Title: Solar Large-scale flows and their variations

Abstract: The study of solar rotation has a 150-year history. Early studies were restricted to looking at the movement of sunspots; much later came the study of rotation using faculae, Ca+ bright points and H_alpha Doppler shifts. Similar studies found evidence of other large-scale flows, such as the meridional flows from the equator to the poles and the zonal flows, or torsional oscillations parallel to the equator. However, until the 1980s, the study of solar rotation and large-scale flows was restricted to what could be observed on the solar surface. The advent of good helioseismic data changed that and opened up a window to studying flows in the solar interior. Instruments like GONG, MDI and HMI have now collected helioseismic data for two solar cycles and these allow us both the large scale flows, and also their variations with time and solar activity. In this talk I shall review what the long data sets tell us about the these flows and discuss differences between solar cycles 23 and 24.

IAUS340_280	Sushant S. Mahajan	Oral

Authors: Sushant S. Mahajan (Georgia State University) Dibyendu Nandy (Center for Excellence in Space Sciences, India)

Title: Torsional oscillations: a tool to map magnetic field amplification inside the Sun

Abstract: Perturbations in the differential rotation of the Sun known as torsional oscillations have been noticed and recorded over the past four decades. Their origin, however, still remains a mystery. In this work, we propose that torsional oscillations are simply a consequence of magnetic field amplification coupled with the conservation of energy in the solar dynamo. This is a very simple and elegant way of explaining the observed torsional oscillation profile. Applying this technique on Helioseismic observations of torsional oscillations allows us to map the toroidal magnetic field inside the Sun which is of extreme importance as this magnetic field is a precursor to sunspots. We find that the active latitudes on the Sun's surface follow a region of high toroidal magnetic field (around 30,000 Gauss) deeper inside the solar convection zone (around $0.8R_o$). We can also see the signatures of magnetic field of the next solar cycle about 4 years before the cycle actually begins.

Session 2. Most widely used Indices of Solar Cycle - Magnetic Field and Sunspot Number [Chair: Alexi Peptsov]

IAUS340_217	Aimee Norton	Invited

Authors: Aimee Norton Stanford University

Title: A Century of Solar Magnetograms

Abstract: What dynamo problems have been solved by studying a century of remote measurements of the Sun's magnetic fields? Has vector polarimetry delivered the discoveries we anticipated from continuous Stokes monitoring? I'll discuss these topics with special emphasize on the long-term observations from the HMI /SDO and MDI/SOHO.

IAUS340_253	J Todd Hoeksema	Oral

Authors: J. Todd Hoeksema, Stanford University

Title: Long-term Measurement of the Solar Magnetic Field

Abstract: Decades-long series of measurements of the solar magnetic field are important for understanding differences among solar cycles and for prediction of future ones. As instruments improve, maintaining the ability to compare results can be difficult. Observations from the Wilcox Solar Observatory (WSO), the Michelson Doppler Imager (MDI) on SOHO, and the Helioseismic and Magnetic Imager (HMI) on SDO span nearly four solar cycles, starting in 1976. Measurements over time from each instrument are compared and differences between cycles are described.

IAUS340_230	Nataliia Shchukina	Oral

Authors: N.G. Shchukina, S.N.Osipov, R.I. Kostik, Main Astronomical Observatory, NAS, Kyiv, Ukraine

Title: Kyiv monitoring program of spectral line variations with 11-year cycle. Quiet Sun.

Abstract: The observational program of monitoring of long-term variation of solar spectral lines at the horizontal solar telescope of the Main Astronomical Observatory of Ukraine is described. The aim of the program is to clarify the issue how the physical parameters of the quiet solar atmosphere change over the 11-year cycle. The diagnostics of the solar atmospheric variation includes analysis of more than 40 spectral lines of neutral and ionized chemical elements observed at the solar disk and at the limb near north and south poles with high spectral resolution. The formation heights of these lines cover the whole photosphere, the temperature minimum and the lower chromosphere. Since 2012 the observations are performed daily, when the weather conditions allow. Observational season lasts from March to October. The high precision metrological stability of this telescope allows to measure the slightest temporal changes of the solar spectral line parameters such as a line depth, an equivalent width, a full width at half maximum, and a bisector curvature. The results of observations show that during 2012-2017 the line core depth and full width at half maximum of the many solar lines show response to the cycle modulation of the global unsigned magnetic field of the Sun. Such a correlation can be explained by assuming that during the maximum of the 11-year solar activity the temperature gradient of the photosphere changes.

IAUS340_184	Dilyara Baklanova	Oral

Authors: V. Butkovskaya, S. Plachinda, D. Baklanova: Crimean astrophysical observatory

Title: Long-term stellar magnetic field study at the Crimean Astrophysical Observatory

Abstract: The era of the continuous observations of the cycles of activity in stars, similar to the solar cycle, began with the pioneering work of Chugainov (1971). Using the photoelectrical observations performed by him at the Crimean Astrophysical Observatory, he reported the long-term light variation in the red dwarf BY Dra. He supposed that the nonuniformity of the surface brightness caused by the presence of spots on the surface of the star varies in different years. Recent long-term photometrical and spectral datasets from ground-based telescopes and satellites allow to obtain rotational periods, butterfly diagrams, S-index behavior, stellar activity cycles, and to study magnetic activity phenomena. To date activity cycles have been detected in hundreds of solar-like stars. One of the new key problem of research today is the stellar magnetic field behavior during the activity cycles at different evolutionary status of stars. The last question requires the long-term series of direct measurements of the magnetic field. Regular spectropolarimetric observations in order to obtain the direct measurements of the magnetic fields of different spectral classes stars have been conducted at the Crimean Astrophysical Observatory since 1987. We will present the result of study of activity cycles in selected stars using own long-term datasets.

IAUS340_109	cesare scalia	Oral

Authors: C. Scalia^(1,2) F. Leone^(1,2) M. Gangi^(1,2) M. Giarrusso^(1,2) M.J. Stift^(3) 1) Università di Catania, Dipartimento di Fisica e Astronomia, Sezione Astrofisica, Via S. Sofia 78, I–95123 Catania, Italy 2) INAF-Osservatorio Astrofisico di Catania, Via S. Sofia 78, I–95123 Catania, Italy 3) Armagh Observatory, College Hill, Armagh BT61 9DG, Northern Ireland, UK

Title: The long term variation of the effective magnetic field of the active star epsilon Eridani

Abstract: Long term periodicities of magnetic fields in cool stars are usually studied from activity indicators, such as the chromospheric Ca II emission lines, which are only indirectly related to the presence of the field. Direct detections are complicated issues since even a complex magnetic structure, as the solar one, has a very low disk integrated magnetic signal, which is usually hidden in the noise level. I will present a method for the direct measurement of small integrated longitudinal stellar magnetic fields (effective magnetic fields), called multi-line slope method, based on the regression of the Stokes V signal with respect to the first derivative of Stokes I. I will present the results of the application of this technique to a dataset of 9 yr of observations of the active star epsilon Eridani, obtained with the spectropolarimeters Narval, HARPSpol and CAOS. I will show that the long term variation of the effective magnetic field corresponds to the period of the cycle retrived by the activity indicators.

IAUS340_177	Frederic Clette	Invited

Authors: Frederic Clette Laure Lefevre Royal Observatory of Belgium

Title: Sunspot number datasets : status, divergences and unification

Abstract: The Sunspot Number provides our only direct record of the long-term evolution of solar activity over multiple centuries. Following the release of the first end-to-end revision of this reference time series in 2015 (version 2), several new results were published both about the sunspot number series and its close counterpart, the group number series. This marked a revived interest for the long-term reconstruction of solar activity but also induced some confusion, as the new proposed series are partly disagreeing. In this review talk, we describe and compare the different approaches and methods leading to the different series, like the corrections to the original database of raw group counts from Hoyt and Schatten (1998) or the active-days method. We show that the resulting series can essentially be separated into two main groups, which differ by the magnitude of a rising secular trend in solar activity over the past 200 years. Over past months, a multi-team collaborative work was undertaken and has already allowed to clarify and reduce some of the divergences. We report on the progresses already achieved and about the upcoming research paths that should lead to a single version for both the sunspot and group number, based on the best data sets and tools at our disposal. This includes the recovery of the original raw data from the Zurich Observatory, multi-scale and gap-filling mathematical techniques, and a better determination of uncertainties. We conclude on the implications for our scientific users of this fundamental change in the nature of the sunspot number series, from a static data set to an evolving series submitted to a continuous quality control, like other modern solar data sets. Our users should be prepared: version 3 is now in preparation!

IAUS340_145	Richard Bogart	oral

Authors: Richard S. Bogart, Charles Baldner, J. Todd Hoeksema, Yang Liu, Aimee Norton, Philip H. Scherrer (Stanford University)

Title: MDI + HMI: 22 Years of Full-Disc Imagery from Space

Abstract: Although separated by about 15 years in time of design, construction, and deployment on their respective space platforms, the Michelson Doppler Imager (MDI) on the Solar and Heliospheric Observatory (SoHO) and the Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO) are fundamentally similar instruments. Together they have now provided a nearly uninterrupted stream of consistently comparable data for study of the solar photosphere and, via helioseismic techniques, subsurface and interior structure and dynamics, for a full magnetic cycle of 22 years. Nevertheless, there are a number of mostly unavoidable differences in the acquisition and processing of the observational data from the two instruments. These differences present challenges to the detailed cross-calibration of the various data sets needed for studies of long-term variability associated with the solar cycle. We describe the available long-term data series amenable for such studies, discuss the particular problems associated with their calibration and the efforts underway to improve them, and speculate on their future extension.

IAUS340_102	Jagdev Singh	Oral

Authors: Jagdev Singh, H. No. 79, 36h Main, BTM, Dollar scheme, Madiwala, Bengaluru, India-560068 Priyal M., Bharathiyar University, Coimbatore, India -641046 Sindhuja, G., Udaipur Solar Observatory, Udaipur, Rajasthan, India Ravindra, B., Indian Institute of Astrophysics, Bengaluru, India-560034

Title: Variations in Ca-K line profiles and normalized Intensity as a function of latitude and solar cycle during the 20th century: Implication to Meridional flows

Abstract: We obtained the Ca-K line spectra as a function of solar latitude and integrated over visible longitudes since 1986 at the Kodaikanal Solar Tower Telescope. We have analysed the spectra taken during the period of 1989–2011 that indicates that the K1 width attains maximum amplitude at various latitude belts at different phases of the solar cycle. The FWHM of the K1 distribution at different latitudes shows that its width varies by about 30% for the equatorial belt (<30°) and 11% for the polar region (>70°) latitudes. Interestingly, the K1 width varies by ∼6% only around the ~60° latitude belt during the solar cycle. The analysis of cross-correlation coefficients of the K1 width between the 35° latitude and other latitude belts as a function of phase differences has been used to determine the speed of shift in the activity from one latitude to other latitudes. The shift of activity in the higher latitude belts showed complex behaviour, indicating pole-ward and equator-ward migration. These findings, especially the fewer variations in mid-latitude belts as compared to polar regions, asymmetry in the speed of the shift in the activity in both hemispheres, and complex variation in the direction of the shift in the activity representing poloidal fields in mid-latitude belts, will have an important implication on the modelling of solar dynamos. Further, we have determined the normalized intensity of the Ca-K line at an interval of 10-degrees using the digitized images obtained at Kodaikanal during the 20th century and investigate its variation as a function of latitude and time. We shall discuss the results of this unique data set generated over a period of ~100 years at Kodaikanal.

IAUS340_212	Angela R. G. Santos	Oral

Authors: A. R. G. Santos, Space Science Institute (Boulder, CO); T. L. Campante, Institut für Astrophysik, Georg-August-Universität Göttingen (Göttingen, DE); W. J. Chaplin, University of Birmingham (UK); M. S. Cunha, Institute of Astrophysics and Space Sciences (Porto, PT); M. N. Lund, University of Birmingham; R. Kiefer, Kiepenheuer-Institut für Sonnenphysik (Freiburg, DE); D. Salabert, Laboratoire AIM, CEA/DRF-CNRS-Université Paris (FR); R. A. Garcia, Laboratoire AIM, CEA/DRF-CNRS-Université Paris (FR)

Title: Seismic signatures of magnetic activity in solar-type stars observed by Kepler

Abstract: In the Sun, the frequencies of the acoustic modes are observed to vary in phase with the activity level. These frequency variations are expected to be common in solar-type stars and contain information about the activity-related changes that take place in their interior. The unprecedented high-quality long-term photometric time-series obtained by Kepler provide an unique opportunity to detect and characterize stellar magnetic cycles through asteroseismology. In this work, we analyze a large sample of solar-type stars, being composed in total by 87 targets. The original time-series are split in 90-d segments overlapped by 45-d. For each segment, the individual frequencies are obtained through a Bayesian peak-bagging analysis and used to compute the mean frequency shift. For each star, the temporal frequency shifts are then compared with those obtained from a cross-correlation method, as well as with the variation in: (1) the mode heights; (2) the granulation characteristic timescale; and (3) the photometric magnetic activity proxie. For some of the stars, we find evidences for (quasi-)periodic variations in the acoustic frequencies accompanied by variations in other activity proxies. Surprisingly, there are cases in which the mode heights appear to vary in phase with the frequency shifts, rather than the expected anti-phase. Our results also suggest that the amplitude of the frequency shifts increase with the stellar effective temperature and decrease with the surface rotation period.

IAUS340_194	Lalitha Sairam	Oral

Authors: Lalitha Sairam, Indian Institute of Astrophysics Vinay Kashyap, Harvard-Smithsonian Center for Astrophysics

Title: A comprehensive variability study of the complex corona of Capella

Abstract: Capella, a strong coronal line source has been observed regularly by both XMM-Newton and Chandra over the last ~17 years. Capella provides an opportunity to yardstick the models used in the interpretation of X-ray spectra from astrophysical plasmas. Using the high-resolution instruments such as the Chandra HETG, LETG, and XMM-Newton RGS spectra, we evaluate the individual coronal lines from different ions and measure their fluxes. This systematic study of the corona of Capella allows us to cross-calibrate the data obtained two of the pioneering X-ray satellites. This study also provides an insight into the intrinsic variability of its corona over a large-time sale. We will present the results of the long-term variability study of Capella obtained from individual lines and the associated variability.

Tuesday, 20th February 2018

[Chair: Todd Hoeksema]

IAUS340_381	Andres Munoz-Jaramillo	Invited

Authors: Andres Munoz Jaramillo SouthWest Research Institute

Title: Uncertainty, Under-counting, and Survey Incosistency: Overlooked Issues While Working With Sunspot Area Data

Abstract: Sunspot group areas are one of the main data sources for understanding long-term solar variability. However, due to the limited lifetime of observational surveys, piecing together a long-term composite involves subtleties that are often overlooked. In particular, the disconnection between the original observers and modern-day scientists results in an inadequate understanding of the limitations of sunspot group data. In this talk we discuss the challenges involved in building a composite of sunspot group area measurements spanning 200 years. In particular we focus on issues that are often overlooked by data users. First we discuss uncertainty, illustrate how it is severely underestimated by modern-day researchers, and discuss the negative impact that inadequate measurements of uncertainty have on both data users and providers. Then we discuss under-counting and the impact that object lifetime has on the statistics of surveys with limited cadence and how this can potentially change the conclusions we draw from observations. Finally we discuss consistency between datasets, the best practices for combining them, and the potential pitfalls of using composites for long-term reconstructions of solar irradiance and solar dynamo studies.

IAUS340_58	Kiran Jain	Oral

Authors: Kiran Jain (1), Sushant C. Tripathy (1), Frank Hill (1), David Salabert (2,3), Rafael A. Garcia (2,3) and Ann-Marie Broomhall (4,5) - (1) National Solar Observatory, 3665 Discovery Drive, Boulder, CO 80303, USA; (2) IRFU, CEA, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France; (3) Université Paris Diderot, AIM, Sorbonne Paris Cité, CEA, CNRS, F-91191 Gif-sur-Yvette, France; (4) Department of Physics, University of Warwick, Coventry, CV4 7AL, UK; (5) Institute of Advanced Study, University of Warwick, Coventry, CV4 7HS, UK

Title: Un-interrupted Sun-as-a-star Helioseismic Observations over Multiple Solar Cycles

Abstract: Long-term observations of solar activity clearly show the variable nature of Sun's magnetism. These records, e.g. in the form of sunspot counts and groups, exist for past few centuries and provide significantly large database to study long-term as well as short-term trends in solar variability visible above the solar surface. However, records of these variations below the surface are only a few decades old and composed of the inferences obtained from the resonant p-mode oscillations. The frequencies of oscillating modes are modified by the mechanical properties of the layers through which the waves traverse, and provide insights for the study of structural and dynamical changes occurring in the Sun's interior. Here we discuss various data sets for the Sun-as-a-star observations of solar oscillations which cover modes travelling deep in the solar interior. We analyze observations spanning over solar cycles 23 – 24 collected by the space-based photometric VIRGO and radial velocity GOLF instruments on board the SoHO satellite, and solar cycles 22 - 24 from the Doppler shift measurements from the ground-based network BISON. We show that both long- and short-term magnetic variabilities are associated with 11-year and the quasi-biennial periodicities, respectively. We also compare different cycles in terms of the interaction between solar interior and different layers in the Sun's atmosphere.

IAUS340_105	Aleksandra Anatolyevna Osipova	Oral

Authors: Yu.A. Nagovitsyn (1), A.A. Pevtsov (2) and A.A. Osipova (1) (presenting author) (1) Central (Pulkovo) Astronomical Observatory, Saint Petersburg, 196140, Russian Federation; (2) National Solar Observatory, Boulder, CO 80303, USA

Title: Two populations of sunspots

Abstract: Statistical methods are applied to the sunspot and sunspot group data from 10 observatories (Royal Greenwich, Kislovodsk Mountain Station, Mount-Wilson, Crimea, Pulkovo, Ural, IMIS, Ussuriysk, IZMIRAN, and Shemakha) for the period covering last 13 cycles (1874–2017). The presence of two physically distinct populations in the distribution of sunspots is confirmed: small sunspots with weaker field strength and large sunspots with stronger field strength. Sunspot groups' lifetime is adopted as a separating factor: Small Short-living Groups (SSG) live less than 6 days, while Large Long-living Groups (LLG) live at least 6 days. The peak of the LLG area distribution remains constant from one cycle to the other while for SSG it shows significant long-term variations. Sunspot groups' differential rotation forms two fundamental rotation modes: for each latitude, the distribution of rotation rates of sunspot groups deviates from simple Gaussian distribution and it is better fitted by two normal distributions. SSG population is connected with the fast rotation mode, while the LLG is divided into slow and fast rotating modes, with fast mode coinciding with SSG rotating mode. It seems to be that LLG population plays the main role in the 11-year solar cycle, while SSG population reflects the long-term variations of solar activity. The results of our research can be interpreted as an indication that SSG and LLG populations arise from either spatially distributed dynamo or independent dynamo mechanisms. Separation criteria can be used to provide observational constraints for dynamo theory.

IAUS340_143	Marielle Eduardo	Oral

Authors: M. Eduardo - University of the Philippines - Baguio; Q. Sugon - Manila Observatory, Ateneo de Manila University; B.A. Pelicano - University of the Philippines – Baguio

Title: Correlation of the New Sunspot Number and Geomagnetic aa Index in the Years 1900-2013

Abstract: While the geomagnetic indices continue to provide a homogenous data base that characterizes the intensity of geomagnetic activity, the recalibration of the sunspot number series has established a new standard version for sunspot time series that requires updating of prior results based on the calibration. We study the correlation between the annual mean of the new sunspot number (SN) and the annual mean of the geomagnetic aa index from 1900-2013. We find that cross-correlation of SN and aa index gives a correlation coefficient of 0.63 with a lag of 1 and 0.89 with lag 0, while for the old sunspot number (ISSN), consistent with previous results by Echer et al. (2004) and Prestes et al. (2005), we find a correlation coefficient of 0.65 with a lag of 1 and 0.93 with lag 0. Linear regression between SN and aa index gave a correlation coefficient of 0.53 vs. 0.56 for ISSN and aa index. The 11-year smoothing of the normalized values and the decomposition of aa index also confirmed the long-term variation of aa index with the sunspot numbers and its dual peak structure. On the other hand, other methods for correlation analysis and spectral analysis are suggested to further confirm the results obtained in this study.

IAUS340_103	Ali Kilcik	Oral

Authors: A. Kilcik, V. Yurchyshyn

Title: Zurich Sunspot Groups, Flaring Activity and their Temporal Variations.

Abstract: We present our recent statistical studies of sunspot groups that include sunspot group categorizations, temporal/periodic variations of these different categories and affect of flaring on sunspot groups since 2011. There are two main conclusions reached. First, different categories have different temporal and periodic behavior. Also flaring and non-flaring active regions behave differently during a solar cycle. Second, flaring activity affects different sunspot groups in a different manner.

Session 3. Indices of Solar Cycle from Photosphere to the Heliosphere

[Chair: Nandita Srivastava]

IAUS340_246	Mathew Owens	Invited

Authors: Mike Lockwood (University of Reading) Pete Riley (Predictive Science Inc)

Title: Long-term variations in the global heliosphere

Abstract: To predict how the solar magnetic field may vary in the future, we first need to understand how it has varied in the past. Reconstructing solar activity further back in time necessitates relying on increasingly indirect proxies. Direct spacecraft measurements of the solar wind and heliospheric magnetic field have been performed near-continuously for the over 60 years. The solar wind is seen to vary over all observed time scales, from sub-seconds to decades, with strong evidence of secular trends. In order to fully assess the longer-term variations, it is necessary to use proxy data. Approximately 170 years of geomagnetic data can be used to provide extremely accurate reconstructions of the near-Earth solar wind speed and the heliospheric magnetic field intensity on annual time scales, and consequently the open solar flux. Prior to 1845, it is necessary to go to more indirect proxies for solar wind conditions. Sunspot number can be used with simple empirical relations and open solar flux modelling to provide estimates of the near-Earth conditions back to ~1610. Extending further back in time is possible through the use of cosmogenic isotope records in natural reservoirs such as tree trunks and ice cores.

IAUS340_133	Takahito Sakaue	Oral

Authors: Sakaue, T.; Notsu, Y.; Notsu, S.; Ueno, S.; Asai, A.; Ichimoto, K. (Kyoto University); Shibayama, T. (Nagoya University); Kitai, R. (Bukkyo University);

Title: CaII K spectroheliogram time series from Kwasan-Ikoma observatories, Kyoto University

Abstract: The long-term variation of the solar activity is a critical issue for the solar and stellar physics since Schwabe's finding of the 11-year cycle in the number of sunspots. The in-phase variation of the solar UV irradiance is, in particular, up to a few tens of percent, which is potential to be responsible for the Earth's climate change (Solanki et al. 2013). Since the accurate measurements of the spectral solar irradiance in UV range are still challenging, the proxy models have been elaborated owning to the centurial history of the ground-based observation. The long term time-series of the synoptic solar images in CaII K line (3934Å) are one of the fundamental datasets for these studies. That means the emission in CaII K and the properties of its source on the solar surface are considered as the good indicators of the solar UV irradiance (Lean 1987). Kwasan and Ikoma observatories, Kyoto University, had engaged in the daily spectroscopic observation of the sun from 1928 to 1969, and more than 5,000 photographic plates in CaII K were obtained. They are recently made open to the public with the image metadata after the digitalization and flat-field correction to remove the plate contamination. For the ultimate goal to derive an index for the variability of solar UV irradiance, we investigated the long-term variation of CaII K emission features from these data, especially their brightness and area, which are compared with the previous researches (e.g., Bertello et al. 2010).

IAUS340_34	Theodosios Chatzistergos	Oral

Authors: Theodosios Chatzistergos (Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany), Ilaria Ermolli (INAF Osservatorio Astronomico di Roma), Sami K. Solanki (Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany & School of Space Research, Kyung Hee University, Yongin, Republic of Korea), Natalie A. Krivova (Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany)

Title: Ca II K spectroheliograms for studies of long-term changes in solar irradiance

Abstract: Measurements of solar irradiance have been performed since 1978. Since only few instruments covered more than a solar cycle, while the long-term stability of the measurements is limited, these data do not provide information on the existence of a long-term trend in irradiance. Models that attribute the irradiance changes to the varying distribution of the solar surface magnetic field have been quite successful in reproducing the measured variations. These models require as input observations or proxies of the solar surface magnetic field. While observations exist for the last four decades, proxies are used for the reconstructions on longer time scales. Proxies used so far give either only indirect information about the magnetic field or describe only its dark component (sunspots). The missing information on the evolution of the bright component can be provided by the historical Ca II K spectroheliograms. Such observations have been regularly performed since 1892 at various places, such as Kodaikanal,Mt Wilson,Arcetri or Mitaka observatories, thus providing a good coverage over the whole 20th century. However, these images suffer from a plethora of artefacts and the majority of them lack the information required to perform their photometric calibration. We have developed a method to accurately account for many of the artefacts and to perform the photometric calibration of the historical photographs. The method has been extensively tested on artificial images to estimate its accuracy. We will present results from the processing of four of the most important Ca II K archives.

IAUS340_285	Emre Isik	Oral

Authors: Emre Isik(1,2), Seda Isik(3) , Bahar B. Kabasakal(4) 1) Max Planck Institute for Solar System Research 2) Feza Gursey Center for Physics and Mathematics, Bogazici Univ., Istanbul, Turkey 3) Kandilli Observatory and Earthquake Research Institute, Bogazici University, Istanbul, Turkey 4) Dept. of Astronomy and Space Science, Ege University, Izmir, Turkey

Title: Sunspot group tilt angles from drawings for cycles 19-24

Abstract: The tilt angle of a sunspot group is a critical quantity in the surface transport of magnetic flux and the solar dynamo. However, there are only a few long-term databases for the tilt angle in the literature. We developed an IDL routine, which allows the user to interactively select and measure sunspot positions and areas on the solar disc. We measured the tilt angles of sunspot groups for solar cycles 19-24, covering the years 1954-2017, using the sunspot drawing database of Kandilli Observatory. The method is similar to that used in the discontinued Mt. Wilson and Kodaikanal databases, with the exception that sunspot groups were identified manually, which has improved the accuracy of the tilt angles. Following consistency tests using SDO white-light images and overlapping tilt angle datasets, we obtain cycle averages of the tilt angle to check for the reported anti-correlation with the cycle strength.

[Chair: Federic Clette]

IAUS340_290	Ilaria Ermolli	Invited

Authors: Ilaria Ermolli INAF Osservatorio Astronomico di Roma Italy

Title: Historical and modern full disk Ca II K observations: a resource for long-term studies of solar activity and variability

Abstract: Various observatories around the globe started sustained and regular full disk imaging of the solar atmosphere in the Ca II K line in the early decades of the 20th century, with a few earlier observations dating back to the last decade of the 19th century. Such observations are continued nowadays with modern telescopes at a few sites. The archives made by the historical and modern Ca II K observations are unique in representing long-term variations of the solar chromospheric magnetic field. Historical observations, as recent data sets derived from their digitization, and modern Ca II K observations suffer however from several problems, e.g. aging of the archiving material, changes in the instrumentation, lack of photometric calibration, variable quality. Thus accurate processing of these data is required to get meaningful results from their analysis. In addition, robust merging of the information stored in different archives is the key to a precise investigation of the long-term variations of the solar magnetic field. I will review the historical and modern full disc Ca II K observations, with special emphasis on their quality and contents, and discuss the most accurate methods applied to their analysis.

IAUS340_304	Nat Gopalswamy	Invited

Authors: Nat Gopalswamy NASA Goddard Space Flight Center

Title: Coronal mass ejections as a new indicator of the active Sun

Abstract: The Sunspot number and the F10.7 indices have been traditionally used as indicators of solar activity. Both of these activities are related to magnetic flux emergence. Coronal mass ejections (CMEs) are closely related to the closed magnetic field regions on the Sun including magnetic regions those that do not include sunspots. Starting in the 1990s, it has been established that CMEs are the primary players in defining solar disturbances in the heliosphere such as geomagnetic storms and solar energetic particle events. In this paper, we introduce two indices based on the speed of the CMEs: maximum speed in Carrington rotation periods and the fraction of halo CMEs associated with solar disturbances. We also consider geomagnetic indices such as aa and Dst indices that are loosely related to solar activity. In particular, we consider polar CMEs and aa index. Finally, we discuss filaments as proxies of CMEs and their relation to the solar polarity reversals.

IAUS340_193	Subhamoy Chatterjee	Oral

Authors: Subhamoy Chatterjee^1, Dipankar Banerjee^1, Manjunath Hegde^1 and B. Ravindra^1 1. Indian Institute of Astrophysics, Bangalore, india

Title: Generation of Carrington maps and automated feature detection from Ca II K spectroheliograms of Kodaikanal Solar Observatory

Abstract: Kodaikanal Observatory (KSO) has archived more than 100 years of solar images in three different wavelengths namely white light, Ca K and H-alpha. These have been captured through a telescope with unchanged optics, which ensured uniformity in image quality for several cycles. Our work here is focused on Ca K images, which have been digitized recently. We have used the full disc spectroheliograms from 1907 till 2007 to detect on disc bright structures called plages and generated area cycle as well as area scaled butterfly diagram. Carrington maps have been generated for the all the years. To validate the correspondence of magnetic fields and Ca K brightness we compared the locations of plages from KSO Ca K Carrington maps and same from MDI/SoHO magnetograms for overlapping periods. We found out clear correspondences. But, just by detection of on-disc structures it is difficult to probe the pole ward migration, which has immense importance in estimating polar field, epoch of pole reversal and prediction of future cycles. Interestingly KSO has also archived disc-blocked Ca K spectroheliograms from 1906 till 2002 clearly depicting the off-limb prominence structures. We framed an automated technique to find out the latitudinal locations of prominences using intensity thresholded binary polar maps and pixel counts. Using this we were able to generate clear trends of the pole ward migration of prominences, their cycle wise variations, N-S asymmetries and latitude wise drift rates. Utilizing the latitudinal count distribution of different sizes of prominences, we also explored the relations between prominences and coronal mass ejections (CMEs).

IAUS340_190	Sudip Mandal	Oral

Authors: Sudip Mandal & Dipankar Banerjee ; Indian Institute Of Astrophysics

Title: Variable nature of differential rotation profile of the Sun: A study using Kodaikanal digitized white-light data archive.

Abstract: The solar equator moves faster than its pole and this phenomena is known as the 'differential rotation' of the Sun. In this study, we use the sunspots, as detected from the newly digitized Kodaikanal white-light data archive, as a proxy to measure the solar rotation. We have implemented an automated sunspot tracking algorithm to uniquely identify the trajectories of each spot. This way, we eliminate the 'human subjectivity' from this analysis which has often been a source of error as found in previous studies. From our analysis, we find that the overall rotational profile changes with the strengths of the individual solar cycles whereas the individual profile parameters (e,g A & B) also found to be dependent on cycle properties. Individual sunspot sizes also seen to be tightly linked with this rotation rate. Our analysis also shows that the rotational profiles are not identical in the two hemispheres (the 'north-south' asymmetry). This knowledge of the profile variations (over ~100 years) may help us to better understand the solar dynamo mechanism.

IAUS340_88	Qi Hao	Invited

Authors: Q. Hao, C. Fang and P. F. Chen; School of Astronomy and Space Science, Nanjing University

Title: Automated Detection Methods for Solar Activities and an Application for Statistic Analysis of Solar Filament

Abstract: With the rapid development of telescopes, both temporal cadences and the spatial resolutions of observations are increasing. This in turn generates vast amounts of data, which can be efficiently searched with automated detection to derive the features of interest in the observations. A number of automated detection methods and algorithms have been developed for solar activities, based on the image processing and machine learning techniques and so on. Here, we also present an efficient and versatile automated detecting and tracing method for solar filaments. It is able not only to recognize filaments, determine features such as position, area, spine, and other relevant parameters, but also to trace the daily evolution of the filaments. It is applied to process the full disk H-alpha data mainly obtained by the Big Bear Solar Observatory and some statistic results spanning nearly recent three solar cycles are obtained.

IAUS340_229	Lionel Bigot	Oral

Authors: BIGOT (Observatoire de la Côte d'Azur)

Title: On the Sun's oscillations during its magnetic cycle

Abstract: Using realistic 3D time-dependent magneto-hydrodynamical simulations of the solar surface, I will show how the magnetic activity can affect the solar acoustic oscillation frequencies. I will explore its subtle effects through the last two cycles and discuss the mechanism responsible for the shifts of frequencies. I will show that we can extract information on the magnetic field strength below the surface at the rising and maximum phases of the last two cycles.

IAUS340_196	Renzo Ramelli	Oral

Authors: R. Ramelli[1], M. Cagnotti[2], M. Bianda[1], S. Cortesi[2], A. Manna[2] [1]: IRSOL, Locarno, Switzerland [2]: Specola Solare Ticinese, Locarno, Switzerland

Title: Sunspot data collection and archiving at Specola Solare Ticinese

Abstract: Sunspot observations and counting are carried out at the Specola Solare Ticinese in Locarno since 1957 when it was built as an external observing station of the Zurich observatory. When in 1980 the data center responsibility was transferred from ETH Zurich to SIDC in Brussels, the observations in Locarno continued and Specola got the role of pilot station. The data collected at Specola cover now the last 6 solar cycles. The aim of this presentation is to discuss and give an overview about the Specola data collection, the applied counting method and the future archiving projects. The latter include the publication of all data and drawings in digital form in collaboration with the ETH-library in Zurich, where a parallel digitazation project is ongoing for the document collections of the Zurich observatory collected since the time of Rudolph Wolf.

IAUS340_159	Andrei Tlatov	Invited

Authors: A.G. Tlatov

Title: Evolution of structures with an open magnetic flux over a hundred years

Abstract: Reconstruction of regions with an open configuration of magnetic force lines was carried out according to synoptic H-α maps of polarity for more than 100 years. It is shown that the maximum area of structures with an open magnetic flux in the cycle of solar activity is reached in the decay phase, 1-2 years before the minimum of solar activity. The total area of open-flow structures in the current cycle n has a high correlation (R ~ 0.9) with the amplitude of the next cycle n+1 activity. There is also a secular envelope of the area of such structures with a maximum in the middle of the 20th century. We assume that there is a relationship between the area of open structures and the method of predicting solar activity by geomagnetic activity, as well as the age-old behavior of the geomagnetic index AA.

IAUS340_403	S. Ananthakrishnan	Oral

Authors: Janardhan,P., Physical Research Laboratory, Ahmedabad; S. Ananthakrishnan, Electronic Science Dept., Pune University, Pune.

Title: Quiet Flows the Solar Wind: Long-term Trends in Solar Photospheric Fields and Solar Wind Micro-Turbulence

Abstract: It is known that the changes in solar cycle magnetic activity modulate the heliospheric environment as well as the near-Earth space and the terrestrial magnetosphere. The current solar cycle 24, with a peak smoothed sunspot number ~75 in November 2013, has been the weakest since cycle 14 in the early 1900's and it was also, preceded by one of the deepest solar minima in the past 100 years. In light of the very unusual nature of the minimum of solar cycle 23 and the current weak solar cycle 24, we have re-examined both solar high-latitude (≥45 degree) photospheric magnetic fields between 1975—2016 and solar wind micro-turbulence levels between 1983—2016 and shown that both photospheric magnetic fields, derived from ground based synoptic magnetograms and solar wind micro-turbulence levels, derived from 327 MHz radio observations, have shown a steady decline for the past two decades. These results and the fact that solar magnetic fields continue to decline at present raises the question of whether we are heading towards a Grand or Maunder like solar minimum in the near-future. An examination of the night time F-region maximum electron density of the Earth's ionosphere in solar cycle 23 suggests that the possible impact of such a long-term decline in solar photospheric fields is a significant decrease in the night time ionospheric cut-off frequency, which could be well below 10 MHz.

Wednesday, 21st February 2018

[Chair: Ilaria Ermolli]

IAUS340_18	Manjunath Hegde	Oral

Authors: Manjunath Hegde^1,Subhamoy Chatterjee^1, Dipankar Banerjee ^1 and Ravindra B^1 1. Indian Institute of Astrophysics

Title: Long term study of the solar filaments from the Synoptic Maps as derived from H Spectroheliograms of Kodaikanal Observatory

Abstract: The century long (1914-2007) H (656.28 nm) spectroheliograms from Kodaikanal Solar Observatory (KSO) have been recently digitised. Using these newly calibrated, processed images we study the evolution of dark elongated on disk structures called filaments, potential representatives of magnetic activities on the Sun. To our knowledge this is the oldest uniform digitised dataset with daily images available today in H-α. We generate Carrington maps for entire time duration and try to find the correspondences with maps of same rotation from Ca II K KSO data. Filaments are segmented from Carrington maps using a semi-automated technique and are studied individually to extract their centroids and tilts. We plot the time-latitude distribution of filament centroids producing Butterfly diagram, which clearly shows presence of poleward migration. We separate polar filaments for each cycle and try to estimate the delay between the polar filament number cycle and sunspot number cycle peaks. We correlate this delay with the same between polar reversal and sunspot number maxima. This provides new insight on the role of polar filaments on polar reversal.

IAUS340_26	Debi Prasad Choudhary	Oral

Authors: Debi Prasad Choudhary, Gary Chapman, Angie Cookson, Marina Slijepcevic, California State University Northridge

Title: Synoptic Solar Chromosphere and Photosphere Observations at San Fernando Observatory for a Complete Magnetic Cycle

Abstract: Chromospheric emission lines influence earth's upper atmosphere and ionosphere affecting near earth space weather. Construction of composite chromospheric index, by comparing and cross-calibrating different long-term synoptic observations, is essential for understanding the variability of this region. Photometric observations of the full solar disk in continuum windows and the Ca II K line of the solar spectrum, taken at the San Fernando Observatory and spanning more than one full magnetic cycle, offer a unique opportunity to study the global properties that govern the Sun's irradiance output and provide clues for the onset of successive solar cycles. We use full disk images in Ca II K line (393.4 nm) and red continuum (672.3 nm) along with magnetograms from Kitt Peak National Observatory to determine hemispheric dependence of the solar cycle.

IAUS340_158	Kseniya Andreevna Tlatova	Oral

Authors: K. A. Tlatova, V. V. Vasil'eva, A.G. Tlatov

Title: Reconstruction of solar activity according to the data of centenary observations

Abstract: Digitization of solar activity data over a period of more than 100 years has been performed. The database presents the characteristics of sunspots, sunspot umbra, filaments, plage and prominences. The series of vector boundaries and photometric properties of the selected objects are created. The database includes digitization of the photographic archives of daily solar synoptic observations. Among them: magnetic fields of sunspots on the sketches of the Mount Wilson Observatory (MWO) for the period 1917-2016; sunspots on photographic plates of the Greenwich Observatory (RGO) for 1919-1972 and Kislovodsk for 1954-2016; floccules in the spectral CaIIK line for the period 1905-2016 according to the observatories Kodaikanal, MWO, Sacramento Peak (SP) and Kislovodsk; solar filaments, observed in the H-alpha line, for 1915-2016 according to the observatories Kodaikanal, Meudon, Sacramento Peak (SP), Kanzelhoee and Kislovodsk; prominences in the H-alpha and CaIIK lines, for the period 1910-2016, according to the data of the observatories Kodaikanal and Kislovodsk, and the sketches of the international observational network of spectrohelioscopes. The characteristics of individual types of solar activity were determined. Interactive atlas of solar activity has been created, on which daily and synoptic maps of solar activity, characteristics of individual elements and summary indices of solar activity are presented. The indices of solar activity were reconstructed and the analysis was carried out.

Session 4. Total Solar Irradiance and Spectral Solar Irradiance

[Chair: Ilaria Ermolli]

IAUS340_213	Greg	Invited

Authors: Greg Kopp Univ. of Colorado / LASP

Title: The Long-Term TSI Data Record

Abstract: The total solar irradiance (TSI) has been observed from space for 39 years, giving uninterrupted measurements of the total energy driving the Earth's climate system. Offsets and trends due to calibration differences between the dozen or more instruments contributing to this record are largely corrected by various means to create a TSI composite spanning the space-borne measurement era. This record is then extended back in time prior to the spacecraft era via TSI models using proxies indicative of historical solar activity. I present an overview of the TSI instruments, their measurement uncertainties, and the causes of differences between them. I discuss a new methodology to create a statistically-driven, unbiased composite using data from all available instruments. I then show how the measurement record is extended to historical times for long-term solar-variability and Earth-climate studies. I also present a status update on the newest TSI instrument, the Total Irradiance Monitor on NASA's Total and Spectral Solar Irradiance Sensor, launched in late 2017 to continue this important solar climate data record into the foreseeable future.

IAUS340_223	Luc Damé	Invited

Authors: L. Damé1, M. Meftah1, M. Snow2, D. Bolsée3, S. Bekki1, A. Hauchecorne1, N. Pereira3 and D. Sluse3 1 Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS), IPSL/CNRS/UVSQ, Guyancourt, France (luc.dame@latmos.ipsl.fr), 2 Laboratory for Atmospheric and Space Physics (LASP), University of Colorado, Boulder, USA 3 BIRA-IASB, Brussels, Belgium

Title: SOLAR/SOLSPEC: new solar reference spectrum 165-3000 nm and 9 years observations of solar spectral ultraviolet irradiance from the ISS

Abstract: Since April 5, 2008 and until February 15, 2017, the SOLSPEC (SOLar SPECtrometer) spectro-radiometer of the SOLAR facility on the International Space Station (ISS) performed accurate measurements of Solar Spectral Irradiance (SSI) from the far ultraviolet to the infrared (165 nm to 3000 nm). These measurements, unique by their large spectral coverage and long time range, are of primary importance for a better understanding of solar physics and of the impact of solar variability on climate (via Earth's atmospheric photochemistry), noticeably through the "top-down" mechanism amplifying ultraviolet solar forcing effects on the climate (UV affects stratospheric dynamics and temperatures, altering interplanetary waves and weather patterns both poleward and downward to the lower stratosphere and troposphere regions). SOLAR/SOLSPEC, with almost 9 years of observations covering the essential of the unusual solar cycle 24, followed UV temporal variability and established a new reference solar spectra from UV to IR (165-3000 nm). A complete reanalysis of data was possible thanks to revised engineering corrections, improved calibrations and advanced procedures to account for thermal influence, aging (degradation) and pointing corrections. These intensive ground and space calibrations allowed a proper evaluation of uncertainties on these measurements. Results, UV variability and absolute reference spectrum (SOLAR-ISS), are presented and compared with other measurements (WHI, ATLAS-3, SCIAMACHY, SORCE/SOLSTICE, SORCE/SIM) and models (SATIRE-S, NRLSSI, NESSY).

IAUS340_337	Martin Snow	Invited

Authors: M Snow, T. N. Woods, F. G. Epariver, A. R. Jones, J. Harder, and E. Richard -- University of Colorado, LASP

Title: Ultraviolet Solar Spectral Irradiance Variation on Solar Cycle Timescales

Abstract: Ultraviolet (UV) Solar spectral Irradiance (SSI) has been measured from orbit on a regular basis since the beginning of the space age. These observations span four Solar Cycles, and they are crucial for our understanding of the Sun-Earth connection and space weather. SSI at these wavelengths are the main drivers for the upper atmosphere including the production and destruction of ozone in the stratosphere. The instruments that measure UV SSI not only require good preflight calibration, but also need a robust method to maintain that calibration on orbit. I will give an overview of the catalog of current and former UV SSI measurements along with the calibration philosophy of each instrument and an estimation of the uncertainties in the published irradiances.

IAUS340_228	Natalie Krivova	Invited

Authors: N. Krivova, K.L. Yeo, S.K. Solanki (Max Planck Institute for Solar System Research)

Title: TSI and SSI variations with solar magnetic cycle: reconstruction and physics

Abstract: The ever changing pattern of the magnetic field on the surface of the Sun induces solar brightness to vary on various time scales, of which the solar cycle variability is most conspicuous. The variability depends on the wavelength, and is significantly stronger in the UV range of the spectrum. This is due to the brightness of the individual magnetic features (such as sunspots of faculae) being a complicated function of their magnetic field strength, position on the visible solar disc and the wavelength. This has to be taken into account when modelling the irradiance variability. Two main classes of models have been developed, empirical and physics-based. We will review and compare the basic concepts of these models and their outcome.

IAUS340_139	Gabriel Giono	Oral

Authors: G. Giono (KTH, Sweden) J.J. Zender (ESA/ESTEC, The Netherlands) R. Kariyappa (Vemana Institute of Technology, India) M. Bergmann (Julius-Maximilians-Universität, Germany) V. Delouille (ROB, Belgium) L. Damé (LATMOS, France) J.-F. Hochedez (LATMOS, France)

Title: SOLARSEG: Correlation and periodicity of the EUV irradiance obtained from the daily segmentation of EUV images over a 7-years period.

Abstract: Understanding the variability of the EUV irradiance on time-scales from hours to months is of critical importance in the context of the Sun-Earth connection. Image segmentation is a promising method to study the impact of the different coronal features, such as active regions and coronal holes. The Solar Segmentation (SOLARSEG) pipeline, based on the Spatial Possibilistic Clustering Algorithm (SPoCA) segmentation algorithm, continuously produce daily maps (4h cadence) of the active regions (ARs) and coronal holes (CHs) using EUV images from the Atmospheric Imaging Assembly (SDO/AIA), and the segmented maps are used to extract the EUV irradiance from these regions of interest. Although the end-goal of the project is to discuss the variability of the EUV irradiance over a full solar cycle period, current results for the 7-years period from 2011 to 2018 already contains interesting results. A strong correlation was found between the coronal irradiance and the photospheric magnetic field not only for ARs but also QS region. The contribution of the Quiet Sun regions to the total EUV irradiance was also estimated to be higher than 60%, suggesting that the photospheric magnetic field has a larger global impact on the EUV irradiance than initially anticipated and indicating its importance for explaining the EUV irradiance variability. Correlation and periodicity found between the different layers observed by the AIA EUV bands, from photosphere to corona, and the underlying magnetic field from HMI during the 7-year period are also discussed.

IAUS340_98	Marianne Faurobert	Oral

Authors: Faurobert,M. University of Nice-Sophia Antipolis Ricort, G., University of Nice-Sophia Antipolis Balasubramanian, R., Paris-Saclay University, Chiavassa, A., Cote d'Azur Observatory

Title: Variation of the photospheric temperature gradient with magnetic activity

Abstract: Solar-cycle variations of the quiet Sun physical structure, such as the temperature gradient, may affect the irradiance. We present a new method that we have developped for measuring the temperature gradient in the low photosphere using high resolution spectroscopic data. The method has been tested on simulated spectra of the FeI 630.15 nm line and on observations of the Hinode/SP irradiance program. Comparing results obtained at the solar minimum in 2008 and maximum in 2014 we find that the temperature gradient was steeper at solar maximum in the low photosphere in the most active hemisphere.

Thursday, 22nd February 2018

Session 5. Solar - Stellar Connection [Chair: Gerry Doyle]

IAUS340_131	Travis Metcalfe	Invited

Authors: Travis Metcalfe (Space Science Institute)

Title: A Stellar Perspective on the Magnetic Future of the Sun

Abstract: After decades of effort, the solar magnetic cycle is exceptionally well characterized but it remains poorly understood. Pioneering work at the Mount Wilson Observatory demonstrated that other sun-like stars also show regular activity cycles, and identified two distinct relationships between the rotation rate and the length of the cycle. Neither of these relationships correctly describe the properties of the Sun, a peculiarity that demands explanation. Recent discoveries emerging from NASA's Kepler space telescope have started to shed light on this issue, suggesting that the Sun's rotation rate and magnetic field are currently in a transitional phase that occurs in all middle-aged stars. We have recently identified the manifestation of this magnetic transition in the best available data on stellar cycles. These observations suggest that the solar cycle is currently growing longer on stellar evolutionary timescales, and that the global dynamo will shut down entirely sometime in the next 0.8-2.4 Gyr. I will review the evidence for this unexpected result and discuss future observational tests, both solar and stellar.

IAUS340_272	Alexander Shapiro	Invited

Authors: Alexander Shapiro (Max Planck Institute for Solar System Research)

Title: Brightness variations of solar-type stars: available datasets and recent achievements

Abstract: Regular spaceborne measurements have revealed that solar brightness varies on multiple timescales. The most striking feature in the solar brightness records is the 11-year solar activity cycles which is caused by the overall modulation of solar magnetic activity. The 11-year cycle is superposed with the rotational cycle caused by the transits of magnetic features across the visible solar disc as the Sun rotates. Concurrently to solar studies, ground-based photometric measurements of Sun-like stars revealed brightness variations similar to solar variability on the 11-year activity timescale but with much wider variety of patterns. The recent advent of the planetary-hunting missions initiated a new era in the study of stellar photometric variabilities on timescales of stellar rotation and below, allowing to trace transits of individual magnetic features. We review a present state-of-the-art in the studies of stellar brightness variability and show how the solar paradigm can help us to explain variability of other stars.

IAUS340_66	Kosuke Namekata	Oral

Authors: Authors: Kosuke Namekata (presenter, 1), Takahito Sakaue (1), Kyoko Watanabe (2), Ayumi Asai (1), Hiroyuki Maehara (3), Yuta Notsu (1), Shota Notsu (1), Satoshi Honda (4), Takako T. Ishii (1), Kai Ikuta (1), Daisaku Nogami (1), Kazunari Shibata (1), Affliations: (1) Kyoto University, Japan, (2) National Defense Academy of Japan, (3) National Astronomical Observatory of Japan, (4) University of Hyogo, Japan

Title: Statistical Study of Solar White-light Flares and Comparison with Superflares on Solar-type Stars

Abstract: Recently, many "superflares" on solar-type stars were discovered by long-term monitoring observations with the Kepler spacecraft (Maehara et al. 2012). The superflares emit 10-10,000 times stronger radiation in "white light" than the maximum solar flares. A statistical study of superflares found a correlation between the energy (E) and duration (t): $t \propto E^{0.39}$, similar to those of solar hard/soft X-ray flares: $t \propto E^{0.2\text{-}0.33}$. This indicates a universal mechanism of energy release of solar and stellar flares, i.e., magnetic reconnection (Maehara et al. 2015). A direct comparison of solar flares and superflares in "white-light" emission can give us more information about the energy release mechanism of superflares. We then carried out a statistical research on 50 solar white-light flares with SDO/HMI and examined the t-E relation. As a result, the t-E relation on solar white-light flares ($t \propto E^{0.42}$) is similar to that on stellar superflares ($t \propto E^{0.39}$). However, the durations of stellar superflares are one order of magnitude shorter than those extrapolated from solar white-light flares. We present the following two interpretations for this discrepancy. (1) In solar flares, the cooling timescale of white-light emission may be longer than the reconnection one, and the decay time can be determined by the cooling timescale. (2) The distribution can be understood by applying a scaling law ($t \propto E^{1/3}B^{-5/3}$) derived from the magnetic reconnection theory. In this case, the observed superflares are expected to have 2-4 times stronger magnetic field strength than solar flares.

IAUS340_136	Veronika Witzke	Oral

Authors: V. Witzke, (1) A. Shapiro (1) , S. K. Solanki (1, 2) , N. A. Krivova (1) (1) Max-Planck-Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany (2) School of Space Research, Kyung Hee University, Yongin, Gyeonggi, 446-701, Republic of Korea

Title: Does the Sun behave unusually for a Sun-like star?

Abstract: Spaceborne measurements of the Sun have shown that its brightness varies on multiple time-scales, where variations on time-scales greater than a day are associated with the surface magnetic field. Independently, observations of Sun-like stars indicate various pattern of photometric variability for stars. Comparing stellar brightness variability of Sun-like stars with the same magnetic activity as the Sun showed that the solar variability on the magnetic activity cycle time-scale appeared to be anomalously low. One recently proposed explanation is based on the fact that solar brightness variability is caused by a delicate balance between dark and bright magnetic features. This balance is sensitive to the combination of stellar fundamental parameters, i.e. effective temperature, metallicity and surface gravity. So that stars with slightly different fundamental parameters can show significantly higher brightness variations. To check this hypothesis it is essential to study the effect of fundamental stellar parameters on stellar brightness variability. We show that even a small change (e.g. within observational error range) of metallicity or the effective temperature significantly increases the photometric variability. This strongly supports the explanation that low solar variability is caused by the incidental combination of solar fundamental parameters. Thus we have no reason to believe that the origin of solar brightness variability is conceptually different from that of Sun-like stars.

IAUS340_346	Ansgar Reiners	Invited

Authors:

Title: Measuring stellar magnetic fields and proxies of magnetic activity

Abstract: Empirical information about stellar magnetic activity can be obtained from a variety of observables. They include measurements of the magnetic field itself, and of tracers of these fields through measurements of non-thermal heating of the chromosphere or of cool spots. I will give an overview about the different measurement techniques and what they tell us, and I will introduce a new technique to characterize stellar surface properties from wavelength-dependent radial velocity observations. The new technique can provide fresh information about temperature contrast of active regions, filling factors, and surface convection velocities.

IAUS340_75	Eliana Maritza Amazo Gómez	Oral

Authors: Eliana Maritza Amazo-Gómez (1,2) Alexander Shapiro (1), Sami K. Solanki (1,3), Natalie Krivova (1), Timo Reinhold (1), Mahmoudreza Oshagh (2), Ansgar Reiners (2) (1) Max-Planck-Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany (2) Georg-August Universität Göttingen, Institut für Astrophysik, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany (3) School of Space Research, Kyung Hee University, Yongin, Gyeonggi 446-701, Republic of Korea

Title: A novel method to obtain stellar rotational periods

Abstract: The combination of high-quality photometric data acquired from the Kepler mission, high-stability and high-accuracy measurements of the solar total irradiance from the SOHO/VIRGO mission, and detailed models of solar brightness variations allow better insights into the variability and activity of Sun-like stars. Analysing periodic patterns in observed and simulated light curves we can link the variability to transits of magnetic features over the stellar surface. This in turn, allows us to calculate stellar rotational periods from the analysis of the Gradient of the Power Spectra (GPS) of stellar light curves. We simulate transits of magnetic features and calculate the GPS of the generated stellar brightness variations for the Sun-like stars. We show that the power spectra of brightness variations of stars with magnetic activity similar to that of the Sun and lower do not contain a prominent rotational harmonic. Nevertheless, the rotational periods of these stars can be reliably determined from the profile of the GPS. We apply this method to 552 Sun-like stars, including the Sun, and we calculate their rotational periods comparing our results to the earlier works. The method gives results consistent with others and allows, also determining, for first time, rotational periods of 705 less variable Sun-like stars.

IAUS340_61	Subhajeet Karmakar	Oral

Authors: Subhajeet Karmakar [Aryabhatta Research Institute of Observational Sciences (ARIES)] and Jeewan C. Pandey [Aryabhatta Research Institute of Observational Sciences (ARIES)]

Title: Active ultra-fast rotators KIC 6791060 and LO Pegasi: Starspot modulation, surface differential rotation, and flares

Abstract: We present an in-depth analysis of two active solar-type ultra-fast rotators KIC 6791060 and LO Peg. While the former is a poorly known F-type star was observed for continuous four years with Kepler satellite, the later is a fairly known K-type star was observed in multi-band for ∼24 yr using various ground- and space-based observatories. In case of KIC 6791060, we derive a rotational period of 0.34365 ± 0.00004 d. Multiple periodicities with a period separation of ∼0.00016 d were detected, which appears to be a result of the relative velocity between the multiple spot-groups in different stellar latitudes due to the surface differential rotation. A total of 38 optical flares are detected. Flare energies have been found to be in the range of 10^{31-33} erg. Preliminary results of surface temperature modeling indicate the existence of two active longitudes on the stellar surface. Whereas using the long-term V-band photometry, we derive the rotational period of LO Peg to be 0.4231 ± 0.0001 d. Using the seasonal variations on the rotational period, the SDR pattern is investigated and shows a solar-like pattern of SDR with a period of ∼2.7 yr. A total of 20 optical flares are detected with a flare frequency of ∼1 flare per two days and with flare energy of $\sim 10^{31-34}$ erg. The surface coverage of cool spots is found to be in the range of ∼9–26%. A flip-flop cycle of ~1 yr appears to be present. The activity in the K-type star is found to be higher than the F-type star, which might be due to a thicker convection zone in K-type star than that of the F-type star.

IAUS340_296	Huiqin Yang	Oral

Authors: Huiqin Yang (1,2) , Jifeng Liu(1,2) , Qing Gao(1), Xuan Fang(3， 4), JinCheng Guo(5) Affiliation: 1 Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China 2 University of Chinese Academy of Sciences, Beijing 100049, China 3 Laboratory for Space Research, University of Hong Kong, Pokfulam, Hong Kong, China 4 Department of Earth Sciences, University of Hong Kong, Pokfulam, Hong Kong, China 5 Department of Astronomy, Peking University, Beijing 100871, China

Title: The flaring activity of M dwarfs

Abstract: Flare events are mainly due to magnetic reconnection and thus are indicative of stellar activity. The Kepler Space Observatory records numerous stellar activities with unprecedented high photometric precision in flux measurements. It is perfectly suitable for carrying out a statistical study of flares. Here we present 540 M dwarfs with flare events discovered using Kepler long-cadence data. The normalized flare energy, as defined by the ratio to bolometric stellar luminosity, Lflare/Lbol, is used to indicate the flare activity. We find that, similar to the Xray luminosity relation, the Lflare/Lbol versus Prot relation can also be described with three phases, supersaturation, saturation, and exponential decay, corresponding to an ultra-short period, a short period, and a long period. The flare activity and the number fraction of flaring stars in M dwarfs rise steeply near M4, which is consistent with the prediction of a turbulent dynamo. The size of starspots are positively correlated with flare activity. The Lflare/Lbol ratio has a power-law dependence on LHa/Lbol, a parameter indicative of stellar chromosphere activity. According to this relation, a small enhancement in chromosphere activity may cause a huge rise in flare energy, which suggests that superflares or hyperflares may not need an extra excitation mechanism. Through a comparison study, we suggest that flare activity is a more suitable indicator for stellar activity, especially in the boundary region. However, contrary to what is expected, some M dwarfs with strong flares do not show any light variation caused by starspots. Follow-up observations are needed to investigate this problem.

IAUS340_201	Han He	Oral

Authors: Han He(1)*, Huaning Wang(1), Mei Zhang(1),(2), Ahmad Mehrabi(3),(4), Yan Yan(1), Duo Yun(1)
*presenting author, email: hehan@nao.cas.cn (1)CAS Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China. (2)School of Astronomy and Space Science, University of Chinese Academy of Sciences, Beijing, China. (3)Department of Physics, Bu Ali Sina University, 65178, 016016, Hamedan, Iran. (4)School of Astronomy, Institute for Research in Fundamental Sciences (IPM), 19395-5531, Tehran, Iran.

Title: Phase difference between long-term magnetic feature activity and flare activity of solar-type stars

Abstract: The light curves of solar-type stars present both periodic fluctuation and flare spikes. The gradual periodic fluctuation is interpreted as the rotational modulation of magnetic features on the stellar surface and is used to deduce magnetic feature activity properties. The flare spikes in light curves are used to derive flare activity properties. In this work, we analyze the light-curve data of three solar-type stars (KIC 6034120, KIC 3118883, and KIC 10528093) observed with Kepler space telescope and investigate the relationship between their magnetic feature activities and flare activities. The analysis shows that: (1) Both the magnetic feature activity and the flare activity exhibit long-term variations as the Sun does; (2) Unlike the Sun, the long-term variations of magnetic feature activity and flare activity are not in phase with each other; (3) The analysis of star KIC 6034120 shows that the long-term variations of magnetic feature activity and flare activity has a similar cycle length. Our analysis and results indicate that the magnetic features that dominate the rotational modulation and flares possibly have different source regions, although they may be influenced by the magnetic field generated through a same dynamo process.

Session 6. Solar behavior over centuries [Chair: Greg Kopp]

IAUS340_355	Kazunari Shibata	Invited

Authors: Kazunari Shibata (Kyoto University)

Title: Extreme Solar Events

Abstract: The total energy of a solar flare is typically 10^{29} - 10^{32} erg. It has been argued that the Carrington flare in 1859 might have been one of the most energetic flares ever observed, with energy 10^{32} - 10^{33} erg. If the Carrington-class flare occur now and its fast CME directly hit the Earth, the economic impacton our civilization through the space weather disastercould exceed $2 trillion, according to a report by the US National Academy of Sciences (2008). Hence, it is very important to clarify how extreme solar events be. Recently, Kepler observations revealed that superflares with energy of 10^{34} - 10^{35} erg occur with frequency of once in 800 - 5000 years on Sun-like stars with slow rotation, which are similar to our Sun. These superflares are usually associated with large spots with area A = 10^3 - 10^5 in unit of one millionth of solar hemisphere, much larger than normal sunspots (with area A= 100 - 1000). Spectroscopic observations by Subaru telescope confirmed that some of the Sun-like stars have actually large spots and slow rotation. The statistics of starspots from Kepler data show basically similarcontinuousdistribution between starspots and sunspots, suggesting that a very large spot (with area A=10^4 - 10^5) could occur on the Sun with low frequency, once in 100 -10000 years. These recent stellar observations suggest that superflares with energy of 10^{34} - 10^{35} erg (100 - 1000 times of the largest solar flares) may occur on the Sun with frequency of once in 800 - 5000 years. The evidence of the superflares on the Sun in recent 1000 years in the tree ring as well as in old literatures will also be discussed.

IAUS340_233	Pete Riley	Oral

Authors: Pete Riley(1) and Matt Owens(2) (1) Predictive Science Inc., San Diego, CA 92121. (2) University of Reading, Reading, England, UK.

Title: The State of the Solar Wind and Magnetosphere During the Maunder Minimum

Abstract: Observations of the solar corona and inner heliosphere during the span of the space era have led to a picture of cycling, but relatively constant output and structure. However, both direct observations and reconstructions from various datasets, suggests that conditions were radially different further back in time. The Maunder Minimum was one such epoch where: (1) sunspots effectively disappeared for long intervals during a 70 yr period; (2) eclipse observations suggested the distinct lack of a visible K-corona but possible appearance of the F-corona; (3) reports of aurora were notably reduced; and (4) cosmic ray intensities at Earth were inferred to be substantially higher. Using a global thermodynamic MHD model, we develop a set of feasible solutions for what the corona and solar wind may have looked like during this interval, and compare them with predictions made by Owens et al. (2017). Additionally, we use these results to drive a global magnetospheric model to speculate on how conditions may have changed in the Earth's upper atmosphere, ionosphere, and radiation belts, due to these extreme conditions.

IAUS340_140	Chi Ju Wu	Oral

Authors: N. A. Krivova(1), S. K. Solanki(1,2), I. G. Usoskin(3,4), G. A. Kovaltsov(5) (1) Max-Planck-Institut fuer Sonnensystemforschung, Goettingen, Germany (2) School of Space Research, Kyung Hee University, Yongin, South Korea (3) Space Climate Research Unit, University of Oulu, Finland (4) Sodankyla Geophysical Observatory, University of Oulu, Finland (5) Ioffe Physical-Technical Institute, 194021 St. Petersburg, Russia

Title: Solar Spectral Irradiance over 9 Millennia from a Multi-isotope Composite Series

Abstract: Reconstructions of the past solar variability are important for understanding the long-term changes in solar magnetic activity and solar dynamo. Furthermore, since the Sun is the dominant energy source to the Earth, they are also critical for our understanding of the solar influence on the terrestrial atmosphere and climate. Two quantities are of special interest: the total (TSI) and spectral (SSI) solar irradiance describing the total energy input and its spectral distribution, respectively. Direct measurements of the solar irradiance are available for less than 40 years. On longer time scales, one has to rely on the available solar magnetic activity proxies. The sunspot number record covers four centuries, while to go further back in time indirect proxies, such as concentrations of cosmogenic isotopes ^{10}Be and ^{14}C in terrestrial archives, can be used. These isotopes are produced in the terrestrial atmosphere by impinging cosmic rays, whose flux is modulated by the heliospheric magnetic field. Therefore the isotope data retrieved from various natural archives around the globe show a very high degree of similarity reflecting changes in the solar activity. Nevertheless, significant short-term deviations can be observed due to the different geochemical production processes and local climatic conditions. To take this into account, we produce a composite ^{10}Be and ^{14}C data set, which is then used to reconstruct TSI and SSI over the last 9000 years. We also apply statistical analysis to reconstruct the pseudo-solar cycle on millennial time scale.

IAUS340_119	Salvo Guglielmino	Oral

Authors: S. L. Guglielmino1; I Ermolli2; P. Romano3; F. Zuccarello1; F. Giorgi2; M. Falco3; R. Piazzesi2; M. Murabito1; M. Stangalini2 1Università degli Studi di Catania 2INAF – Osservatorio Astronomico di Roma 3INAF – Osservatorio Astrofisico di Catania

Title: Long-term optical monitoring of the solar atmosphere in Italy

Abstract: Probably, the long-term monitoring of the solar atmosphere started in Italy with the first telescopic observations of the Sun made by Galileo Galilei in the early 17th century. His recorded observations and science results, as well as the work carried out by other following outstanding Italian astronomers inspired the start of institutional programs of regular solar observations at the Arcetri, Catania, and Rome Observatories. These programs have accumulated daily images of the solar photosphere and chromosphere taken at various spectral bands over a time span greater than 80 years. In the last two decades, regular solar observations were continued with digital cameras only at the Catania and Rome Observatories, which are now part of the INAF National Institute for Astrophysics. At the two sites, daily solar images are taken at the photospheric G-band, Blue (λ=409.6 nm), and Red (λ=607.2 nm) continua spectral ranges and at the chromospheric Ca II K and Hα lines, with a 1" spatial resolution. Solar observation in Italy, which benefits from over 2500 hours of yearly sunshine, currently aims at the operational monitoring of solar activity and long-term variability and at the continuation of the historical series as well. Existing instruments will be soon enriched by the SAMM double channel telescope equipped with magneto-optical filters that will enable the tomography of the solar atmosphere with simultaneous observations at the K I 769.9 nm and Na I D 589.0 nm lines. In this contribution, we will present the available observations and outline their scientific relevance.

IAUS340_195	Tanmoy Samanta	Oral

Authors: Tanmoy Samanta (Peking University), Dipankar Banerjee (Indian Institute of Astrophysics), Sudip Mandal (Indian Institute of Astrophysics), Manjunath Hegde (Indian Institute of Astrophysics), Gopal Hazra (Indian Institute of Science), and Ravindra B.(Indian Institute of Astrophysics)

Title: Periodic and quasi-periodic activity in the 100-years of Kodaikanal sunspot data

Abstract: 100-years of Kodaikanal historical data have been recently digitized from photographic plates for studying long-term variations in the solar activity. Using intensity calibration, and implementing features identification code, we identified sunspots in the digitized images and computed their area, location on the solar disk, etc. We study the periodic variations of different time scales using the monthly averaged sunspot area data. We use the wavelet analysis tool to examine the periodic and quasi-periodic changes in the sunspot area time series. Wavelet analysis was also applied in each individual solar cycle to find the behavior of different short periodicities within the solar cycle. We find periodicities as long as 22 years and also as small as 124 days in the data. Two of the most significant and persistent periods (shorter than the 11 years regular solar cycle) seem to be approximately 160 days and 1.3 years in most of the cycle, though, in some cycles they are not the strongest. Our analysis shows that the shorter-period oscillations are evolving very rapidly compared to the longer-period oscillations. It also indicates that the shorter-period oscillations are prominent around the solar maximum. The study can provide an important clue to understanding the origin of these shorter periodicities and how they are linked to the solar dynamo.

Friday, 23rd February 2018

Session 7. Solar and Stellar Dynamo [Chair: Andres Lagg]

IAUS340_302	Maria A Weber	Invited

Authors: Maria A Weber University of Chicago & Adler Planetarium

Title: Dynamo Processes Constrained by Solar and Stellar Observations

Abstract: Our understanding of stellar dynamos has largely been driven by the magnetic phenomena we have observed of our own Sun. Yet, as we amass longer-term datasets for an increasing number of stars, it is clear that there is a wide variety of stellar behavior. Such observations provide a glimpse into the Sun's future and past magnetism, while placing key constraints on the dynamo mechanism. From a theorist's perspective, I will discuss how observed trends in starspot (and sunspot) patterns, cycle variations, the activity-rotation correlation, global-scale field topology, and mean field flows such as stellar differential rotation and solar meridional circulation provide insight into the fundamental dynamo operation of solar-type stars down to fully convective M dwarfs. A number of dynamo simulations have been able to model and recover some particular aspects of these observational trends, but none (as of yet) can reproduce them all. I will conclude by highlighting some dynamo puzzles posed by observations that we have yet to fully understand, including the generation and rise of magnetic field bundles that may be starspot progenitors and the processes that establish the strength and time-varying properties of stellar magnetism.

IAUS340_129	Jie Jiang	Invited

Authors: Jie Jiang (School of Space and Environment, Beihang University, Beijing, China Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences, Beijing, 100012, China)

Title: State-of-art of kinematic modeling solar cycle

Abstract: Global MHD simulation of solar convective zone is the most direct way to deal with the solar dynamo problem. Due to wide separation of spatial and temporal scale characterizing solar convection, it is still an extremely challenging task to understand solar cycle based the MHD simulations. The kinematic modeling remains the workhorse of solar dynamo to understand the solar cycle. During the past several years, the major progress in understanding the solar cycle using kinematic models are as follows. (1). BL mechanism was confirmed to be at the heart of the solar cycle. (2). The scatter of sunspot tilt angles are identified as a major cause of solar cycle irregularities. (3) The important roles of the magnetic pumping in the dynamo process are recognized. (4). Some 3D kinematic BL type dynamo models have been developed. As a key part of the solar dynamo loop, the surface observable part of the BL mechanism makes the physics-based solar cycle prediction feasible. Including the effects of the tilt scatter on the polar field generation, the possible strength of the subsequent cycle can be predicted when a cycle starts for a few years.

IAUS340_112	Arnab Rai Choudhuri	Oral

Authors: Arnab Rai Choudhuri Indian Institute of Science

Title: The Sun's polar magnetic field: datasets, proxies and theoretical issues

Abstract: With the development of the flux transport dynamo model, the importance of the Sun's polar magnetic field has been recognized. This field is an indication of the strength of the Babcock-Leighton process and can be used to predict the strength of the upcoming cycle. Although we have good data of the solar polar fields only from mid-1970s, certain proxies (such as polar faculae) help us reconstruct the history of this field from the beginning of the 20th century and allow us to develop dynamo models of past cycles. Over the years, surface flux transport models have been used to study how the polar field builds up from decaying tilted bipolar sunspots by the Babcock-Leighton process. We find on the basis of 3D kinematic dynamo simulations that some results of the surface flux transport models have to be interpreted with caution.

IAUS340_86	Bidya Binay Karak	Oral

Authors: Bidya Binay Karak & Mark Miesch High Altitude Observatory, NCAR, USA

Title: Long term Variability of Solar Cycle in the Babcock-Leighton dynamo framework

Abstract: The solar cycle is irregular and the extreme example of this irregularity is the Maunder minimum when Sun produced only a few spots for several years. We explore the cause of these variabilities using a 3D Babcock--Leighton dynamo. In this model, based on the toroidal flux at the base of the convection zone, bipolar magnetic regions (BMRs) are produced with flux, tilt angle, and time of emergence all obtain from their observed distributions. The dynamo growth is limited by a tilt quenching. The randomnesses and nonlinearity in the BMR emergences make the poloidal field unequal and eventually cause variable solar cycle. When observed fluctuations of BMR tilts around Joy's law i.e., a standard deviation of 15 degrees, are considered, our model produces a variation in the solar cycle comparable to the observed solar cycle variability. Tilt scatter also causes occasional Maunder-like grand minima, although the observed scatter does not reproduce correct statistics of grand minima. However, when we double the tilt scatter, we find grand minima consistent with observations. Importantly, our dynamo model can operate even during grand minima with only a few BMRs, without requiring any additional alpha effect.

IAUS340_186	Antoine Strugarek	Invited

Authors: A. Strugarek, P. Beaudoin, P. Charbonneau, A.S. Brun, J.D do Nascimento Jr.

Title: MHD Models of Solar and Stellar Dynamos with magnetic cycles

Abstract: Global simulations of the convective dynamo of the Sun and solar-type stars have exhibited in the past decade a rich variety of magnetic self-organization, from small-scale turbulent fields; stable magnetic structures; to periodically reversing large-scale magnetic fields. In the cyclic cases, tough, the physical ingredients setting the cycle period still need to be unveiled. I will first give a brief tour of the present status of non-linear dynamo simulations in deep stellar convection zones, with a particular focus on results obtained using implicit large eddy simulations (ILES) for a solar-like, cyclic, turbulent dynamos. I will present a series of 3D global simulations performed with the EULAG code where the period of the simulated magnetic cycle systematically varies with the rotation rate and luminosity of the modelled star. The dynamo acting in these simulations is fundamentally non-linear, where the Lorentz force feedback on the mean flows plays a major role in the dynamo loop, radically changing from the standard α-Ω dynamo paradigm. These results shed a new light on non-linear dynamo processes possibly acting in solar-like stars, and provide novel ways of interpreting the observations of solar and stellar magnetic cycles.

IAUS340_327	Maarit Käpylä	Invited

Authors: Maarit Käpylä, MPS

Title: State-of-art of MHD modeling solar cycle

Abstract: Global magnetoconvection models have become abundant during the recent years thanks to the ever-increasing computational resources. Many groups have reported on oscillatory dynamo solutions, some on the co-existence of multiple dynamo modes, and also on long-term variations resembling grand minima type events. Such simulations provide important laboratories to study stellar dynamos and rotation profiles, both of which are challenging to study observationally. These simulations are not yet very realistic, however. For example, the velocity amplitudes at large horizontal scales are too high in contrast to the Sun, and it is very difficult to obtain a solar-like angular velocity profile with the solar rotation rate. It is usually necessary to increase the rotation rate somewhat, and in this regime solar-like dynamo solutions also emerge. Already at modest rotation rates, however, the solutions tend to become non-axisymmetric. Such a transition from axisymmetric dynamo modes into non-axisymmetric ones is also implied by some observations, but at much larger rotation rates. In this talk I will discuss what useful can be learnt about dynamos from these models given these drawbacks.

IAUS340_130	Abraham C.-L. Chian	Oral

Authors: Abraham C.-L. Chian and Erico L. Rempel, National Institute for Space Research (INPE), Brazil

Title: Kinematic and magnetic coherent structures in turbulent solar dynamo

Abstract: Solar dynamo is studied using 3D numerical simulation of MHD turbulence driven by a helical forcing. On-off intermittency similar to the long-term behaviour of solar cycles is seen, where the magnetic field alternates randomly between periods of large- and small-amplitude variations (Rempel et al. MNRAS 400, 509, 2009). Turbulence and chaos play a crucial role in solar convective layer through the transport of particles, energy, and momentum, as well as the stretching, twisting, and folding of magnetic flux tubes. Lagrangian coherent structures are material lines or surfaces that act as transport barriers in plasmas. First, we detect attracting and repelling LCS in a helical MHD dynamo simulation (Rempel et al. ApJ 735, L9, 2011; J. Fluid Mec. 729, 309, 2013). Next, we detect attractive and repulsive LCS in solar photospheric flows near the active region AR10930 using the horizontal velocity data derived from Hinode/Solar Optical Telescope magnetograms (Chian et al. ApJ 786, 51, 2014). We show the correspondence of the network of high magnetic flux concentration to the attracting LCS in the photospheric velocity. Moreover, the computation of attracting LCS provides a measure of the local rate of contraction/expansion of the flow. Finally, we present a novel technique for detecting objective vortices in a helical MHD dynamo simulation (Rempel et al. MNRAS 466, L108, 2017). The relevance of our study for observation of vortices in solar plasmas is discussed.

IAUS340_85	Valentina Abramenko	Oral

Authors: V.I.Abramenko, Crimean Astrophysical Observatory of RAS

Title: Turbulent diffusion in the photosphere as observational constraint on dynamo theories

Abstract: One of the key parameters of these flux transport models -- the value of turbulent magnetic diffusivity - is the most poorly constrained both theoretically and observationally. We utilized Line-of-sight magnetograms acquired by HMI/SDO. Two areas, a coronal hole area (CH) and an area a super-granulation pattern, SG, were analyzed. We explored the displacement and separation spectra. The behavior of the turbulent diffusion coefficient on time scales of 1000-40000 s and spatial scales of 500-6000 km was explored. We found that the displacement and separation spectra are very similar to each other, which allows us to suggest that influence of large-scale velocity patterns is negligible on scales of interest. Small magnetic elements in both CH and SG areas disperse in the same way and they are more mobile than the large elements . The regime of super-diffusivity is found for small elements (the turbulent diffusion coefficient K growths from 100 to 300 km^2/s). Large magnetic elements disperse differently in the CH and SG areas. Comparison of these results with the previously published shows that there is a tendency of saturation of the diffusion coefficient on large scales, i.e., the turbulent regime of super-diffusivity gradually ceases so that normal diffusion with a constant value of $K \approx 500$ km^2/s might be observed on time scales longer than a day. The results show that, first, the turbulent diffusivity should not be considered in modeling as a scalar, the flux- and scale-dependence is obvious; the tensorial structure of turbulent diffusion is also plausible. Second, small-scale magnetic flux concentrations (within the ranges studied here) seem to be not a subject of the meridional flows.

Session 8. Predictions and Predictability of Solar Cycle [Chair: Jie Jiang]

IAUS340_266	Mausumi Dikpati	Invited

Authors: Mausumi Dikpati NCAR/HAO

Title: Forecasting phase-by-phase progression of a solar cycle using data assimilation and machine learning

Abstract: Solar energetic particles and magnetic fields can reach the Earth pervading through interstellar and interplanetary space and cause damages in our technological society. The root of energetic events is the solar activity cycle, which progresses phase by phase through "solar seasons", which consist of the enhanced bursts followed by relatively quiet periods, occurring with 6-18 months periodicity. It is difficult to accurately predict the solar cycle features. After describing what we have learned from validation or nonvalidation of cycle 24 forecasts, I will discuss how we can refine the solar cycle prediction scheme if we can successfully predict the quasi-periodic solar seasons 1-2 years ahead of their occurrence. I will demonstrate that the interaction between the solar Rossby waves and differential rotation in an MHD shallow-water model can lead to Tachocline Nonlinear Oscillation (TNOs), which can produce the quasi-periodic solar bursts. I will show that we can forecast these bursty seasons by assimilating surface magnetogram observations of bursts amplitudes and locations through an Ensemble Kalman Filter data assimilation scheme. I will also present a possible implementation of a "machine learning" scheme, through which certain unknown parameters of the model, responsible for producing distinct patterns of bursts, can be estimated. Thus forecasting the phase-by-phase progression of solar cycle will allow sufficient lead time for avoiding space-weather related hazards to our technological society and also help refine the solar cycle prediction scheme.

IAUS340_115	Prantika Bhowmik	Oral

Authors: Prantika Bhowmik (1), Dibyendu Nandy (1,2), (1) Center of Excellence in Space Sciences India, Indian Institute of Science Education and Research Kolkata, Mohanpur 741246, West Bengal, India (2) Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata, Mohanpur 741246, West Bengal, India

Title: Predicting Solar Cycle 25 Using a Coupled Surface Flux Transport and Dynamo Model

Abstract: Solar variability primarily influences the space weather conditions in the heliosphere. As space weather studies have gradually gained momentum, predicting the future solar cycle has become an important scientific goal. The intrinsic stochastic nature of the solar convection zone limits the predictability up to one cycle. Physics-based predictions utilize solar dynamo models. However, prediction with a dynamo model is only possible if the poloidal magnetic field at cycle minimum is known. Here we present a methodology to extend the time window by first using a Surface Flux Transport (SFT) model to generate the probable poloidal field at cycle 24 minima and eventually implementing this in a dynamo model to predict the amplitude of the toroidal component of cycle 25.

IAUS340_114	Gopal Hazra	Oral

Authors: Gopal Hazra (IISc) and Arnab Rai Choudhuri (IISc)

Title: A theoretical model of the variation of the meridional circulation with the solar cycle

Abstract: Observations of the meridional circulation of the Sun, which plays a key role in the operation of the solar dynamo, indicate that its speed varies with the solar cycle, becoming faster during the solar minima and slower during the solar maxima. To explain this variation of the meridional circulation with the solar cycle, we construct a theoretical model by coupling the equation of the meridional circulation with the equations of the flux transport dynamo model. We consider the back reaction due to the Lorentz force of the dynamo-generated magnetic fields and study the perturbations produced in the meridional circulation due to it. This enables us to model the variations of the meridional circulation without developing a full theory of the meridional circulation itself. We obtain results which reproduce the observational data of solar cycle variations of the meridional circulation reasonably well. We get the best results on assuming the magnetic Prandtl number to be close to unity. We have to assume an appropriate bottom boundary condition to ensure that the Lorentz force cannot drive a flow in the subadiabatic layers below the bottom of the tachocline. Our results are sensitive to this bottom boundary condition.We also suggest a hypothesis how the observed inward flow towards the active regions may be produced.

IAUS340_322	Dibyendu Nandi	Invited

Authors: Dibyendu Nandy, Center of Excellence in Space Sciences India, Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata

Title: The Physics of Solar Cycle Predictability

Abstract: The Sun's activity varies and this variability modulates the electromagnetic, particulate and radiative environment in space, creating space weather. Space weather impacts space- and Earth-based technologies on short-time-scales and climate on longer time-scales. At the heart of solar variability is the role of magnetic fields, most strikingly manifest in the 11-year cycle of (strongly magnetized) sunspots that has been systematically observed since the times of Galileo Galilei and his contemporaries. Although sunspot cycle observations constitute the longest running time series of any naturally observed phenomena in the Universe, understanding and predicting the solar cycle still remains an outstanding challenge. In this talk, drawing upon our own, as well as independent research, I will describe recent attempts to understand the underlying physics of solar cycle predictability.

IAUS340_265	Kristof Petrovay	Invited

Authors: Eötvös University, Department of Astronomy, Budapest

Title: Rogue active regions and the inherent unpredictability of the solar dynamo

Abstract: New developments in the modeling and theory of flux transport dynamos have given rise to the notion that certain large active regions with anomalous properties (location, tilt angle and/or Hale/non-Hale character) may have a major impact on the course of solar activity in coming years, impacting also on the amplitude of the following solar cycles. In this talk I review our current understanding of the role of such `rogue' active regions in cycle-to-cycle variations of solar activity.

IAUS340_40	Sacha Brun	Oral

Authors: A.S. Brun (AIM/DAp), C.P. Hung (AIM/DAp), A. Fournier (IPGP), L. Jouve (IRAP) & O. Talagrand (LMD)

Title: Solar Predict: a novel 4-D Var method for predicting the 11-yr solar cycle

Abstract: We have developed a 4D Var data assimilation method to predict the 11-yr cycle of the Sun. We first test its performance by inferring the internal time varying and multi-cellular meridional circulation used to create synthetic magnetic proxy data via a mean field Babcock-Leighton dynamo model. We then apply it over 40 years of Wilcox observatory solar magnetograms data, hence inferring for the first time the solar meridional circulation over the last 3 cycles. We then use the Data assimilation pipeline to make a first forecast of cycle 25.

Public Lecture

Nat Gopalswamy	Public Lecture

Title: Public Lecture : Our life-giving star, the Sun and its dark side

Abstract: We all know that life thrives on Earth because the Sun shines. All the food and fuel we have on Earth are from the Sun's energy received in the form of light and heat. Sun has also another side, which adversely affects life on Earth. Scientists are involved in understanding this dark side of the Sun under a subject known as space weather. The dark side is represented by the mass emission from the Sun in form of coronal mass ejections and solar wind that gush into space with speeds exceeding several hundred kilometers per second. In particular, coronal mass ejections can disturb Earth's magnetosphere for days and produce energetic particle storms that can affect human technology in space and on the ground. This talk focuses on the bright and dark sides of the Sun.

List of Posters

Session 1: Velocity fields in the convective zone

S1-P1	IAUS340_138	B Lekshmi	Poster

Authors: 1. Lekshmi B, CESSI, IISER Kolkata 2. Dibyendu Nandy, CESSI, IISER Kolkata and Department of Physical Sciences, IISER Kolkata

Title: Study on Hemispherical Asymmetry of Torsional Oscillation

Abstract: Solar torsional oscillations are migrating bands of slower and faster rotation, which are strongly related to the Sun's magnetic cycle. We study the hemispherical asymmetry in torsional oscillation by using ring diagram analyzed rotation data obtained from the Global Oscillation Network Group (GONG) Doppler images. The variation in asymmetry with respect to depth, time and latitude are considered to study the North – South asymmetry in rotation .We do a comparative study of asymmetry for the overlapping period of GONG data with surface doppler velocity observations from the Mt.Wilson 150-foot tower and also with the magnetic flux distribution in the two hemispheres. We find significant departure from a typically assumed symmetric profile of torsional oscillation

S1-P2	IAUS340_261	Bekki Yuto	Poster

Authors: Yuto Bekki (The University of Tokyo), Hideyuki Hotta (Chiba University), Takaaki Yokoyama (The University of Tokyo)

Title: Deep convective amplitude and stratification in an effectively high-Prandtl number thermal convection

Abstract: It has recently been recognized that the convective velocities achieved in the current solar convection simulations might be over-estimated (Hanasoge et al. 2012). The newly-revealed effects of the prevailing small-scale magnetic field within the convection zone may offer possible solutions to this problem. The small-scale magnetic fields can reduce the convective amplitude of small-scale motions through the Lorentz-force feedback, which concurrently inhibits the turbulent mixing of entropy between upflows and downflows (Hotta et al. 2015). As a result, the effective Prandtl number may exceed unity inside the solar convection zone. In this talk, we propose and numerically confirm a possible suppression mechanism of convective velocity in the effectively high-Prandtl number regime. If the effective horizontal thermal diffusivity decreases (the Prandtl number accordingly increases), the subadiabatic layer which is formed near the base of the convection zone by continuous depositions of low entropy transported by adiabatically downflowing plumes is enhanced and extended. The global convective amplitude in the high-Prandtl thermal convection is thus reduced especially in the lower part of the convection zone via the change in the mean entropy profile which becomes more subadiabatic near the base and less superadiabatic in the bulk.

S1-P3	IAUS340_170	Bhattacharya Jishnu	Poster

Authors: Jishnu Bhattacharya, Shravan M. Hanasoge, Aaron C. Birch and Laurent Gizon. Affil: Jishnu Bhattacharya: Tata Institute of Fundamental Research. Shravan M. Hanasoge: Tata Institute of Fundamental Research. Aaron C. Birch: Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 G\

Title: Iterative inversion of synthetic travel times successful at recovering sub-surface profiles of supergranular flows

Abstract: We develop a helioseismic inversion algorithm that can be used to recover sub-surface vertical profiles of 2-dimensional supergranular flows from surface measurements of synthetic wave travel times. We carry out seismic wave-propagation simulations through a 2-dimensional section of a flow profile that resembles an averaged supergranule, and a starting model that has flows only at the surface. We assume that the wave measurements are entirely without realization noise for the purpose of our test. We expand the vertical profile of the supergranule stream function on a basis of B-splines. We iteratively update the B-spline coefficients of the supergranule model to reduce the travel-times differences observed between the two simulations. We carry out the exercise for four different vertical profiles peaking at different depths below the solar surface. We are able to accurately recover depth profiles of four supergranule models at depths up to 8-10Mm below the solar surface using f-p_4 modes, under the assumption that there is no realization noise. We are able to obtain the peak depth and the depth of the return flow for each model. A basis-resolved inversion performs significantly better than one where the flow field is inverted for at each point in the radial grid. This is an encouraging result and might act as a guide in developing more realistic inversion strategies that can be applied to supergranular flows in the Sun.

S1-P4	IAUS340_387	Boening Vincent	Poster

Authors: Böning, Vincent (Kiepenheuer-Institut für Sonnenphysik, Freiburg; Max-Planck-Institut für Sonnensystemforschung, Göttingen)

Title: Inversions for the Deep Solar Meridional Flow and the associated Error Analysis

Abstract: Here, I present the main results from my PhD. thesis, to which a number of publications are entering. The solar meridional flow is a crucial ingredient in modern dynamo theory. Seismic estimates of this flow have, however, been contradictory in deeper layers. Here, we develop and validate a method for computing spherical Born approximation kernels for time-distance helioseismology and we employ these kernels to invert GONG data for the deep solar meridional flow. Above about 0.85 solar radii, our inversions confirm the result obtained by Jackiewicz et al. with the ray approximation regarding the general structure of the flow. This especially concerns a shallow return flow at about 0.9 solar radii, although some differences in flow magnitude are apparent. Below about 0.85 solar radii, we obtain several different results that are consistent with the measured travel times within the measurement errors. While one result is similar to the original single-cell flow found by Jackiewicz et al., other results exhibit a multi-cell flow structure in the southern hemisphere. To reach an unambiguous conclusion on the meridional flow in this region, the errors in the measured travel times have to be considerably reduced. In addition, we show that the errors of the inverted flows are underestimated by a factor of 2 to 4 if the covariance of the travel-time measurements is not taken into account. We conclude that the controversy about measurements of the deep meridional flow is relaxed by properly taking the measurement errors into account.

S1-P5	IAUS340_297	Gao Qing	Poster

Authors: Qing Gao

Title: A study of Be star activity in Kepler field of view

Abstract: The processes of Be star outburst and its circumstellar disk formation are a long time mystery. Thanks to the long term observation and high precision photometry of Kepler space telescope, we observed 4 B type stars have been through long time (more than 1000 days) outbursts. We used Lomb-Scargle method and Short-time Fourier transform (STFT) mathematic method to analyze their light curve. As a result, we found there is a tight correlation between the beating of non-radial pulsations and series of “minor” outbursts. Moreover, the pulsation behavior dramatically changes during outbursts. Some pulsation modes are tend to exhausted after the burst. Our detections provide a new clue to uncover the mystery of Be outburst phenomenon.

S1-P6	IAUS340_58	JAIN KIRAN	Poster

Authors: Kiran Jain (1), Sushant Tripathy (1), Rudolf Komm (1), Frank Hill (1) and Rosaria Simoniello (2) - (1) National Solar Observatory, 3665 Discovery Drive, Boulder, CO 80303, USA; (2) Geneva Observatory, University of Geneva, Geneva, Switzerland

Title: 22 Year Solar Magnetic Cycle and its relation to Convection Zone Dynamics

Abstract: The dynamics of the convection zone plays a crucial role in understanding the activity cycles and to predict the strength of the next solar cycle. It is believed that the solar dynamo, which governs the solar activity, is seated in a thin layer called the “tachocline” at the base of the convection zone. This layer in the solar interior can only be studied by using the techniques of helioseismology, where propagating acoustic waves are used to infer the properties of the region they travel through. Now continuous Dopplergrams at high-resolution and high-cadence are available for about 22 years, which allow us to map this region over a complete Hale magnetic cycle. Here we use observations from a ground-based network GONG and from space-borne instruments MDI onboard SoHO and HMI onboard SDO to study both global and local properties of the convection zone and their variations with time. We investigate the progression of the solar cycle as observed in helioseismic data at different latitudes and subsurface layers, and also in different hemispheres. We also discuss flows in near-surface shear layer occupying the outer 2% and their link with the surface magnetic activity.

S1-P7	IAUS340_86	Karak Bidya Binay	Poster

Authors: Bidya Binay Karak, Mark Miesch (High Altitude Observatory, NCAR) and Yuto Bekki (Department of Earth and Planetary Science, The University of Tokyo)

Title: The increase of effective Prandtl number, a possible solution to the solar convection conundrum, causes anti-solar differential rotation

Abstract: Arguably, the most challenging problem in the solar convection modeling at present is that the global convection simulations might be producing much higher convective velocity at large scales compared to the observations. A plausible remedy of this could be that the small-scale magnetism, which is not achieved in most of the global simulations due to higher molecular diffusions, can suppress the convective velocity. The small-scale magnetism can also suppress the turbulent mixing of entropy between the upflows and the downflows, leading to an increased effective Prandtl number. To explore this, we perform a set of three-dimensional rotating global convection simulations in spherical geometry at different Prandtl numbers. We find that at larger Prandtl number the convective velocity is suppressed and a subadiabatic layer is formed near the base of the convection zone due to continuous deposition of low entropy plumes. This result is in broad agreement with previous non-rotating (local) Cartesian simulations. However, on increasing the effective Prandtl number, the momentum carried by the plumes increase and thus these plumes transport angular momentum downward. In our global convection simulations, this inward transport of angular momentum by plumes leads to an anti-solar differential rotation. Our results suggest that a large effective Prandtl number cannot solve the solar convection conundrum.

S1-P8	IAUS340_280	Mahajan Sushant	Poster

Authors: Sushant S. Mahajan (Georgia State University) David H. Hathaway (NASA Ames Research Center) Andres-Munoz Jaramillo (Southwest Research Institute) Petrus C. Martens (Georgia State University)

Title: Measurements of Meridional Flow and Differential Rotation on the Sun's surface from 1995 to 2017

Abstract: Meridional flow and differential rotation are two flow profiles which are believed to govern the dynamics of the solar magnetic cycle. Measuring them precisely on the solar surface requires advanced numerical techniques which are capable of detecting movements of less than the pixel size in images of the Sun. We have identified sources of systematic errors which influence previous measurements of such flows from correlation tracking on solar magnetograms and propose numerical techniques which can successfully account for these errors. Our analysis of solar magnetograms from Michelson Doppler Imager (MDI) and Helioseismic Magnetic Imager (HMI) shows a long-term trend in variations of meridional flow and differential rotation from 1995 to 2017 which seems to depend on the strength of solar activity. These measurements would serve as vital inputs for solar dynamo simulations.

S1-P9	IAUS340_284	Mandal Krishnendu	Poster

Authors: Krishnendu Mandal, Shravan Hanasoge, H.M. Antia, S.P. Rajaguru

Title: Inversion for meridional circulation with the spherical Born kernels

Abstract: Understanding meridional flow in the Sun is very important to understand solar dynamo theory. There are many contradictory result how meridional circulation varies in the deeper layer of the Sun using the kernel based on ray theory. Ray theory is an infinite-frequency limit in which the travel time is sensitive only to perturbations along the ray path. Results from ray theory are reliable only if the length scale of the perturbation is significantly greater than the wavelength. Since the length scales over which perturbations vary are not known a priori in these inverse problems, it is important to perform inversions using the best possible kernels. After developing a method to compute the Born approximation kernels in spherical geometry, we have used them for the inversion of meridional circulation. We have considered sensitivity kernels for stream function which automatically takes into account mass conservation. Preliminary results suggest a single cell meridional flow. We have used the same set of GONG data which Rajaguru et al. 2015 have used for their work. I shall discuss the inversion technique we have considered for our work and implication of our results to the popular dynamo theory.

S1-P10	IAUS340_365	Milic Ivan	Poster

Authors: Ivan Milic, Michiel van Noort, Smitha Narayanamurthy, Andreas Lagg (MPS)

Title: Atmospheric diagnostics using spectropolarimetric inversions

Abstract: Observations of solar surface, performed with high spatial and angular resolution provide us with possibility of diagnosing velocities and magnetic fields in solar photosphere and chromosphere. Spectropolarimetric inversion is a process of fitting a model atmosphere to the observed Stokes spectrum in the given pixel. In this contribution we present our recent attempts to improve current state-of-the-art methods. We present a novel inversion code, tailored especially for lines formed in non-local thermodynamic equilibrium, which provide information on upper layers of solar atmosphere. We show results of inversions applied to spectropolarimetric data in the spectral region around sodium D lines, obtained at Swedish Solar Telescope (SST). Additionally, we discuss a possibility of using infrared lines of iron in the spectral region around 1560 nm, which might provide an insight in convective velocities in the deep photosphere.

S1-P11	IAUS340_100	Schunker Hannah	Poster

Authors: H. Schunker, A.C. Birch, R.H. Ca meron, D.C. Braun, L. Gizon Max-Planck-Institut für Sonnensystemforschung, Institut für Astrophysik Georg-August-Universität, NorthWest Research Associates

Title: Statistical analysis of the evolution of active region tilt angles

Abstract: Joy's law is a statistical phenomena where the polarity in the prograde direction of an active region bipole is closer to the equator than the following polarity. We measure the motion of the polarities in 154 emerging active regions. We find that, on average, the tilt angle increases as the active region emerges. The separation in the north-south direction is dependent on latitude. However, neither the separation in longitude nor latitude is dependent on the flux of the active region. The scatter in the position of the polarities is consistent with supergranular buffeting. This suggests that convection plays a significant role in active region formation.

Session 2. Most widely used Indices of Solar Cycle - Magnetic Field and Sunspot Number

S2-P1	IAUS340_211	Amareswari K	Poster

Authors: Amareswari K.(1), Sreejith Padinhatteeri (2), Sankarasubramanian K. (1), 1.ISRO Satellite Centre,Bengaluru 2. Manipal Center for Natural Sciences, Manipal University, Maipal

Title: Connection between Active region complexity and Solar Flare strength

Abstract: Since Hale (1908) discovered the existence of magnetic fields in sunspots, a consensus has been reached that magnetic fields play an important role in various forms of solar activity, such as flares (Wang & Liu 2015). Modified Mount-Wilson scheme is one of the methodology to classify active regions based on their complexity (Hale e. al., 1919, Kunzel, 1965). As per this scheme, sunspots are classified as alpha, beta, gamma, and delta with the complexity of the magnetic topology increasing from alpha to delta. The delta sunspots are known to be highly flare- productive. An existing automated algorithm (SMART-DF) is modified and used to identify delta-spots for the existing full disk SOHO/MDI data. The automatically identified delta-spots is compared with the NOAA-SRS database and found to be reproducing almost all the identified delta-spots. In this study, the connection between formation of delta-spot and flares is also carried out using GOES flare flux and NOAA-SRS sunspot classification. Preliminary results from this statistical study on solar flare-delta spots connections along with the flare strength will be presented.

S2-P2	IAUS340_63	Aroori Mahender	Poster

Authors: Mahender Aroori, G Yellaiah, K Chenna Reddy

Title: Microwave studies of Quiet Sun Radiation during Solar Minimum and Maximum Phase of Solar Cycle 23 and 24

Abstract: In this paper, we will be studied the solar radio emission at micro-wavelengths during solar minimum and maximum phase of solar cycle 23 and 24. The correlation between microwave solar emissions and the sunspot activity has been found. The quiet sun component has been estimated statistically for successive solar rotations using the data obtained from National Geophysical Data Centre (NGDC). Further, we will be estimated the brightness temperature of the corresponding phases

S2-P3	IAUS340_147	Atulkar Roshni	Poster

Authors: P.K. Purohit, National Institute of Technical Teachers' Training and Research, Bhopal – 462002, MP, India.

Title: Evaluation of long term solar activity effects on critical frequency of F layer

Abstract: The ionosphere exhibits the variability over different time scales. In the present paper we presents the long term solar activity variations of mid latitude ionosphere. To accomplish this study we have considered a famous Australian station namely Hobart (42.88°S 147.32°E) which falls in the mid latitudinal region. The variability is examined over the previous three solar cycles i.e. 21, 22 and 23rd solar cycles. To characterize the long term variability of the solar activity we have used four indices namely sunspot number (Rz), solar radio flux (F 10.7cm), Mg II core to wing ratio and solar flare index. Similarly, for ionospheric variability we have the critical frequency of F2 layer (foF2). From our study, we found that the long term changes in the solar activity indices are closely and synchronously reflected in the ionospheric foF2. To quantify the magnitude of association between the long term solar activity variations and the ionsopheric variations we performed the single regression analysis and computed the correlation coefficients between the two types of indices and found that there exists an extremely strong correlation between the two types of indices for all the three solar cycles. Hence, it is concluded that the ionospheric foF2 is strongly influenced by solar activity with an 11-year variability.

S2-P4	IAUS340_52	Battula Prem Kumar	Poster

Authors: B.PREM KUMAR, K.CHENNA REDDY,A.MAHENDER, G.YELLAIAH.

Title: Variations of the meteor count rate and echo height during solar cycle 23 and24

Abstract: The meteor ablation is an important source for the upper atmosphere's metal atoms. Many meteoroids ablate between about 110 km and 70 km and form ionized trails which are detected by radar techniques. And it is also known that the ablating heights of the meteors depend on various factors such as meteor velocity, mass, and composition, etc. The meteor ablating heights provide new opportunities to gather the information on the neutral atmosphere in the Mesosphere and Lower Thermosphere (MLT) region. In this study, we analysed the 12 years of meteor radar data (2004 to 2015), i.e. descending phase of solar cycle 23, and ascending phase of solar cycle 24, detected at SKiYMET meteor radar, Thumba. From such long term data set, we studied variation of meteor count rate with solar activity. We also examined the possible relationship between alteration of meteor echo height and echo duration with solar activity during solar cycle 23-24. We studied the effect of solar flux over meteor count and find a positive correlation.

S2-P5	IAUS340_221	Bhatt Miral	Poster

Authors: Miral Bhatt(Research Scholar), Prof. Nandita Srivastava, Dr. Ravindra Jadhav3

Title: A study of Stealth CMEs and associated ICMEs

Abstract: Coronal Mass Ejections (CMEs) are large eruptions of plasma and magnetic field from the sun into interplanetary space. CMEs are most frequently associated with a variety of phenomena occurring in the lower corona before, during and after onset of eruption. CMEs are visible in coronagraph observation, so-called Stealth CMEs do not obviously exhibit any of the low-coronal signatures (LCS). Interplanetary Coronal Mass Ejection (ICME) is heliospheric counterpart of a CME. In this study, Stealth CMEs events are selected using LASCO/SOHO CME catalogue and CACTus catalogue and associated ICMEs for selected Stealth CMEs were studied using data from STEREO, ACE and WIND. In particular, five events of ICMEs associated with the Stealth CMEs are studied here. Among which 3 of the events arrived at L1 point and produced strong geomagnetic storm of ~100 nT or more. The remaining two events were not Earth directed, and were observed at STEREO S/C. From the analysis of in-situ parameters, we also found that 3rd June 2008 CME arrived at the STEREO B spacecraft however, if it would have arrived at the Earth, then it would have led to a moderate to strong geomagnetic storm. Solar eruption without any LCS can lead to unexpected space weather impacts, since many early warning signs for the same activity are not present in these events. Our study also shows that although ICMEs associated with Stealth events are associated with minor shocks they can sometimes lead to strong geomagnetic storms. The present study will improve our understanding of Stealth CMEs and the associated ICMEs.

S2-P6	IAUS340_185	Bose Souvik	Poster

Authors: Souvik Bose and K. Nagaraju, Indian Institute of Astrophysics, Koramangala-2nd block, Bangalore, India.

Title: Role of the active regions and background field towards the solar mean magnetic field

Abstract: The Solar Mean Magnetic Field (MMF) typically refers to the total line-of-sight (LOS) magnetic flux divided over the entire solar disk area. It generally exhibits a mean period of about 11 years, similar to the sunspot cycle. The recent revival in the MMF, during the declining phase of solar cycle 24 led us to investigate this behavior in detail. We took advantage of the daily seeing-free high quality data available from Atmospheric Imaging Assembly (AIA) and Helioseismic and Magnetic Imager (HMI) on-board the Solar Dynamics Observatory (SDO) over a period of nearly 6 years, which reveals the crucial role played by the background fields in the overall MMF variation. We used automated detection methods to create binary masks corresponding to the plage, and Enhanced Network (EN) regions from AIA 1600 Å images and the sunspot using AIA 4500 Å datasets. The detection of the plage and the EN regions (in AIA 1600 images) was originally calibrated using Ca-K 3934 Å data from the CHROTEL telescope operated by KIS, which to the best of our knowledge has been done for the very first time. Further, we used the HMI LOS full-disk magnetograms and the binary masks to obtain the mean magnetic field corresponding to those regions and the background (entire disk without the plage, enhanced network and the sunspot). Our results reveal that the MMF magnitude is largely defined by the background field regimes, instead of the active regions on the Sun and this caused the observed revival of the MMF in cycle 24.

S2-P7	IAUS340_235	Brajesh Kumar	Poster

Authors: Brajesh Kumar (Udaipur Solar Observatory / Physical Research Laboratory)

Title: Study of solar cycle induced variations in the solar mean velocity flows : GONG observations

Abstract: The solar oscillation frequencies have shown variation over the solar activity cycle, which is believed to be the indicator of the structural and magnetic changes taking place in the Sun. The network of solar telescopes located at six sites around the globe in the Global Oscillation Network Group (GONG) program have been nearly-continuously observing the Sun since the last quarter of 1995 for Doppler imaging of the solar-disk aimed to study the oscillations and velocity flows on the solar surface. In this work, we study the solar cycle induced variations in the disk-integrated mean velocity flows on the solar surface as observed with the GONG over the complete Cycle 23 and ongoing Cycle 24. The correlation analysis of these solar mean velocity flows relative to the various solar activity indicators will also presented.

S2-P8	IAUS340_177	Clette Frédéric	Poster

Authors: Frédéric Clette Royal Observatory of Belgium Laure Lefèvre Royal Observatory of Belgium

Title: The new Sunspot Number: continuing upgrades and possible impacts

Abstract: The sunspot number provides our only multi-century record of solar activity, and as such, provides a key input to a wide range of long-term scientific studies. The first-ever revision of this time series was carried out over 2011-2015, leading to the release of a new version (V2.0) in July 2015 by the World Data Center (WDC) SILSO. This new series includes major corrections of diagnosed inhomogeneities in the original heritage series of up to 40%, and is still the target of further analyses since 2015. We describe the main corrections included in the current versions of the sunspot number and group number series, and the diagnostics on which they are based. As we have now moved towards a continuous maintenance and quality control of this series, we also describe the current ongoing collaborative process that was started in 2017 for preparing the next upgrade (Version 3). This innovative process involves a broad community of specialists and a supervision by the International Astronomical Union. We also describe the implementation of the entirely new data management and distribution scheme adopted by the WDC-SILSO, which goes along with this end-to-end modernization of the sunspot number data themselves. We conclude by describing the impact that those recent changes in the sunspot number can have on different applications, including solar cycle predictions. As we have now moved from a static series to a dynamic data set open to new research and future upgrades, our scientific users must be prepared for a more flexible integration of the sunspot number series in the future.

S2-P9	IAUS340_255	Das Vipin V	Poster

Authors: Vipindas V.*, Sumesh Gopinath and T.E. Girish Department of Physics, University College, Trivandrum-695034, Kerala, India

Title: A study on the variations in long-range dependence of solar energetic particles during different solar cycles

Abstract: Solar Energetic Particles (SEPs) are high-energy particles ejected by the Sun which consist of protons, electrons and heavy ions having energies in the range of a few tens of keV to GeV. Long-range dependence is an outstanding characteristic of a time series that has found applications in a variety of fields such as solar physics and astrophysical phenomena. For stochastic processes, long-range dependence is usually quantified with the Hurst exponent. Even though solar activity is a periodic process, the constituent solar cycles, if taken separately, are different in amplitude, duration and progress. The statistical features of the solar energetic particles (SEPs) during different periods of solar cycles are highly variable and these puzzling statistical observations call for new ideas and new theoretical tools, like anomalous transport, non-Markovian phenomena, different transport regimes inside and in between coherent magnetic flux tubes and the non-Gaussian nature of turbulent transport in order to be able to reconcile theory and observations. As a step in this direction, in the present study we try to quantify the long-range dependence or long-memory of the solar energetic particles during different periods of solar cycle 23 and 24. We compare the Hurst exponent of SEP proton flux for the energies (>1MeV to >100 MeV) of different years, which include both solar maximum as well as minimum years in order to find cyclic variations in the persistency of SEP flux.

S2-P10	IAUS340_97	Dash Soumyaranjan	Poster

Authors: Soumyaranjan Dash (1) Dibyendu Nandy (1,2) (1) Center of Excellence in Space Sciences India, IISER Kolkata (2) Department of Physical Sciences, IISER Kolkata, India

Title: Modeling of Solar Corona: A Magnetofrictional Approach

Abstract: Dynamics of magnetic fields in the solar corona lead to eruptive events like coronal mass ejection and flares which create severe space weather. Lacking the technology for direct coronal magnetic field observations, we must rely upon theoretical models and simulations for understanding coronal dynamics. Keeping this in mind, we have developed a 3D magnetofrictional model in spherical polar coordinates. The model solves the magnetic induction equation in solar corona with the plasma velocity modulated by the Lorentz force. Using this model we simulate the evolution of sunspots in response to various photospheric motions.

S2-P11	IAUS340_57	Dave Kunjal	Poster

Authors: Kunjal Dave (Research scholar, C.U.Shah University, Surendranagar-363030, India); Wageesh Mishra (Postdoctoral Researcher, University of Science and Technology of China, China); Nandita Srivastava (Prof.,USO, Udaipur-313001, India);RavindraJadav (Assistant Prof., Gujarat Arts and Science College, Ahmedabad-380006, India)

Title: Study of Interplanetary and Geomagnetic Response of Filament Associated CMEs

Abstract: It has been established that Coronal Mass Ejections (CMEs) have significant impact on terrestrial magnetic field and lead to space weather events. In the present study, we select several CMEs which were associated with filament eruptions on the Sun. These CMEs have been identified using observations from Solar Dynamic Observatory (SDO) and coronagraphic observations from LASCO/SOHO. The arrival of these CMEs at 1AU is estimated using their solar wind in-situ signatures, i.e. plasma, magnetic and compositional signatures. We attempt to identify the presence of filament material within interplanetary component of CMEs (ICMEs) at 1AU. We discuss how different ICMEs associated with filaments lead to moderate or major geomagnetic activity on their arrival at the Earth.Our study also highlights the difficulties in identifying the filament material at 1AU within isolated and in interacting CMEs.

S2-P12	IAUS340_153	Deo Amar Chandra	Poster

Authors: Amar Deo Chandra, Center of Excellence in Space Sciences India (CESSI), Rohan E. Louis, Center of Excellence in Space Sciences India (CESSI), Ayan Banerjee, Department of Physical Sciences, IISER Kolkata, Dibyendu Nandy, Department of Physical Sciences, IISER Kolkata and Center of Excellence in Space Sciences India (CESSI)

Title: Development of a High Resolution Imaging Spectrometer for exploring the Sun's corona

Abstract: Myriad energetic manifestations such as flares and coronal mass ejections (CMEs) originate in the solar corona, which affect the space weather in the vicinity of the Earth. Understanding the dynamics of the corona requires sensitive spectrometers accompanied by high resolution imaging to resolve feeble emission lines emanating from this tenuous layer, which is very faint compared to the photosphere. This work discusses the development of a novel imaging spectrometer, which is one of the modules of the Solar Hyperspectral Imaging Polarimeter (SHIP) instrument being developed at CESSI. SHIP is envisaged to operate between 600-1100 nm and will provide 2D spectro-polarimetric investigations and simultaneous wavefront corrected imaging of the solar corona, utilizing the phase/amplitude modulation properties of Spatial Light Modulators (SLMs). We shall discuss potential solar coronal diagnostics which can be performed using this high resolution imaging spectrometer.

S2-P13	IAUS340_215	Fleck Bernhard	Poster

Authors: Bernhard Fleck(1), Joseph B. Gurman(2) & George Dimitoglou(1,3) (1) ESA, (2) NASA/GSFC, (3) Hood College

Title: Long-term data sets from SOHO

Abstract: SOHO, launched on 2 December 1995, has provided a nearly continuous record of solar and heliospheric phenomena over a full 22-year magnetic cycle. SOHO's long-term data sets include measurements of total and spectral solar irradiance, He II 304 Å and integrated (1-500 Å) EUV solar output, low-frequency global velocity oscillations (including frequency tables), solar wind parameters (proton speed, density, thermal speed and arrival direction), energetic particles (electrons, protons, He), full disk EUV images in He II 304 Å, Fe IX/X 171 Å, Fe XII 195 Å, and Fe XV 284 Å, white light images and thus electron densities in the range from 2.5 to 30 R, full-sky Ly- flux, and for the first 15 years of the mission also medium-l helioseismology data and full disk magnetograms at 96 min cadence. This presentation will give an overview of all the SOHO long-term data sets and how they can be accessed.

S2-P14	IAUS340_101	Gosain Sanjay	Poster

Authors: Sanjay Gosain and SOLIS Team

Title: Synoptic Magnetic Fields Measurements of the Solar Chromosphere: Properties during Cycle 23 and 24

Abstract: Full disk magnetic field measurements of the photosphere and chromosphere have been performed at National SOlar Observatory, USA for many decades. We will present properties of solar magnetic field inferred from chromospheric magnetograms during cycle 23 and 24. The estimates of polar fields derived independently from chromospheric magnetograms is compared to photospheric values and other proxies such as polar facular index. The relation between network magnetic field, line core intensity in different features would be presented.

S2-P15	IAUS340_285	Isik Emre	Poster

Authors: I. Ozavci (1), H.V. Senavci (1) E. Isik* (2,3), G.A.J. Hussain (4,5) D. O'Neal (6) M. Yilmaz (1), S.O. Selam (1) *) Presenting author (1) Dept. of Astronomy, Ankara University, Turkey (2) Max-Planck-Institut fuer Sonnensystemforschung, Germany (3) Feza Gursey Center for Physics and Mathematics, Bogazici University, Turkey (4) ESO, Garching, Germany (5) Universite de Toulouse, UPS-OMP, IRAP, France (6) Keystone College, USA

Title: Starspot activity and differential rotation in KIC 11560447

Abstract: Using four years of high-precision photometry from the Kepler mission, we investigate patterns of spot activity on the K1-type subgiant component of KIC 11560447, a short-period late-type binary system. Prior to light curve inversions, we test the validity of maximum entropy reconstructions of starspots by numerical simulations. Our procedure successfully captures up to three large spot clusters migrating in longitude. We suggest a way to measure a lower limit for stellar differential rotation, using slopes of spot patterns in the reconstructed time-longitude diagram. We find solar-like differential rotation and recurrent spot activity with a long-term trend towards a dominant axisymmetric spot distribution during the Kepler period of observations.

S2-P16	IAUS340_276	J. Javaraiah	Poster

Authors: Formerly in Indian Institute of Astrophysics, Bengaluru-560034

Title: Long term variation in meridional motion of sunspot groups : comparison of DPD and SOON data

Abstract: We have analyzed Debrecen Photoheliographic Data (DPD) and the Solar Optical We have analyzed Debrecen Photoheliographic Data (DPD) and the Solar Optical Observing Network (SOON) sunspot group data during the period 1977-2015 and find that the mean latitude variation of the meridional velocity of sunspot groups over the whole period 1977-2015 is toward the center of activity in all the latitudes of the sunspot latitude belt and its range is about 10 m s^{-1}. This property is better observed in SOON data than in DPD data. In fact, in DPD data the equaterward velocity is significant from zero only in 30°- 35° latitude interval of southern hemisphere with only about 4 m s^{-1}. The aforesaid result differs with the result that poleward/equaterward motion of sunspot groups in the higher/lower latitudes of sunspot belt was found in an earlier analysis (Javaraiah and Ulrich,*Solar Phys.*237, 245 (2006)). In another earlier analysis (Javaraiah, *Solar Phys.*509, A30 (2010)) it was found that during the maximum of solar cycle~23 the meridional motion determined from SOON data was reasonably strong (about 10 m s^{-1}) and northbound direction in both northern and southern hemispheres. This result is not confirmed here from the analysis of the DPD data. The DPD data suggest that during the maximum of solar cycle~23 there was a weak poleward motion in both the northern and southern hemispheres.

S2-P17	IAUS340_395	Joshi Chandan	Poster

Authors: 1. Chandan Joshi (JECRC, University) 2. B. Shobha (JECRC, University) 3. Vishwas Deep Joshi (JECRC, University)

Title: Search for Correlation between Solar Flare Count and Mean Solar Magnetic Field

Abstract: Here we represent a study of the search for correlation between daily mean solar magnetic field and daily solar flare count. The method of cross wavelet transform is used to find the correlation. The mean solar magnetic field data is provided by Wilcox Solar Observatory and flare count is provided by National Centers for environmental information.

S2-P18	IAUS340_33	K R Varsha	Poster

Authors: Varsha. K. R, Hiremath. K. M and Manjunath Hegde, Indian Institute of Astrophysics, Bengaluru-560034, India

Title: ROTATION RATE OF HIGH LATITUDE CORONAL HOLES

Abstract: Coronal holes are one of sun's important activity phenomena which can easily be observed in the sun's corona, especially in the x-ray or uv wavelengths. Coronal holes appear to be darker, cooler, and have low density plasma compared to the ambient medium. Genesis of their origin, thermal and dynamical properties and of their feeble magnetic field structure remain a mystery. Aim of present study is to examine whether coronal holes that occur at higher latitudes rotate rigidly or differentially. In order to achieve this goal, nearly one cycle (1997–2006), SOHO/EIT 195 Å calibrated images are used. Using basic morphological operations like erosion and dilation, coronal holes are accurately detected from the images. Individual pixel information enclosing coronal holes is obtained. After fixing the heliographic coordinates for these individual pixels, average heliographic coordinates (latitude and longitude) for each coronal hole are computed and rotation rates of coronal holes are estimated. The important results are as follows: For different latitude zones, between 80° north and 75° south, irrespective of their area and the number of days observed on the solar disk, coronal holes rotate rigidly.

S2-P19	IAUS340_120	Kim Bogyeong	Poster

Authors: Hwajin Choi(Korea Polar Research Institude, KORDI); Jeongwoo Lee(Seoul National University); Suyeon Oh(Chonnam National University); Bogyeong Kim(Chungnam National University); Hoonkyu Kim(Chungnam National University); Yu Yi(Chungnam National University)

Title: Cycle length dependence of stellar magnetic activity and solar cycle 23

Abstract: Solar cycle (SC) 23 was extraordinarily long with remarkably low magnetic activity. We have investigated whether this is a common behavior of solar-type stars. From the Ca II H and K line intensities of 111 stars observed at Mount Wilson Observatory from 1966 to 1991, we have retrieved data of all 23 G-type stars and recalculated their cycle lengths using the damped least-squares method for the chromospheric activity index S as a function of time. A regression analysis was performed to find relations between the derived cycle length, Pavg, and the index for excess chromospheric emission, R ¢ HK. As a noteworthy result, we found a segregation between young and old solar-type stars in the cycle length-activity correlation. We incorporated the relation for the solar-type stars into the previously known rule for stellar chromospheric activity and brightness to estimate the variation of solar brightness from SC 22 to SC 23 as (0.12 ± 0.06)%, much higher than the actual variation of total solar irradiance (TSI) ⩽0.02%. We have then examined solar spectral irradiance (SSI) to find a good phase correlation with a sunspot number in the wavelength range of 170–260 nm, which is close to the spectral range effective in heating the Earth's atmosphere. Therefore, it appears that SSI rather than TSI is a good indicator of the chromospheric activity, and its cycle length dependent variation would be more relevant to the possible role of the Sun in the cyclic variation of the Earth's atmosphere.

S2-P20	IAUS340_120	Kim Bogyeong	Poster

Authors: Bogyeong Kim(Chungnam National University);Yu Yi(Chungnam National University)

Title: States of solar activities and interplanetary parameters during solar cycles 21 – 24

Abstract: In this study we make a comparison between the temporal variations of the solar, interplanetary, and geomagnetic (SIG) parameters and open solar magnetic flux from CR1642 to CR2185 (from Solar Cycle 21 to the early phase of Cycle 24) for a purpose of identifying their possible relationships. We examine which component of solar magnetic multipoles best correlates with the SIG parameters. In our result, there is strongly correlation of the dynamic pressure of the solar wind with the solar magnetic dipole flux, which varies in anti-phase with SC. most SIG parameters except the solar wind dynamic pressure show rather poor correlations with the open solar magnetic field. Good correlations are recovered when the contributions from individual multipole components are counted separately. Other solar activity indices such as the sunspot number, total solar irradiance, 10.7cm radio flux, and solar flare occurrence and highly correlated with quadrupole component. The geomagnetic activity represented by the Ap index is correlated with higher order multipole components, which show relatively a slow time variation with SC. We suggest that such dependences of the SIG parameters on the individual multipole components of the open solar magnetic flux may clarify why some SIG parameters change in phase with SC and others show seemingly delayed responses to SC variation.

S2-P21	IAUS340_135	Lin Chia-Hsien	Poster

Authors: Chia-Hsien Lin (National Central University, Taiwan); Guan-Han Huang (National Central University, Taiwan); Lou-Chuang Lee (Academia Sinica, Taiwan)

Title: Studying solar-cycle variation of open magnetic flux regions using coronal holes

Abstract: Magnetic field lines in coronal holes extend far away from the Sun. In this study, we identify coronal holes as regions with inward or outward open magnetic fields, and study the temporal variation of the coronal hole areas at different latitudes. The data used in this study are the radial-field synoptic maps from Wilcox Solar Observatory from May 1970 to December 2014, which covers 3.5 solar cycles. Our results reveal a pole-to-pole trans-equatorial migration pattern for both inward and outward open magnetic fluxes. The pattern consists of open flux migrating across the equator, open flux generated at low latitude and migrating poleward, and open flux locally generated at polar regions. The results also indicate dissipation of open fluxes during the migration from pole to equator, and at low latitude regions.

S2-P22	IAUS340_222	Liu Suo	Poster

Authors: Liu, S., Yang, X., Lin G.H. National Astronomical Observatories, Chinese Academy of Sciences

Title: Toward Standard Data Production for Magnetic Field

Abstract: Data with internationally agreed standards are the common pursuits for all astronomical observation instruments both ground and spacebased undoubtedly. The routine solar bservations are available at Huairou Solar Observing Station (HSOS) since 1987, which were considered as one of main solar observations in the world. The data storage medium and format at HSOS experienced lots of changes, hence there were some inconveniences for solar physicist to use. This paper shows that the observations data of HSOS are further processed both for storage medium and format toward international standards, in order to explore HSOS observations data for scientific research.

S2-P23	IAUS340_248	Louis Rohan Eugene	Poster

Authors: Rohan E. Louis(1), A. Raja Bayanna (2), Nirmalya Ghosh (1,3), Ayan Banerjee (1,3), Dibyendu Nandi (1,3) (1) CESSI, IISER Kolkata (2) Udaipur Solar Observatory, Physical Research Laboratory (3) Department of Physical Sciences, IISER Kolkata

Title: Design of an adaptable Stokes polarimeter for exploring chromospheric magnetism

Abstract: The chromosphere is a highly complex and dynamic layer of the Sun, that serves as a conduit for mass and energy supply between two, very distinct regions of the solar atmosphere, namely, the photosphere and corona. Inferring the chromospheric magnetic field is of paramount importance for deciphering the coupling of the solar atmosphere and for constraining models that extrapolate the magnetic field to the corona. In this talk, I will present a design of a polarimeter for investigating the chromospheric magnetic field. The instrument consists of a number of lenses, two ferro-electric liquid crystals, a Wollaston prism, and a CCD camera. The optical design is similar to that of a commercial zoom lens which allows a variable f# while maintaining focus and aberrations well within the Airy disc, making it portable. The optical design of the Adaptable ChRomOspheric POLarimeter (ACROPOL) makes use of off-the-shelf components and is described for two configurations - a 70 cm, f#33 telescope and a 1.5 m, f#40 telescope. The design shows that the optical train can be separated into two units where the first unit, consisting of a single lens, has to be changed while going from one configuration to the other. I shall also discuss the tolerances within which, diffraction limited performance can be achieved with the design.

S2-P24	IAUS340_250	Mancuso Salvatore	Poster

Authors: Mancuso Salvatore (1), Taricco Carla (1,2), Rubinetti Sara (1,2), Lee Tae Song (3) (1) Istituto Nazionale di Astrofisica - Osservatorio Astrofisico di Torino, Pino Torinese, Italy (2) Dipartimento di Fisica, Università di Torino, Torino, Italy (3) Georgia Gwinnett College, Lawrenceville, GA, USA

Title: Multivariate analysis of intermediate quasi-periodicities of the green corona intensity

Abstract: Solar activity is known to fluctuate with time, undergoing a wide range of periodicities from a few minutes up to centuries. Except for the 11-year Schwabe cycle due to the solar dynamo and the 27-day period due to solar rotation, however, the origin and persistence of the intermediate periodicities in the solar activity are not clear as yet. In this work, we use the Multichannel Singular Spectrum Analysis, a data-adaptive, multivariate, non-parametric technique to investigate the intermediate quasi-periodicities of the Fe XIV green coronal emission line at 530.3 nm during six solar cycles covering the period from 1944 to 2008. Our results will be compared with the ones obtained in the literature using different solar datasets and analysis methods.

S2-P25	IAUS340_190	Mandal Sudip	Poster

Authors: Sudip Mandal, Tanmoy Samanta, Dipankar Banerjee, Manjunath Hegde, Gopal Hazra, Subhamoy Chatterjee and Ravindra B.; Indian Institute of Astrophysics, Indian Institute of Science

Title: Science results obtained from century-long Kodaikanal white-light digitized data archive

Abstract: The Kodaikanal Observatory in India, has been acquiring the full disc images of the Sun in photographic plates/films, in white-light broadband filter since early 1900. Recently, these plates have been digitized in high-resolution fits formats and are made available to the global solar community. We have implemented a semi-automated 'sunspots detection' algorithm to identify the feature over 9 solar solar cycles (cycle 16-23). All the feature parameters such as sunspot area, longitude and latitude have also been extracted during the procedure. Using these detected sunspots, we find that the cycle properties change with the individual spot sizes. Such a behaviour essentially points toward a puzzling sunspots generation mechanism which is generally believed to be governed by a global dynamo. We also study the presence and persistence of 'solar active longitudes' using this dataset. Our analysis, which covers the two widely accepted method s for such a study, confirms the existence of 'active longitude' over century scale time. We also establish the role of solar differential rotation in connection to the observed periodicities in these active longitudes.

S2-P26	IAUS340_163	Megha A	Poster

Authors: A. Megha(1), M. Sampoorna(1), K. N. Nagendra(1) and K. Sankarasubramanian(1,2,3), (1) Indian Institute of Astrophysics, Koramangala, Bengaluru, India (2) Space Astronomy group, ISRO Satellite Centre, Bengaluru, India (2) CESSI, IISER, Kolkata, India

Title: Coronal magnetic field measurements using forbidden emission lines

Abstract: Coronal magnetic field measurement is still a challenging problem in solar physics. The polarization measurement of coronal forbidden emission lines that arise from magnetic dipole (M1) transitions in the highly ionized atoms present in the corona, is the most promising method of determining the direction of magnetic fields in the corona. Here we present the classical scattering theory of the forbidden lines formulated for a more general case of arbitrary-strength magnetic fields. The scattering matrix for M1 transitions is derived using the classical magnetic dipole model of Casini & Lin, and by applying the scattering matrix approach of Stenflo. The scattering matrix so derived is used to study the Stokes profiles formed under coronal conditions. To this end, we consider a two-level atom model and neglect collisional effects. We take into account the integration over a cone of an unpolarized radiation incident from the solar disk on the scattering atoms and perform an integration along the line of sight to calculate the emerging polarized line profiles. For illustrations we adapt the atomic parameters corresponding to the [Fe XIII] 10747 Å coronal forbidden line. We further extend our approach by implementing the surface integration to study the stellar coronal magnetic fields.

S2-P27	IAUS340_163	Megha A	Poster

Authors: A. Megha(1), K. Sankarasubramanian(1,2,3), Jagdev Singh(1), M. Sampoorna(1) and K. N. Nagendra(1), (1) Indian Institute of Astrophysics, Koramangala, Bengaluru, India (2) Space Astronomy group, ISRO Satellite Centre, Bengaluru, India (3) CESSI, IISER, Kolkata, India

Title: Estimation of coronal plasma parameters using coronal spectroscopy

Abstract: Understanding coronal phenomena, such as plasma heating and acceleration, explosive activities like CMEs, has become a difficult task due to the lack of reliable measurements of key parameters such as densities, temperatures, velocities, etc. Simultaneous spectroscopy of multiple spectral lines is one of the best diagnostic methods to study such a dynamic plasma. The physical parameters of the plasma such as density and temperature can be derived using line ratio methods. In this work, we apply a forward modeling technique using CHIANTI databases and its spectral synthesis capabilities to the observed visible and IR coronal emission line data obtained at Norikura Solar Observatory, Japan. The motivation behind this work is to study the feasibility of generating an inversion procedure for spectral lines formed in solar coronal plasma as in the case of photospheric and chromospheric spectral lines. This study includes the determination of major plasma parameters such as temperature structure, densities and emission measures. We find that the isothermal approximation used in CHIANTI is not sufficient to simultaneously model all the spectral lines that we have considered. Therefore, we try to derive differential emission measure (DEM) using EUV lines observed in EIT. This study would also discuss the forward modeling of coronal magnetic field observations, and serve as a basis for the analysis of the data to be acquired from the upcoming ADITYA mission.

S2-P28	IAUS340_162	Panda Suman	Poster

Authors: 1. Suman Panda, Department Of Physical Sciences, IISER Kolkata 2. Dibyendu Nandi, CESSI, IISER Kolkata, Department Of Physical Sciences, IISER Kolkata

Title: A study of Twist and Tilt angle distribution of solar active regions from SDO/HMI observations

Abstract: Twist and tilt of solar active Regions (ARs) can be derived from photospheric magnetic field measurements. They provide us information regarding the creation and dynamics of magnetic flux tube inside the Sun. In this study, we have focused on ARs during their time of emergence. We have calculated tilt and twist of ARs using vector magnetograms from Helioseismic Magnetic Imager (HMI) aboard the Solar Dynamic Observatory (SDO). We have analyzed the dependence of tilt with latitude which confirms to the Joy's law. We have also looked at dependence of twist on latitude. We find that dispersion and amplitude of twist decreases with increasing magnetic size of ARs. We have also analyzed the correlation of twist and tilt which shows that they are realated. This result is in conformity to the conservation of magnetic helicity in ideal MHD systems; the sun having conditions close to ideal MHD.

S2-P29	IAUS340_328	Pandey Deepak	Poster

Authors: Seema Pande, Bimal Pande KUMAUN UNIVERSITY

Title: Coparison between Associated and Non-associated type II solar radio bursts during increasing phase of solar cycle 23

Abstract: The study of association between type II radio bursts and type III radio bursts, will lead to understanding the drivers of type II radio bursts. Type III radio bursts are mostly followed by type II bursts. In this work we have presented a comparison between the associated and non-associated type II radio bursts during increasing phase of solar cycle 23 using statistical analysis and found a correlation between associated and non-associated radio-bursts. In our study, we have compared the different parameters of radio bursts such as duraton drift rate, shock speed, band width of associated and non-associated bursts. Our study indicated that the radio parameters almost remain uniform and variation in the parameters is very marginal except in the case of bandwidth for associated and non-associated events.

S2-P30	IAUS340_375	Pandya Umang V	Poster

Authors: 1. UmangKumar VijayKumar Pandya [Pacific Academy Of Higher Education And Research University Udaipur] 2. Rajmal Jain [Kadi Sarva Vishwavidyalaya, Gandhinagar, Gujarat] 3. S.N.A.Jaaffrey [Pacific Academy Of Higher Education And Research University Udaipur]

Title: STUDY OF X-RAY EMISSION CHARACTERISTICS In SOLAR FLARES employing SOXS: CZT detector

Abstract: My project involves a unique sample of 11 solar flare events observed by the space mission "Solar X-ray Spectrometer (SOXS)" particularly by CZT detector. I study temporal characteristics of 11 flares in general and rise time characteristics in particular. For this purpose I got an opportunity to learn newly developed software in IDL. The flares selection is based on the GOES intensity in the range of M1.0-X1.0. The catalogue of all the flares chosen for this work is presented in table. The rise time of flares vary between 123 and 433 secs in 4-5.5 keV energy band while shortest rise time of the order of ~60 secs has been observed in 20-56 keV high energy bands. I have discussed analysis methodology and results in Table. My results reveal unique feature that rise time decays exponentially towards high energy. This result suggests that short rise time at high energy tail may be due to faster acceleration of electrons and thereby producing non-thermal bremesstrahlung via collisions of electrons with ambient plasma in solar flare loops.

S2-P31	IAUS340_146	Prasad Avijeet	Poster

Authors: A. Prasad(1), R. Bhattacharyya(1), and Sanjay Kumar(2) (1) Udaipur Solar Observatory, Physical Research Laboratory, Dewali, Bari Road, Udaipur-313001, India (2) Department of Physics, Patna University, Patna-800005, India

Title: Magnetohydrodynamic modeling of solar atmosphere using non-force-free magnetic fields

Abstract: The solar atmospheric plasma can be described by the non-diffusive limit of magnetohydrodynamics (MHD) due to the large length scales and the high temperatures involved. For a realistic simulation of the solar atmospheric magnetic field, we need to determine the boundary conditions from the photospheric observations. The minimum dissipation rate based non-force-free field (NFFF) extrapolation technique is well suited to the vector magnetogram data obtained from an externally-driven system like the solar photosphere, where the force-free assumptions don't hold. Here, we present the topological evolution of solar coronal magnetic fields, inferred through the photospheric vector magnetograms using the EULAG-MHD numerical model. The simulations are performed on vector magnetograms of the active region NOAA 12192, which had produced multiple flares during the solar cycle 24. Particularly, we examine the strongest X-3.1 non-eruptive flare that took place on October 24, 2014 at 21:30 hours. Our analysis indicates magnetic reconnections at a three-dimensional null-type geometry occurring close one of the polarity inversion lines, in the vicinity of the flaring site. This can potentially explain the trigger mechanism for the flare and also the subsequent brightening seen in the ultra-violet channels.

S2-P32	IAUS340_218	Santhosh Kumar G	Poster

Authors: Santhosh Kumar G., Sumesh Gopinath and Prince P.R Department of Physics, University College, Trivandrum-695034, Kerala, India

Title: A study on universality, non-extensivity and Lévy statistics of solar wind turbulence

Abstract: The solar wind is a complex plasma system in which intermittent turbulence, wavy fluctuations and embedded magnetic field structures coexist over multiple scales. As the Sun unevenly emits slow and fast speed streams and transient ejecta, a single mechanism cannot fully reproduce the observed complexity in the solar wind. For now, certain aspects of this complexity can be described only through statistical methods. Recently, statistical evidence has been accumulating in support of the possibility that a number of complex systems arising in diverse disciplines may have certain quantitative features that are surprisingly similar. Such features of similarity can be conveniently classified under the paradigm of 'universality'. In other words, the dynamics of complex systems are founded on universal principles that can be used to describe disparate problems. The non-extensive Tsallis statistical mechanics and Lévy flights dynamics provides a firm basis for analyzing out-of-equilibrium complex systems that may exhibit long-range correlations, anomalous diffusion, memory, or fractal properties and hence considered as an appropriate mathematical tool to investigate universality. The present work analyzes the scope of employing non-extensive Gutenberg-Richter (G-R) type law for the magnitude distribution of energy of solar wind, in order to investigate the existence of a universal behavior as well as to compute the relations of degree of non-extensivity and waiting time (Lévy) statistics in solar wind turbulence.

S2-P33	IAUS340_249	Sen Samrat	poster

Authors: S. Sen (IIA) and A. Mangalam (IIA)

Title: Magnetohydrostatic equilibrium solution of a fluxtube

Abstract: We construct a magnetohydrostatic equilibrium model of an open fluxtube spanning from the photosphere to the lower part of the transition region within a realistic stratified solar atmosphere subject to solar gravity. The fluxtube we build is vertically straight and expands with height. Using the azimuthal symmetry in the cylindrical geometry, we use two formulations which are separable in the two spatial coordinates r and z. Incorporating specific forms of gas pressure, poloidal current and shape function in the Grad-Shafranov equation we solve for the magnetic flux function along r and z by using standard boundary conditions. We obtain the solutions semi-analytically and study the homology of the solutions. Using the study of the homology parameters which is consistent with the solar atmosphere, we obtain the range of the magnetic field structures and the thermodynamic quantities inside the fluxtube. We study both models and find that our estimates are consistent with the size, magnetic structure and thermodynamic quantities of photospheric magnetic bright points (MBPs) as estimated from the observations and simulations.

S2-P34	IAUS340_249	Sen Samrat	Poster

Authors: S. Sen (IIA) and A. Mangalam (IIA)

Title: Energy distribution of solar flare events

Abstract: Observational evidence of the braiding of magnetic field lines has been reported. The magnetic reconnection within the loop (nanoflares) and with other loops (microflares) disentangle the field. The coronal field then reorganizes itself through a Taylor like relaxation process to attain a force-free field configuration. We have evaluated the power law index of the energy distribution f(E)=f_0 $E^{-\alpha}$by using a model of relaxation incorporating different profile functions of winding number distribution f(w) based on braided topologies. We study the radio signatures that occur in the solar corona using the radio data obtained from the Gauribidanur Radio Observatory (IIA) and extract the power law index by using the Statistic sensitive nonlinear iterative peak clipping (SNIP) algorithm. We see that the power law index obtained from the model is in good agreement with the calculated value from the radio data observation.

S2-P35	IAUS340_342	Sowmya Krishnamurthy	poster

Authors: Sowmya Krishnamurthy^1, Andreass Lagg^1, and Sami K. Solanki^{1,2} ^{1}Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Goettingen, Germany ^{2}School of Space Research, Kyung Hee University, Yongin, 446-701 Gyeonggi, Republic of Korea

Title: Downflows in the chromosphere seen by He I 10830 A lines

Abstract: We report and characterize downflows in an active region observed by the GRIS instrument at GREGOR in the He I 10830 A triplet. Using multi-component and multi-line inversions of the spectropolarimetric data assuming Milne-Eddington-type atmospheres, we derive the velocities and magnetic vector. We investigate the velocity structure and topology of the magnetic fields in the chromosphere where the He lines are formed (8000--10000 K).

S2-P36	IAUS340_169	Suji K. J.	Poster

Authors: Suji K J and Prince P R, Department of Physics, University College, Thiruvananthapuram 695034, Kerala, India

Title: Superposed Epoch Analysis of high latitude Ionospheric Joule Heating During Major Geomagnetic Storms over three Solar Cycles

Abstract: Superposed epoch analysis (SPEA) is commonly used to determine some basic “structure” in a collection of geophysical time series. Recently, Ionospheric absorption associated with interplanetary conditions (Marcz, 1992), ionization impacts in the ionospheric D region at mid-latitudes because of Forbush decrease (Satori, 1991) etc have been shown with the assistance of the epoch analysis. The present study tries to analyse ionospheric Joule heating response, at high latitudes, to the prevailing solar wind and IMF conditions on the basis of SPEA. Major geomagnetic storms (CME driven) over three consecutive solar cycles (SC 22, 23 and 24) have been selected. The rising phase, maximum phase, and declining phase are investigated separately, for each solar cycle, to find out crucial controlling parameters for the generation of high-latitude ionospheric Joule heating. Production rate of Joule heating was observed to increase over the main phase, while it decreased during recovery phase for the storms considered. SPEA results demonstrate that, the main phase variations synchronize well with components of IMF and IMF clock angle. Solar wind dynamic pressure and proton density are found to influence Joule heating production rate significantly. Meanwhile, the relentlessness of the other parameters shows that they have poor impact on Joule heating.

S2-P37	IAUS340_169	Suji K. J.	Poster

Authors: Suji K J and Prince P R, Department of Physics, University College, Thiruvananthapuram 695034, Kerala, India

Title: Energetics of Magnetosphere-Ionosphere System during main Phase of Intense Geomagnetic Storms over three Solar Cycles

Abstract: Geomagnetic storms are global disturbances in the Earth's magnetosphere caused by varying strength and configuration of geo-effective solar wind/ IMF features. During southward IMF, the rate of reconnection at the subsolar magnetopause is enhanced which leads to more effective coupling of the magnetosphere to the solar wind dynamo, driving more intense convection. The energy produced by the dynamo gets injected into various dissipation channels in the coupled magnetosphere – Ionosphere (MI) system. In the present study, 70 intense geomagnetic storms (CME driven) are analyzed for the period between 1986 and 2015, which covers the solar cycles 22, 23 and 24. By using the 1-minute solar wind data and IMF data from OMNI group, the solar wind kinetic energy, solar wind energy input and different energy dissipation channels such as ring current injection rates, high latitude Ionospheric Joule heat production rates, and auroral particle precipitation rates have been estimated. The solar wind kinetic energy available in the solar wind ranges from 4.8×1017J to 1.6×1019J. The average solar wind energy that was transferred into MI system using Epsilon parameter was estimated to be 7.3×1016J. Moreover, the relative importance of the energy sinks are quantified, and it was found that, on an average, 66% of energy dissipated into the inner magnetosphere is through high-latitude ionospheric Joule heating.

S2-P38	IAUS340_126	Sushma GN	Poster

Authors: Sushma G. N.^2, Hiremath, K. M^{1}, Nadaf, Y. F.^2 1. Indian Institute of Astrophysics, Koramangala, Bengalauru-560034 2. Department of Physics, Bengaluru University, Bengaluru

Title: Decadal Variation of Equatorial Rotation Rate of the Sun from Kodaikanal Digitized Data

Abstract: DECADAL VARIATION OF EQUATORIAL ROTATION RATE OF THE SUN FROM KODAIKANAL DIGITIZED DATA Hiremath, K. M^1, Sushma G.N^2, Nadaf Y.F^3 1. Indian Institute of Astrophysics, Koramangala, Bengaluru-560034 2. Research scholar, Department of physics, Maharani Science College and Research center, Bangaluru 3. Department of Physics, Maharani Science College and Research center, Bangaluru-560001

Aim of present study is to confirm whether equatorial rotation rate of the sun is constant or not. By using calibrated daily sunspots data from Kodaikanal Observatory digitized white light pictures, after applying correction for the limb darkening and distortion of the optics, center and radius of the sun are estimated uniquely from the images. Sunspots are detected, heliographic coordinates and areas of the sunspots are computed accurately. For the 15 years (1996-2011), after taking into account for the projectional effects, rotation rates of the sunspots are estimated and, equatorial rotation rate rotation rate of the sun is determined. In contrast with the previous studies, which used the crude sunspot data from Greenwich photo heliographic results, for all the 15 years, present study yields the constant equatorial rotation rate and, magnitude of equatorial rotation rate of the sun is independent of sunspot activity.

S2-P39	IAUS340_385	Yan Yan	Poster

Authors: Yan Yan, Zhanle Du, Huaning Wang, Han He, Xin Huang, Juan Guo, Xiaoshuai Zhu, Xinghua Dai

Title: Decades of Chinese Solar and Geophysical Data

Abstract: The Chinese Solar and Geophysical Data (CSGD) was first issued at the Beijing Observatory, Chinese Academy of Sciences (now National Astronomical Observatories) in 1971, when China's satellite-industry was booming. CSGD covers the observational data (observations of the sunspots, solar flares, solar radio bursts, ionospheric storm and geomagnetic storm) from a couple of domestic observatories , and the forecast data. The compiler of CSGD still keeps the data exchange with other institutes worldwide. The type of the dataset includes texts, tables, figures and so on. Up to now, we have electronized all the historic archives, making them easily accessible to people who are interested in them.

Session 3. Indices of Solar Cycle from Photosphere to the Heliosphere

S3-P1	IAUS340_160	A M Aslam	Poster

Authors: 1.Aslam A M., SORT, People's University-Bhopal,India. 2.Azad Ahmed Mansoori, Department of Physics and Electronics, Barkatullah University-Bhopal,India. 3. A.K. Gwal, AISECT University-Bhopal, India

Title: Nature of Response of Geomagnetic Field to Soalr Cycle at Different Latitudes

Abstract: In this paper a study on the response of geomagnetic field characteristics to the solar wind variation during three solar cycles (SC 21, SC 22, SC 23) have been conducted. The difference in the response of two different latitudinal characteristic indices has been investigated. For the purpose we have considered the high latitude index AE and the mid-latitude Aa index and both gives the knowledge about the perturbations in the geomagnetic field conditions. Eventually we can infer the idea about the ionospheric current system changes in response to the solar wind conditions. The variation found in the AE and Aa indices have been found to follow a 11 year cycle as similar to the sunspot variation. Also the correlation between the annual means of the solar wind parameters velocity V, magnetic filed B and the composite parameters BV and BV2 have been calculated . A difference was found between the correlations obtained for the AE and Aa indices . We could also see that the difference in correlation follows a cyclic pattern i.e. the difference is large difference is found during the solar maxima while a small difference is observed during the minima. Keywords: Geomagnetic Storms, Solar wind, Interplanetary Magnetic field, Geomagnetic Indices.

S3-P2	IAUS340_211	Amareswari K	Poster

Authors: Amareswari K.(1), Sankarasubramanian K. (1), and Ravindra, B.(2), 1.ISRO Satellite Centre, Bengaluru. 2.Indian Institute of Astrophysics, Bengaluru

Title: Century long study of sunspot activity using the Kodaikanal white-light data

Abstract: Sunspots are the most obvious and high contrast observable feature of solar magnetic activity. The morphological and kinematic behavior of sunspots on the solar surface need to be studied over a long time period to understand solar magnetic activity. For this, it is important to understand the long term emergence patterns, developments and decay of the sunspots on the solar surface over many cycles. The long time sequence of the Kodaikanal white-light images provides a consistent data set for this study. The digitized images were calibrated for relative plate density and aligned in such a way that the solar north is in upward direction. A sunspot detection technique was used to identify the sunspots on the digitized images. In addition to describing the calibration procedure and availability of the data, we here present results on the sunspot, umbral and penumbral area measurements and their variation with time.

S3-P3	IAUS340_386	Amrita Prasad	Poster

Authors: Amrita Prasad1, Soumya Roy2, Susovan Chowdhury3, Subhash Chandra Panja1, Sankar Narayan Patra3 1Mechanical Engineering Department, Jadavpur University, Kolkata, India 2 Dept. of AEIE, Haldia Institute of Technology, Haldia, India 3Dept. of Instrumentation Science, Jadavpur University, Kolkata, India

Title: Short Memory and Fractal behavior of The Solar radio flux at 10.7 cm wavelength (2800 MHz) obtained from Ottawa and Penticton, British Columbia, Dominion Radio Astrophysical Observatory during the per

Abstract: Solar Radio Flux exhibits an estimate of diffuse, non-radiative heating of the coronal plasma which is trapped by magnetic fields over active regions. It is an exceptional indicator of gross solar activity levels and correlates properly with Solar UV emissions. The solar radio observations can be used to investigate the chromosphere up to the middle of the corona. Radio observations provide information about the magnetic field. Strong emissions can be produced at low harmonics of the electron gyro-frequency where the magnetic fields are strong. The Solar radio emissions in the centimeter and decimeter regions, which arise at distinct levels between the chromosphere and the corona, can structure the basis of solar radio indices. The analysis of the memory process within the Solar Radio flux signal carries a significant role in understanding the solar dynamics. This paper investigated the antipersistent behavior as well as memory process and fractality of solar radio flux by computing the Hurst exponent and Fractal Dimension using Rescaled-Range Analysis and Higuchi Method of Fractal Geometry. From our analysis it is found that the value of Hurst exponent H is 0.109. The value of the fractal dimension obtained is between 1 and 1.5. This value of Hurst Exponents suggest that the given time series is governed by short memory process and has mean-reverting characteristics and there is strong negative correlation within the time series. Whereas Fractal dimension implies that the signal roughly lies between straight line and Gaussian random walk. This implies strongly the fractal nature of solar radio flux signal. Since solar radio flux is the indicator of the interior solar structure so it may be said that the nuclear energy generation inside the sun is fractal in nature.

S3-P4	IAUS340_116	Anshu Kumari	Poster

Authors: Anshu Kumari (IIA) R. Ramesh (IIA) C. Kathiravan (IIA) Nat Gopalswamy (Solar Physics Laboratory, NASA)

Title: New Evidence for Coronal Mass Ejection Driven High Frequency Type II Burst Near the Sun

Abstract: Type II solar radio bursts are considered to originate from plasma waves excited by magneto-hydrodynamic (MHD) shocks and converted into radio waves at the local plasma frequency and/or its harmonics. They are the direct diagnostic of MHD shocks in the solar atmosphere. The burst is recognized in the radio spectral observations, where the intensity is plotted in the time- frequency plane, as a drift towards the lower frequencies. We report observations of the high frequency type II radio burst (≈ 430 – 30 MHz) that occurred in the solar corona on 4 November 2015. The drift rate of the burst, estimated close to the start frequency of its fundamental component (≈ 215 MHz), is unusually high (≈ 2 MHz/sec). Our analysis shows that the estimated speed of the magneto-hydrodynamic shock driver of the burst varies with time. The peak speed and acceleration are very large, ≈ 2450 km/s and ≈ 17 km/s^2 , respectively. There is spatio-temporal correlation between the type II burst, and the associated coronal mass ejection in the whitelight and extreme-ultraviolet images. The time profile of the shock speed, and the light curve of the associated soft X-ray flare correlate well. These results indicate that in the present case: i) the magneto-hydrodynamic shock responsible for the high frequency coronal type II burst is driven by the coronal mass ejection; ii) the time profile of the type II burst shock speed represents the near-Sun kinematics of the coronal mass ejection.

S3-P5	IAUS340_35	Banerjee Dipankar	Poster

Authors: Teams from IIA, Bangalore and IUCAA, Pune

Title: Century-long, multi-wavelength Solar Database From Kodaikanal Solar Observatory

Abstract: The Kodaikanal observatory has been obtaining solar images since 1904 in broad band white light, narrow band Ca-K 393.37 nm and Hα 656.3 nm wavelengths. Many of these observations are still continuing. The historical data which were on photographic plates has been digitized. The calibration of the Ca-K, white light and Hα images have been completed. Currently all the raw data are available in online portal. Under the NKN Data driven initiatives project, a new python based search engine is developed. The search engine will give inputs like example data, understanding the data and FAQ pages.

S3-P6	IAUS340_171	Bzowski Maciej	Poster

Authors: M. Bzowski, M.A. Kubiak, J.M. Sokół, I. Kowalska-Leszczyńska Space Research Centre PAS (CBK PAN)

Title: Solar activity affecting the heliosphere and heliospheric particle populations

Abstract: Heliosphere is created due to the interaction of solar wind with the partly ionized, magnetized matter of the Local Interstellar Cloud (LIC) penetrated by the Sun. While the ionized component of the LIC flows past the heliopause, the neutral component penetrates freely inside the heliosphere, bringing in momentum and energy, which are gradually deposited in the solar wind. This happens when the atoms are ionized due to charge exchange with solar wind protons, photoionization, or ionization by solar wind electron impact. As a result of ionization of interstellar gas, new populations of particles are created: energetic neutral atoms (ENAs, one of the products of the charge exchange reaction) and pickup ions (PUIs, product of all ionization processes). These populations and the interstellar gas (composed mostly of H and He, with a small contribution from Ne, O, and D), are useful sources of information on the size and asymmetry of the heliosphere, as well as on the direction and strength of the interstellar magnetic field and the element composition of the LIC. However, due to solar cycle modulation, a thorough knowledge of the solar forcing and its evolution with solar activity is needed. We present the connection between the solar activity and the heliospheric particle populations and potential synergy between investigating the solar activity at all heliolatitudes and heliospheric observations, including the heliospheric backscatter glow of interstellar H and He and direct-sampling observations of interstellar neutral gas, ENAs and PUIs.

S3-P7	IAUS340_154	Chandra Ramesh	Poster

Authors: Ramesh Chandra Department of Physics, DSB Campus, Kumaun University, Nainital - 263001, India; P. F. Chen School of Astronomy & Space Science, Nanjing University, Nanjing—210 023, China; Bhuwan Joshi Udaipur Solar Observatory, Physical Research Laboratory, 313 004 Udaipur, India

Title: EUV Wave Event: Deflection and Stationary Fronts

Abstract: We present here the observation of an extreme ultraviolet (EUV) wave event observed on 2016 July 23. The EUV wave event was observed by the Atmospheric Imaging Assembly (AIA) instrument on board Solar Dynamics Observatory (SDO) satellite. The wave event is associated with a filament eruption and a GOES M7.6-class flare from the NOAA active region 12565, which was located near the western limb. Major part of the EUV wave moves towards the south direction. We observed the deflection of the EUV wave from the null-point located in the south direction, which was about 0.5 Rsun from the flare source region. Together with the deflection of the EUV wave, we observed several stationary fronts in the north and south direction of the source region. We believe that the deflected EUV wave is the fast MHD wave and the stationary fronts are the slower EIT wave. These observed features can be explained by the hybrid model of Chen et al. (2002).

S3-P8	IAUS340_193	Chatterjee Subhamoy	Poster

Authors: Subhamoy Chatterjee^1, Dipankar Banerjee^1, Scott McIntosh^2 1. Indian Institute of Astrophysics 2. High Altitude Observatory, USA

Title: Detection and Time-latitude Study of Network Bright Elements from Century-long Kodaikanal Ca II K Data

Abstract: Ca II K solar image presents itself with well-defined tessellation made by polygonal structures called supergranules. The supergranule boundaries, known as networks, are seen as brighter than background because of concentration of magnetic fields. Kodaikanal Solar Observatory (KSO) has archived Ca K data from 1907 till 2007 in films/photographic plates through an unchanged optics. We have detected supergranules from the digitized version of that data. Using those supergranular boundaries as mask we detected bright network elements through intensity thresholding in the quiet regions not consisting of plages. Along with the number of those bright elements we recorded their individual areas with latitudinal and longitudinal locations. We used Carrington maps for this purpose. With the recorded features we tried to explore the cyclic variations of number, area of the bright elements and their relations with sunspot cycle. We feel those provide new constraints to local and global dynamo. We also examined whether their latitudinal migration has any implication to the polar fields and drift in Carrington longitudes has Rossby wave like features.

S3-P9	IAUS340_53	Choithani Veena Manohar	Poster

Authors: Veena Choithani1, Rajmal Jain1 and D. Pallamraju2 KadiSarvaVishwavidyalaya, Gandhinagar, Gujarat 382016 Physical Research Laboratory, Ahmedabad, Gujarat 380009

Title: Study of solar flares associated with CMEs affecting the geosphere

Abstract: We study flares associated with CME and SEP events. Our investigation has two-fold objectives: first we probe the temporal relationship between flares and CMEs within the cadence of observations, and next we focus on the CME dynamics and associated SEP events. We employ observations from GOES for X-ray emissions from flares as well as protons emitted in association to the flare-CME event. The CME data has been considered from LASCO/ SOHO mission. We study the temporal characteristics of the flare in 1 to 8 Å. The data is of 3s cadence. Employing this data and CME data we attempt to find temporal correlation. The cadence of CME observations is 12 min and thus correlation is restricted to this time limit. We have also studied the proton flare characteristic start time, peak time, end time and proton flux in different seven channels range from 0.6-500 MeV. We made spectra from temporal observations in each energy band. We consider 3-hour interval to form the spectra in view of count statistics. The spectra for each proton flare event are fitted with the chi-squared method. The spectral index (negative power-law index) is derived at every 3-hour interval for a given event. We then study growth of spectral index over time of the proton flare event to understand the acceleration process. We found that acceleration process continues for about 20 hours. On the other hand the CME velocity as a function of integrated proton flux over the rise time enables us to conclude that CME produces the shock (correlation coefficient of ~ 0.77) and the shock further accelerates the particles. The shock speed depends on the CME dynamics. We further derive the power of SEP (impulsiveness) to observe the geomagnetic storm activity. The relative effects of these different CME events on the geosphere are evaluated to assess their geo-effectiveness. These aspects of space weather will be presented.

S3-P10	IAUS340_44	Chowdhury Partha	Poster

Authors: Dr.Partha Chowdhury University of Calcutta, India

Title: Midrange periodicity of basal component of Ca K plage index

Abstract: Solar chromosphere is a complex, inhomogeneous and dynamical layer consisting of both cool gases and hot ionized plasma. The spectrum of chromosphere is dominated mainly by emission lines like K and Hα lines.It has been found that observations near the core of Ca II K emission line (3933.67 Å) is very effective tool to investigate the morphology and dynamical behavior of Ca –plage and networks which are magnetic in nature.Ca –plages waxes and wanes periodically in about 11 year time scale, closely similar to the sunspot variation.We have considered the century long Ca K-plage index data set (1907 -1998) from Kodaikanal Observatory and investigated the mid-range periodicities for non-magnetic (basal)components of this index.Power spectrum decomposition technique revealed a number of mid-term periodicities including Rieger type and quasi-biennial (QBOs)one. The observations of basal component (non magnetic component of Ca K plage index) are interpreted in terms of the internal dynamics of the Sun. The obtained periodicities also provide physical information about the source region of the solar atmosphere.

S3-P11	IAUS340_245	Gogoi Jinee	poster

Authors: Junmi Gogoi (Student, Dibrugarh University) Kalyan Bhuyan (Professor, Dibrugarh University)

Title: A study of effects of Geomagnetic Storms on Ionosphere and their relationship with Sub storms during solar cycle 23.

Abstract: The effect of geomagnetic storms on the F2 layer has been studied here by calculating the normalized deviation dfoF2 of the critical frequency foF2 during 63 intense storms (Dst ≤ -100 nT) of 23rd solar cycle. foF2 data were taken from four ionosonde stations in the Southern Hemisphere. The stations were chosen within a small longitudinal range (146.90-152.90), so that their local time difference is negligible. The foF2 variations have been studied according to three seasons (summer, winter and equinoxial) and four interplanetary structures (CIR, nonMC, sMC and SH). It has been observed that during the storms negative phase is more certain. The foF2 variations are found to vary from season to season. Negative ionospheric storms are more pronounced in summer and during SH storms, whereas positive phases are more pronounced in winter and during nonMC storms. These storms have been studied to investigate the storm-sub storm relationship. The association of various magnetospheric and solar wind parameters such as BZ (southward interplanetary magnetic field), BT (tangential magnetic field), V (plasma flow speed), ρ (plasma proton density), θc (clock angle) etc. with the Dst index has also been investigated. The correlation of Dst with Bz, θc and ρ are found to be very poor for the storms studied. Comparatively better correlation of Dst have been found with V and BT.

S3-P12	IAUS340_51	Hariharan Krishnan	poster

Authors: Hariharan K and NCRA-TIFR

Title: Study of Solar Eruptive Phenomena using archived Radio Observational Dataset

Abstract: Ground-based observations of the solar atmosphere at visible wavelengths have been carried out for over a couple centuries now. With the advent of space technology, observations at both the visible and other high energy bands like UV and X-ray using space-borne instruments, viz. Coronagraph, spectroscographs etc., have become possible acquiring a wealth of data over the last few decades. However, such observations are limited to specific regions in the solar atmosphere. The solar atmosphere at the heliocentric distance range from approximately 1.05 – 1.7 solar radii is still inaccessible at these wavebands. Radio emission from the Sun at low radio frequencies below 300 MHz has been observed to originate in this region. There have been several efforts by different research groups across the globe in developing instruments particularly for wide-band radio spectral observations of the Sun at these frequencies. I will briefly discuss the various low radio frequency archives which have resulted from some of the long-term efforts of different groups. These archives are available in the public domain and can provide useful complimentary information to that obtained at other wavebands. I will provide some illustrations by using the data to trace the dynamics of solar eruptive phenomena across various regions in the solar atmosphere .

S3-P13	IAUS340_18	Hegde Manjunath	poster

Authors: Manjunath Hegde, Subhamoy Chatterjee and Dipankar Banerjee ; Indian Instiutute of Astrophysics

Title: Long term study of sunspot characteristics from Cak images of Kodaikanal Observatory

Abstract: Ca II K spectroheliograms from kodaikanal solar observatory have been digitized recently. These has been the longest studied dataset in Ca II K spanning about 9.5 solar cycles. We, for first time as per our understanding, used the calibrated images to detect and study characteristics of sunspots . We calculated intensity thresholds for every image removing active regions by plage detection and using intensities of the remaining full disc pixels. Along with their centroid longitude and latitude, area of sunspots are extracted. We plot time latitude distribution of sunspot centroid producing butterfly diagram. Using the known information about sunspot location from photosphere, one to one correspondence with sunspot from chromosphere are studied. We explore some new implications from that study.

S3-P14	IAUS340_167	Jha Bibhuti Kumar	poster

Authors: Bibhuti Kumar Jha, Sudip Mandal and Dipankar Banerjee (Indian Institue Of Astrophysics)

Title: Long-term variation of sunspot penumbra to umbra ratio: A study using Kodaikanal white-light digitized data

Abstract: A typical sunspot, as seen in white-light intensity images, has a two part structure: a dark umbra and a lighter penumbra. Such distinction primarily arises due to the different orientations of magnetic fields in these two regions. In this study, we use the Kodaikanal white-light digitized data archive to analyze the long-term evolution of umbral and penumbal area. We developed an 'automated algorithm' to uniquely identify the sunspot umbra (including the calculation of penumbra to umbra ratio) from these digitized intensity images. Our analysis reveals that the ratio increases slightly with the increase of sunspot area upto 100 mhm but eventually settles down to a constant value after that. Interestingly, this ratio, does not show any noticeable correspondence with the change of heliographic latitude and also with different phases of a solar cycle. Apart from that, when divided into two different sunspot size classes, we find that the ratio does not show any long-term trend for spot sizes <100 mhm which contradicts a previous report on the presence of the same. This study, not only allows us to better understand the evolution of an individual spot and its corresponding magnetic field but this is also beneficial for solar dynamo studies which aim to reproduce such structures using a MHD theory.

S3-P15	IAUS340_267	Joshi Anand	Poster

Authors: Anand D Joshi, NAOJ

Title: Statistical Study of Eruptive and Disappearing Filaments

Abstract: Solar filaments are dense and cool material suspended in the low solar corona. They are found to be on the Sun for periods up to a few weeks, and they end their lifetime either as a gradual disappearance or a sudden eruption. Filament eruptions are found to be closely associated with coronal mass ejections (CMEs) wherein a large mass from corona is ejected into the interplanetary space. CMEs with a favourable orientation of magnetic field can cause magnetic storms in Earth's atmosphere. Thus filaments assume great significance. We would therefore analyse such filament eruptions and disappearances statistically for various parameters, through which the common underlying properties of such events can be deduced. For this purpose, we have developed an automated detection and tracking technique by making use of full-disc H-alpha images. Various processing steps are used before subjecting an image to segmentation, that would extract only the filaments. Further steps track the filaments between successive images, label them uniquely, and generate output that can be used for a comparative study. In particular we are interested in eruption time of filaments, and whether this time is correlated with the filament length and/or size. We also aim to arrive at a threshold value for filament size, that can act as a predictive parameter for eruption. In this poster, we would present the automated filament detection and tracking technique in brief, and present the conclusions obtained from the statistical study.

S3-P16	IAUS340_104	Joshi Reetika	Poster

Authors: Reetika Joshi, Ramesh Chandra

Title: Multiple Hot and Cool Jets on 2017 April 04

Abstract: It is believed that the solar jets and surges are due to the magnetic reconnection processes on the solar atmosphere. There dynamics is helpful to understand the large scale solar eruptions. We present here the Ultraviolet (UV) and Extreme Ultraviolet (EUV) observations of solar jets observed on 2017 April 04 using high temporal and spatial resolution AIA data onboard SDO satellite. During the whole day, we have observed several continuous jets and surges form the active region NOAA 12644. Some of the jets were triggered by the nearby failed filament eruptions. While as in some other jets, we observed brightening close to and below the jet site. The evolution indicate this brightening site looks connected to jet site by loops. During the jet activity few of them were observed by the RHESSI in X-rays. The RHESSI analysis indicate the loop-top source, which corresponds to the null-point structures as evidenced by dome like structures visible in AIA EUV images. The multi-band observations evidenced that these jets were triggered due to the magnetic reconnection at low (~ 7 Mm) coronal null point.

S3-P17	IAUS340_125	K Sasikumar Raja	poster

Authors: K. Sasikumar Raja, Indian Institute of Science Education and Research, Pashan, Pune - 411 008, India. Prasad Subramanian, Indian Institute of Science Education and Research, Pashan, Pune - 411 008, India. R. Ramesh, Indian Institute of Astrophysics, 2nd Block, Koramangala, Bangalore - 560 034, India.

Title: Solar cycle dependence of the density fluctuations and proton heating rate in the solar wind

Abstract: We use the remote sensing observations to study the solar cycle dependence of solar wind properties like dissipation and extended solar wind heating. In the present study, we use historical angular broadening observations of the Crab nebula and recent observations from Gauribidanur radioheliograph spanning over the years 1952 - 2013. In the heliocentric distance 10 - 45~ R$\odot$, we found that density modulation index ranges from ~ 0.1 to 0.001 and proton heating rate from ~1.58 X 10^{-14} to 1.01X10^{-8} erg~ $cm^{-3}s^{-1}$. We noted that these observationally derived quantities correlate well with the solar cycle. These results are significant to comprehend the recent reports on declining solar wind properties with the long term variations of the solar activity.

S3-P18	IAUS340_288	Kaushik Sonia	poster

Authors: Sonia Kaushik and D.C.Gupta School of Studies in Physics, Jiwaji University, Vidya Vihar, Gwalior, India

Title: Solar Wind Plasma Flows and Space Weather Aspects during recent solar cycles

Abstract: Solar transients are responsible for initiating short - term as well as long - term variations in earth's magnetosphere. These variations are termed as geomagnetic disturbances, and driven by the interaction of solar wind features with the geo-magnetosphere. The strength of this modulation process depends upon the magnitude and orientation of the Interplanetary Magnetic Field and solar wind parameters. These interplanetary transients are large scale structures containing plasma and magnetic field expelled from the transient active regions of solar atmosphere. As they come to interplanetary medium the interplanetary magnetic field drape around them. This field line draping was thought as possible cause of the characteristic eastward deflection and giving rise to geomagnetic activities as well as a prime factor in producing the modulation effects in the near Earth environment. The Solar cycle 23 and 24 have exhibited the unique extended minima and peculiar effects in the geomagnetosphere. Selecting such transients, occurred during this interval, an attempt has been made to determine quantitative relationships of these transients with solar/ interplanetary and Geophysical Parameters. In this work we used hourly values of IMF data obtained from the NSSD Center. The analysis mainly based on looking into the effects of these transients on earth's magnetic field. The high-resolution data IMF Bz and solar wind data obtained from WDC-A, through its omniweb, available during the selected period. Dst and Ap obtained from WDC-Kyoto are taken as indicator of geomagnetic activities. It

S3-P19	IAUS340_287	Kaushik Subhash Chandra	Poster

Authors: Subhash Chandra kaushik (1) and Sonia Kaushik (2) (1) Department of Physics, Government PG Autonomous College, Datia, 475661, India (2)School of Physics, Jiwaji University, Gwalior, MP, India

Title: Long term Variations of the Solar Plasma Events and Their Interplanetary Consequences

Abstract: In the present study we have analyzed the interplanetary plasma / field parameter, which have initiated the complex nature intense and highly geo-effective events in the magnetosphere. It is believed that Solar wind velocity V. interplanetary magnetic field (IMF) B and Bz are the crucial drivers of these activities. However, sometimes strong geomagnetic disturbance is associated with the interaction between slow and fast solar wind originating from coronal holes leads to create co-rotating plasma interaction region (CIR). Thus the dynamics of the magnetospheric plasma configuration is the reflection of measured solar wind and interplanetary magnetic field (IMF) conditions. While the magnetospheric plasma anomalies are generally represented by geomagnetic storms and sudden ionosphere disturbance (SIDs). The study considers 220 geomagnetic storms associated with disturbance storm time (Dst) decreases of more than -50 nT to -300 nT, observed during solar cycle 23 and the cycle 24. These have been analyzed and studied statistically. The spacecraft data acquired by STEREO mission and those provided by SOHO, ACE and geomagnetic stations like WDC-Kyoto are utilized in the study. It is observed that the yearly occurrences of geomagnetic storm are strongly correlated with 11-year sunspot cycle, but no significant correlation between the maximum and minimum phase of solar cycle have been found. It is also found that solar cycle-23 and 24 are remarkable for occurrence of intense geomagnetic storms during its declining phase. The detailed results are discussed in this paper.

S3-P20	IAUS340_287	Kaushik Subhash Chandra	Poster

Authors: S. Kaushik (1) and Subhash Chandra Kaushik (2) (1)School of Studies in Physics, Jiwaji University, Gwalior, 474 001, MP, India (2)Department of Physics, Government PG College, Datia475661, India

Title: Study of Geo-effective Solar Plasma Transients and Associated Geoeffectiveness

Abstract: The study investigate the relationship between magnetic structure of coronal holes and/or coronal mass ejection (CME) source region and their influence on Earth's geomagnetic field, i.e. storms and sub storms. It considers very intense geomagnetic storms that occurred during Solar Cycle 23 and 24. The disturbance storm time index Dst is taken as an indicator of geomagnetic activity by setting a value of Dstmin ≤ −200 nT as threshold. By examining halo CMEs that erupted during solar cycles 23as well as 24. We have identified 08 events associated with M-class and X-class solar flares. Furthermore, as the geomagnetic field (BGeomag) puts a lower cutoff rigidity (Rc) to the entry of cosmic particles in to the earth, depending upon the geomagnetic activity. Sometimes when this entry of charged particles exhibits very sudden sharp and short lived increases in cosmic ray intensities, registered by neutron monitor, it is termed as Ground-level enhancement (GLEs). In this present investigation we also studied GLE events associated with solar flare and coronal mass ejection (CMEs). The spacecraft data acquired by spacecraft missions and those provided by SOHO, ACE and geomagnetic stations like WDC-Kyoto are utilized in the study.

S3-P21	IAUS340_183	Khan Parvaiz Ahmad	Poster

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Title: Study of positional Error on the GPS signals due to ionospheric variations

Abstract: In this paper we have investigated the variations of positional error in different geomagnetic conditions. The paper envisages the absolute positional error with the regular and irregular patterns of ionospheric activities. This investigation is carried out on the data collected at a high latitude Indian station, Maitri (70.4° N, 11.4° E), Antarctica during the low solar activity period i.e. 2006. The five most disturbed days were then selected. For each disturbed day we calculated the absolute positional error in meters. The dilution of precession parameters namely PDOP were also derived for each day. We found that the value of absolute of absolute positional error and PDOP is significantly increased during the disturbed days.

S3-P22	IAUS340_174	Kubiak Marzena A.	Poster

Authors: M.A. Kubiak, M. Bzowski, J.M. Sokół, I. Kowalska-Leszczyńska Space Research Centre, PAS (CBK PAN)

Title: Modulation of interstellar gas and heliospheric backscatter glow due to variation in solar activity

Abstract: Interstellar neutral (ISN) gas penetrates freely inside the heliosphere, but within ~10 AU from the Sun it gradually becomes ionized by solar wind and solar EUV radiation, and modulated by the solar resonant radiation pressure in the Lyman-α line, which all evolve during the solar cycle. ISN H and He produce a resonant backscatter glow, which carries characteristic imprints of the solar activity at all heliolatitudes. Direct-sampling observations of ISN gas as well as remote-sensing observations of the helioglow are valuable tools of investigating the interstellar matter of the Local Interstellar Cloud (LIC) and the solar activity. Direct-sampling observations allow studying the temperature of ISN gas and the vector of Sun's motion through the LIC as well as element abundances of H, He, Ne, O, and – importantly – D, but this analysis requires a good understanding of solar forcing. On the other hand, observation of the helioglow bring important information on the solar wind at all heliolatitudes and its evolution during the solar cycle, which are otherwise challenging to investigate. We show simulations of the density distribution of ISN H, He, Ne, O and D and their variation during the solar cycle at 1 AU, where they are sampled directly in situ, and the evolution of the helioglow of H observed remotely from 1 AU, and show the connection between their time series with the time series of the heliospheric modulation factors.

S3-P23	IAUS340_351	Mathpal Mahesh Chandra	Poster

Authors: Mahesh Chandra Mathpal, Bimal Pande,Seema Pande* Department of Physics DSB Campus, Kumaun University Nainital

Title: Study of all India Homogeneous Rainfall with Solar Activity Features during 1900-2014

Abstract: In this paper we study the connection between all India homogeneous rainfall with solar activity features (sunspot number (SN), solar active prominence (SAP), solar flare(SF),) during 1900-2014 (114-year period). We have studied the occurrence of rainfall variability and solar activity features by using the annual as well as seasonal months (January, February(JF), March, April, May, (MAM) June, July, August September(JJAS), October, November December(OND). Here, we have calculated different statistical parameters of rainfall (RF) and occurrence of solar activity features (SN, SAP, SF) and found the correlation and its significance between rainfall and solar activity for annual and seasonal months (JF, MAM, JJAS, OND). We have also calculated the R- square values of rainfall with different solar activity features (SN, SAP, SF) for annual and seasonal months and found that R- square values are lies between 75% to 95%. This results implies that rainfall strongly influence by solar activity features. Our study indicates that occurrence of solar activity features play an important role for variability of rainfall. This study may represent a theory to understand the connection between rainfall and occurrence of solar activity and explain, how solar phenomena recorded a variation in Earth atmospheric phenomena like rainfall, climate change etc.

S3-P24	IAUS340_121	Mazumder Rakesh	Poster

Authors: Rakesh Mazumder.1 Prantika Bhowmik.1 Dibyendu Nandy.1,2 1.Center of Excellence in Space Sciences India(CESSI), IISER KOLKATA. 2.Department of Physics, IISER KOLKATA.

Title: Filament, Polarity Inversion Line and Coronal Hole properties in Solar Cycle 23 from McItosh database

Abstract: In the context of space weather research, the study of solar filaments has become relevant as the eruption of filaments results in hazardous events like coronal mass ejections (CMEs). Here we investigate various observational properties of filaments during solar cycle 23 using the McIntosh archives and their correlation with the solar magnetic cycle. We reconfirm that filament formation always occurs above the polarity inversion lines (PILs) separating two opposite polarity magnetic field on the solar photosphere. A detailed study of tilt angle distribution of filaments reveals that PILs associated with the large-scale surface magnetic structures is the primary contributor to filament formation and not the active region PILs. Apart from filaments and PILs, we also study the variation of coronal hole area during cycle 23 provided by the same database and explore their relation with the solar magnetic activity.

S3-P25	IAUS340_204	Mishra Wageesh	Poster

Authors: Wageesh Mishra (affiliation: University of Science and Technology of China, China), Nandita Srivastava (Udaipur Solar Observatory, PRL, India), Zavkiddin Mirtoshev (Department of Physics, Samarkand State University, Samarkand- 140104, Uzbekistan) Yuming Wang (affiliation: University of Science and Technology of China, China)

Title: Solar Cycle Variation of Coronal Mass Ejections and the Near Earth Solar Wind Parameters

Abstract: Coronal Mass Ejections (CMEs) are important for our understanding of solar corona and heliosphere as they carry a huge amount of magnetized plasma from the Sun to the near Earth environment. Thus, depending on the different stages of the solar cycle and the rate of CME occurrence, a significant contribution to solar wind parameters near the Earth is made from the CMEs. In the present study, we focus on the long term occurrence rate of CMEs and its comparison with solar wind ram pressure and magnetic field. We have used the white light imaging data for coronagraphic observations and near Earth in-situ data for solar wind measurements. We attempt to examine the long term correlation between CME occurrence rate and measured solar wind parameters at 1AU. Our analysis attempts to find that what fraction of the averaged solar wind ram pressure and magnetic field near the Earth is provided by the CMEs. We also attempt to delineate the solar-cycle dependence on the derived correlation.

S3-P26	IAUS340_150	Mohan Atul	Poster

Authors: Atul Mohan, Divya Oberoi

Title: Exploring Coronal Magnetic Field dynamics using Low Radio Frequency Observations

Abstract: Owing to low plasma beta, the coronal plasma dynamics is almost entirely dictated by the solar magnetic field. So, comprehending coronal magnetic field and its dynamics is a pre-requisite to building an in-depth understanding of coronal physics. Measurements of coronal magnetic field using available techniques only rarely go beyond photospheric heights. The existing extrapolation techniques to extend the field to greater heights solve only for steady state magnetic topology. Radio metre-waveband imaging observations of the corona capture the non-thermal plasma emission at very high contrast against the thermal emission due to the beamed or coherent nature of plasma emission processes involved. Sensitive new generation radio interferometric arrays, like the Murchison Widefield Array (MWA), provide an unprecedented high fidelity spectroscopic snapshot imaging capability. The 80-300 MHz spectral coverage of MWA allows us to probe coronal heights in the range ~ 1-1.6 Rsun. These studies help us understand the magnetic field topology and dynamics through observations, without relying on any models or assumptions. Using high dynamic range imaging ability, we study the emission from various regions of corona using SPatially Resolved Dynamic Spectra (SPREDS). These studies suggest the presence of sub-minute periodicities in the emission intensity and Quasi Periodic Pulsations (QPP) even during the times of low solar activity. We explore the properties of these QPPs across the coronal heights and their possible physical origins.

S3-P27	IAUS340_144	Mondal Surajit	Poster

Authors: Surajit Mondal (National Centre for Radio Astrophysics), Divya Oberoi (National Centre for Radio Astrophysics), Leonid Benkevitch (MIT Haystack Observatory),Meagan Crowley (University of Massachusetts), Colin J. Lonsdale (MIT Haystack Observatory), John Morgan (Curtin University)

Title: A low-frequency radio interferometric solar imaging pipeline for the Murchison Widefield Array

Abstract: Solar corona is very dynamic in both temporal and spectral domains. Spectroscopic snapshot imaging is required to fully capture this dynamic nature. This however has not been possible till very recently, simply because of the limitations imposed by the available technology. With the advent of new-generation telescopes like Murchison Widefield Array (MWA), Long Wavelength Array (LWA), Low-Frequency Array (LOFAR), many of these technological limitations are being addressed and the state-of-the-art has improved considerably. Early studies from these instruments are already demonstrating their scientific merits and utility. These instruments, in principle, can be used for regular solar-monitoring. A major hurdle in doing this is the lack of automation in the process of low-frequency solar interferometric imaging. In its present state solar radio imaging is very effort and time intensive, which makes it unsuitable for long-term monitoring. In this work, we present our initial steps towards bridging this gap between raw data and science ready images. We have been developing a flexible pipeline tailored to the needs of solar imaging with the MWA. The pipeline is based on CASA and its output improves the imaging dynamic range by more than an order of magnitude. With this pipeline we have explored the imaging properties of the array under a variety of solar conditions. Here we present some initial results ranging from solar-science applications to the nature of small-scale ionospheric variations.

S3-P28	IAUS340_56	Monga Aabha	Poster

Authors: Aabha Monga, Aryabhatta Research Institute of observational sciencES (ARIES), Nainital Wahab Uddin, Aryabhatta Research Institute of observational sciencES (ARIES), Nainital Ramesh Chandra, Department of Physics, DSB Campus, Kumaun University, Nainital

Title: Failed filament eruption associated with small scale magnetic features

Abstract: We have investigated the interpretation of two consecutive M and C-class flares occurred on the solar disk on 2015 January 28 during 04:00 UT to 06:00 UT in NOAA AR 12268 using the ground based ARIES H-alpha and the space borne multi-wavelength data. The active region was highly complex and produced large number of M and C-class flares during it's span on the solar disk. Active region consists of two filaments F1 and F2 and only one filament F1 erupts resulting the failed filament eruption. The eruption speed of the filament F1 is $\sim$ 23 kms^{-1} and the falling speed is $\sim$ 26 kms^{-1}. Other filament F2 is not associated to any flare as there was no energy build up due to the small scale magnetic field. Although the flare occurred with F1 was highly energetic and reaches to the umbra of the active region. The filament eruption fails due to the high-lying magnetic field lines extrapolated using PFSS.

S3-P29	IAUS340_173	Narang Nancy	Poster

Authors: N. Narang (Indian Institute of Astrophysics), D. Banerjee (Indian Institute of Astrophysics), K. Chandrashekhar (Shandong University at Weihai), Vaibhav Pant (Indian Institute of Astrophysics)

Title: Association of calcium network bright points with underneath photospheric magnetic patches

Abstract: The small-scale bright elements visible in the bright network lanes of solar network structure are termed as network bright points when observed in chromospheric and transition region lines. Polar network bright points are the ones which are present in the polar regions of the Sun (above 70° latitude). We use special HINODE campaigns devoted to observe polar regions of the sun to study the polar network bright points during the phase of last extended solar minimum. The importance of studying polar region of the sun lies in the fact that the detailed information about polar magnetic fields helps us in the understanding of the mechanism of solar cycle and origin of fast solar wind. Different high resolution and co-ordinated observations from Solar Optical Telescope (SOT), Spectro-Polarimeter (SP) and Helioseismic Magnetic Imager (HMI) are used for detailed analysis. We are able to find a considerable association between the polar network bright points and magnetic field concentrations which led us to conclude that these bright points can serve as a good proxy for polar magnetic fields, especially for the historical periods (before 1970) where the direct and regular measurements of polar magnetic fields are not available.

S3-P30	IAUS340_373	Nayak Sushree Sangeeta	Poster

Authors: Sushree S. Nayak, R. Bhattacharyya and, A. Prasad

Title: Magnetic field topology from non-force-free extrapolation and magnetohydrodynamic simulation of its eventual dynamics

Abstract: Magnetic field line (MFL) topology is important in various eruptive phenomena, in the like of flares and coronal mass ejections, occurring in the solar atmosphere. It is then necessary to understand and quantify the MFL topology of the solar atmosphere, especially the solar corona. In absence of any direct measurement of the coronal magnetic field, the contemporary methods used for this purpose rely on extrapolation of the photospheric field into the solar corona, where the coronal field is modeled to be either current-free or force-free. Notably, such extrapolations treat the photosphere as force-free which, is not true. However, a new technique which treats the photosphere to be non-force-free, has shown its viability to extrapolate physically realizable MFLs. In the work, we use non-force-free extrapolation to generate coronal MFLs for the active region NOAA 11158 using magnetograms from Helioseismic and Magnetic Imager(HMI) onboard Solar Dynamics Observatory (SDO). The AR 11158 produced an M-class flare on 14th and an X-class flare on 15th February 2011 along with several B and C class flares. Interestingly, before onset of the M- and the X-class flares, quasi-separatrix layers (QSLs) are detected in the extrapolated MFLs. The QSL being known to trigger magnetic reconnection (MR), magnetohydrodynamic simulation of the MFL dynamics is performed to contemplate the onset of the flares.

S3-P31	IAUS340_166	Oberoi Divya	Poster

Authors: Divya Oberoi (NCRA-TIFR), Atul Mohan (NCRA-TIFR), Surajit Mondal (NCRA-TIFR), Rohit Sharma (NCRA-TIFR), Akshay Suresh (Cornell Univ.), Leonid Benkevitch (MIT Haystack Observatory), Colin Lonsdale (MIT Haystack Observatory), John Morgan (Curtin Univ.)

Title: Solar science at low-radio frequencies: Coming of age

Abstract: The merits of solar radio diagnostics at low-radio frequencies for studying coronal magnetic fields have long been recognised. On the one hand, dealing with the small spectral and temporal scales of variation in solar radio emission requires a data product capable of tracking the emission simultaneous across time, frequency and morphology. Fourier imaging nature of interferometry, on the other hand, imposes severe limitations restricting the instrumental ability to gather sufficient information to do this with the required fidelity and resolution. Benefiting from the enormous advances in technology the new generation of instruments, of which the Murchison Widefield Array (MWA) is an example, represent a quantum leap in our ability to gather data suitable for radio solar physics. Though our instruments are now a lot more capable, the use of radio data is not yet mainstream. In many ways, the problem has shifted from the limited intrinsic capacity of the data to our ability to deal with the data transport, storage, computational, algorithmic and human effort issues related to extracting the information of interest from the vast volumes of data produced by these instruments. We present an overview and current status of our efforts to build an understanding of the MWA data and our work towards building the necessary automated pipelines needed for solar science with these data. We present the case that time is now ripe for planning, defining and beginning to generate the data products for long-term archives to utilise the strengths of solar radio diagnostics.

S3-P32	IAUS340_414	Panesar Navdeep	Poster

Authors: Navdeep Panesar (NASA MSFC), Alphonse Sterling (NASA MSFC), and Ron Moore (CSPAR, MSFC)

Title: The Triggering Mechanism of Coronal Jets and CMEs: Flux Cancelation

Abstract: Recent investigations (e.g. Sterling et al 2015, Panesar et al 2016) show that coronal jets are driven by the eruption of a small-scale filament (10,000 - 20,000 km long, called a minifilament) following magnetic flux cancelation at the neutral line underneath the minifilament. Minifilament eruptions appear to be analogous to larger-scale solar filament eruptions: they both reside, before the eruption, in the highly sheared field between the adjacent opposite-polarity magnetic flux patches (neutral line); jet-producing minifilament and larger-scale solar filament first show a slow-rise, followed by a fast-rise as they erupt; during the jet-producing minifilament eruption a jet bright point (JBP) appears at the location where the minifilament was rooted before the eruption, analogous to the situation with CME-producing larger-scale filament eruptions where a solar flare arcade forms during the filament eruption along the neutral line along which the filament resided prior to its eruption. In the present study, we investigate the triggering mechanism of CME-producing large solar filament eruptions, and find that enduring flux cancelation at the neutral line of the filaments often triggers their eruptions. This corresponds to the finding that persistent flux cancelation at the neutral is the cause of jet-producing minifilament eruptions. Thus, our observations support coronal jets being miniature version of CMEs.

S3-P33	IAUS340_165	Pant Vaibhav	Poster

Authors: Vaibhav Pant, Indian Institute of Astrophysics

Title: Automated detection of coronal mass ejections in Heliosphere

Abstract: An automated algorithm is designed to detect coronal mass ejections (CMEs) in data from the inner heliospheric imager (HI-1) cameras on the STEREO-A spacecraft. Detection of CMEs is done in time-height maps based on the application of the Hough transform, using a modified version of the CACTus software package, conventionally applied to coronagraph data. I will describe the method of detection and present the results of the application of the technique to a few CMEs, which are well detected in the HI-1 imagery, and compare these results with those based on manual-cataloging methodologies. I will also show the performance of the algorithm when applied on the entire duration of the STEREO mission. I will discuss, in detail, the advantages and disadvantages of this method.

S3-P34	IAUS340_164	Patel Ritesh	Poster

Authors: Ritesh Patel (IIA); Vaibhav Pant (IIA); Dipankar Banerjee (IIA)

Title: Automated detection of Coronal Mass Ejections in Visible Emission Line Coronagraph (VELC) on-board ADITYA-L1

Abstract: Coronal mass ejection plays an important role in driving the space weather. Therefore, automated detection of CMEs becomes necessary to monitor the space weather. For this purpose, an on-board automated CME detection algorithm is designed which is planned to be implemented in Visible Emission Line Coronagraph (VELC) on board ADITYA-1. The automated detection logic had been written for this purpose and successfully tested on the data of LASCO C2 (2Ro to 6Ro) and STEREO COR1(1.2Ro to 4Ro). However, VELC's FoV extends from 1.05Ro to 3Ro. No space based coronagraph has an onboard automated detection algorithm to monitor CMEs at such lower heights. We have created synthetic images of background corona and CMEs for ADITYA-L1 field of view (FoV). Once the background corona is prepared, CMEs of different types and orientation are launched to get simulated CME images. These images will serve as sample data for VELC/ADITYA-L1. It will not only test the automated CME detection technique but it will also be useful to calibrate the VELC. The synthetic coronal and CME images can also help in optimising the free parameters for automated detection and hence decide the exposure time and cadence for ADITYA-L1 VELC.

S3-P35	IAUS340_50	Pramod Kumar	Poster

Authors: 1. P Kumar, Jagannath Universty, Jaipur, Raj., India 2. R K Choudhary, SPL, VSSC, ISRO, Trivandrum, India 3. Y C Bhatt, Jagannath University, Jaipur, India(Former affiliation), 4. Y S Shishodia, Jagannath University, Jaipur, India(Former Affiliation)

Title: Monte Carlo analysis of X-ray emissions observed from RHESSI X class solar flares during 2002-2004

Abstract: In this paper we constrain thermal and non-thermal parameters of X class solar flares in ≈ 13-250 keV using modeling of ≈ 80 hard X-ray spectra of 60 second time duration. The X-ray spectra were constructed from the observations of 6 X class solar flares during 2002-2004 by the RHESSI. The thermal and non-thermal components of the X-ray spectra were modeled with the isothermal and thick target bremsstrahlung model using forward fitting and Monte Carlo method of error estimation in order to obtain best fit parameters. We have obtained significant mean values of plasma temperature, T = 31.6 ±10.2 MK, emission measure, EM = 1.40± 2.0 ×10^49 cm-3 , total integrated electron flux, F0 = 557 ±1155.0 ×10^35 electrons sec-1, index of electron distribution function below break (low delta), δ_1 = 9.5±3.7, index of electron distribution function above break (high delta), δ_2 = 7.7±5.0, low cutoff energy, Ec = 24.0±14.0 keV and break energy of the order of Eb = 117.7±153.1 keV. In this analysis, we find that isothermal and thick target bremsstrahlung models are consistent to the X-ray spectra in 13-250 keV with a goodness of model fitting value χ^2= 1.2±0.64. The results found are comparable to the earlier analysis carried out with the broken power-law functional form for non-thermal spectrum of the injected electrons and return current collisional thick target model. Further we also find that scaling between parameters shows consistency with the theoretical models of the solar flare.

S3-P36	IAUS340_402	Rangarajan K E	Poster

Authors: Rangarajan K.E., Prabhu. K, Ravindra. B, Indian Institute of Astrophysics

Title: Mapping of Chromospheric Velocity from Imaging Spectroscopy using Tunable Lyot Filter at the Kodaikanal Observatory

Abstract: Observations of the Sun in H-alpha wavelength still remains one of the best ways to study the characteristics of the filaments, fibrils and solar flares. A 20-cm sized refractive type telescope along with 0.04 nm passband Lyot filter is not only apable of making the chromospheric imaging in the line center, it is also capable of making the images at any position on the line profile with scanning step size of 0.001 nm. With the 13.5 micron CCD camera, the telescope is able to make the chromospheric images at 1.21" pixel resolution. In this poster, we present the details about the telescope optics, Lyot filter, and the observations of the solar chromosphere in Halpha wavelength from Kodaikanal Observatory. Preliminary results on the velocity map of the solar filaments and other chromospheric structures will also be presented.

S3-P37	IAUS340_363	Roy Soumya	Poster

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Title: Scaling Analysis of the Flare Index Data from Kandilli Observatory

Abstract: The solar flare is the outcome of explosions in the Sun's atmosphere which is also determined as an acute and rapid fluctuation in it's brightness. The short-lived action inside the Sun's atmosphere is measured by a parameter called flare index which permits the analysis of short and long-term variation inside the Sun's atmosphere. The daily time series flare index data of Northern Hemisphere, Southern Hemisphere and Total Disk for Solar Cycle 21- 23 and 24 up to Dec., 2014 has been pre-processed using 2nd order exponential smoothing algorithm to remove hidden trends. The smoothed data in each case is processed for scaling analysis using Rescaled-Range Analysis (R/S) as well as Finite Variance Scaling Method (FVSM) in order to search for the Hurst exponent (H). From our analysis it is observed that the H is 0.033, 0.096 & 0.099 in R/S and 0.196, 0.204 & 0.251 in FVSM for flare index data of Northern, Southern Hemisphere & Total Disk respectively. As the value of H obtained from our analysis lies in between 0 and 1, so it can be said that the signal may behave like Fractional Brownian Motion (FBM). Also, it is observed that H is less than 0.5 which indicates the data is anti-persistent in nature and it has a strong negative correlation within the signal. According to the dynamics of anti-persistence, the signal has Short Range Dependent memory (SRD) and is governed by a negative feedback mechanism for stabilizing the Sun's atmosphere. The value of H also indicates the oscillating features of the signal which might have some fundamental periodicities in the Sun's atmosphere.

S3-P38	IAUS340_347	Sarkar Aveek	poster

Authors: Aveek Sarkar, Bhargav Vaidya, Soumitra Hazra, Jishnu Bhattacharyya

Title: Numerical Simulation of active region MHD oscillations and coronal loop implosion

Abstract: We simulate a part of the solar active region which is hit by a flare like explosive event. We carefully trace magnetic field lines of the active region and their time evolution. It is found that field lines of the active region demonstrate various compressible MHD modes such as sausage and kink. We also see that following the flare disturbance, such magnetic field structure collapse (formally known as coronal loop implosion) or oscillate vertically depending on the nature of the local plasma beta. Contrary to common believe, the present model shows that loop implosion is an independent ideal magnetohydrodynamic (MHD) effect. It is initiated by variations of the system coordinates arising due to the transmitted disturbance originating at the event site, but otherwise has no connection to the flaring site itself.

S3-P39	IAUS340_273	Sarkar Ranadeep	poster

Authors: Ranadeep Sarkar and Nandita Srivastava, Affiliation- Udaipur Solar Observatory, Physical Research Laboratory

Title: Geometric and magnetic properties of coronal flux ropes associated with CMEs leading to geomagnetic storms

Abstract: We have studied the geo-effective Interplanetary Coronal Mass Ejections (ICMEs) and their associated solar sources during the solar cycle 24. Particularly, both the geometrical and magnetic properties of the near-sun coronal flux ropes have been reconstructed using the Flux Rope Eruption Data (FRED) model and compared with the flux-rope properties associated with the magnetic clouds at 1 AU. Incorporating the FRED model, the poloidal flux of the coronal flux rope have been determined by calculating the reconnection flux from the line-of-sight magnetic field underlying the post-eruption arcades (PEA). The coronagraphic white light structures of the CMEs have been fitted geometrically and the magnitude and orientation of the axial magnetic field of the coronal flux rope have been calculated using the Landquist formulation assuming the total poloidal flux of the flux rope is equal to the reconnection flux calculated from the photospheric magnetic field. To examine the flux rope properties of the magnetic clouds associated with the ICMEs at 1 A.U, the in-situ data obtained from the Wind spacecraft have been modeled by using a cylindrical force free flux rope model. The geometrical and magnetic properties of both the flux ropes reconstructed from the remote-sensing and in-situ data respectively, are compared for all the CMEs leading to major and moderate geo-magnetic storms having Dst index less than -50 nT during May 2010 to Sept 2016. In this work, we attempt to investigate how the magnitude and orientation of the axial and poloidal magnetic field content of coronal flux ropes are related with those of the magnetic clouds at 1 AU causing geomagnetic storms.

S3-P40	IAUS340_106	Sarmah Pranjal	Poster

Authors: Pranjal Sarmah,Department of Physics,Tezpur University,Assam. Durgesh Tripathi,IUCAA,Pune. Amit Pathak,Department of Physics,Tezpur University,Assam.

Title: Understanding the Dynamics of Prominences

Abstract: Solar prominences are cooler chromospheric plasma hanging in million degree hot solar corona supported by magnetic field. Prominences are considered to be the best proxies for Coronal Mass Ejections (CMEs) and are the best targets to understand the initiation mechanism(s) of CMEs.We have analysed a large multi-wavelength data set of the erupting prominences obtained by the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO). We have selected events between 2010 and 2015 and have studied their evolution including the evolution of magnetic field in the source regions. We have also studied the dynamics of brightening propagation after the eruptions and measured the speed of the prominence eruption and the brightening propagation. The data is used to understand prominence eruption and magnetic reconnection in three dimensions.

S3-P41	IAUS340_219	Seema C S	Poster

Authors: Seema C.S.,Prince P.R. Dept of Physics, University College, Thiruvananthapuram

Title: Phase analysis of solar activity indices using wavelet techniques

Abstract: A precise knowledge of solar extreme ultraviolet (EUV) irradiance is of great importance for better understanding of Earth's ionosphere and thermosphere. The search for an ideal solar EUV proxy is vital since the ionospheric and thermospheric models are based on the solar proxies of EUV radiation. The commonly used proxies for studying solar EUV activity are Solar EUV data, Solar 10.7 cm radio noise (F10.7), Coronal Index, Mg II core-to-wing index and Sunspot number (RZ). Since the EUV data are available only for a limited period, it is necessary to substitute the other proxies for long term studies. In this study, the phase asynchrony analysis of solar EUV data with other solar activity indices during solar cycle 23 is done. The cross-wavelet transform (XWT) technique is used to reveal the phase difference between the two time series of solar indices. Analysis reveals that the phase relationships between the indices are both time and frequency dependent. The solar indices F10.7 and Mg II core-to-wing index are found to be more synchronous with solar EUV data for low frequency components.

S3-P42	IAUS340_168	Sharma Rohit	Poster

Authors: (1) Rohit Sharma, National Center for Radio Astrophysics, Tata Institute of Fundamental Research, Pune, India (2) Divya Oberoi, National Center for Radio Astrophysics, Tata Institute of Fundamental Research,Pune, India (3) Akshay Suresh, Cornell University,Ithaca, New York, USA (4) Mihir Arjunwakar, Centre for Modeling and Simulation, Savitribai Phule Pune University, Pune, India

Title: Quantifying weak non-thermal meterwave solar emission using non-imaging techniques

Abstract: Murchison Widefield Array (MWA) dynamic spectra (DS) often show numerous weak, short-lived and narrow-band non-thermal solar emission features even during quiet times. Their presence is also a necessary consequence of nanoflare based coronal heating theories. We have been working towards exploring this possibility. Analysis of large numbers of very voluminous datasets (data rates ~ 1 TB/hr) from the MWA, however, is challenging on multiple fronts ranging from data transport and storage issues to the human and computational burden they entail. To begin to meet these challenges we have developed a set of automated non-imaging techniques. They use less than 0.1% of the full interferometric dataset and are computationally very lean when compared to the standard imaging analysis. These techniques use DS from a handful of low-resolution MWA baselines and have three independent aspects – flux calibration of the DS; detection and characterisation of the weak non-thermal emissions seen in the DS; and quantification of the presence and strength of the weak non-thermal emissions using a Gaussian mixture based decomposition technique. We find that the distributions of these non-thermal emissions peak at 1-2 seconds and 4-5 MHz. These techniques have also enabled us to establish the presence of non-thermal features down to ~0.2 SFU, the weakest yet reported in the literature. In this presentation, we will summarise these non-imaging analyses, establish their robustness and present our results.

S3-P43	IAUS340_76	Singh Prithvi Raj	Poster

Authors: Prithvi Raj Singh, C. M. Tiwari, A.K. Saxena Department of Physics A.P.S. University, Rewa, M.P. – 486003

Title: Heliospheric Modulation of Cosmic Rays and Solar Activity during Solar Cycles 22 -24

Abstract: We have studied, the relationship between the monthly variations of the average counting rates of the cosmic ray intensity (CRI) at Oulu super neutron monitoring station with cut-off rigidities (~ 0.85 GV), and the solar radio flux at 10.7 cm (F10.7) and sunspot number (SSN) during the solar cycles 22 – 24 . The F10.7 (2800 MHz) and SSN is an excellent indicator of solar activity for the study period. We have investigated the patterns of long-term and mid-term periodicities for F10.7, CRI, and SSN using Fast Fourier Transform (FFT) and Morlet Wavelet Transformation (WT). The observed value of correlation coefficient related to F10.7 and SSN is R=0.98, which found positively correlated for the period 1986-2016. We have studied the relation of CRI with F10.7 and SSN and found that they are anti-correlated during solar cycle 22-24. We have observed the time -lag between maximum to a minimum for CRI with F10.7 and SSN during solar cycle 22-24.

S3-P44	IAUS340_178	Singh Vivek Kumar	Poster

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Title: Study of Coronal Rotation using X-ray Images observed by Hinode

Abstract: Solar rotation is still one of the unresolved concern of solar physics measured by three methods i.e. Feature tracing, Spectroscopic and Flux modulation. The last method studied extensively has been used to estimate of rotation of the solar corona. These studies used X-ray images of the Sun taken by Japanese's solar observatories Hinode. Since its launch into space, satellite Hinode has delivered spectacular imagery and invaluable measurements of Sun for last 11 years. We performed time series analysis on the bins formed on equally separated latitude regions of the solar full disc (SFD) images that extend from 80°S to 80°N. These images are observed with the X-ray telescope (XRT) on board the Hinode solar observatory. The flux modulation method traces the passage of X-ray feature over the solar disc and autocorrelation analysis of the time series data of the X-ray images (one per day) for the period extends from year 2006 to 2017 gives the coronal rotation period as a function of latitude. The investigations have provided quite detailed and systematic information of the solar rotation and its variability. This has established that solar atmosphere has differential rotation and the differentiality has a significant temporal and spatial variability. In this paper a detail interrelation of the solar activity cycle and solar atmospheric rotation will be presented. Keywords: Solar rotation, differential rotation, flux modulation method, corona, solar activity cycle.

S3-P45	IAUS340_337	Snow Martin	Poster

Authors: M. Snow(1), J. Machol (2), F. G. Eparvier (1), A. R. Jones (1), and T. N. Woods (1) (1) University of Colorado / LASP (2) University of Colorado / CIRES

Title: Magnesium II index measurements from SORCE SOLSTICE and GOES-16 EUVS

Abstract: The solar magnesium II core-to-wing ratio has been a well-studied proxy for chromospheric activity since 1978. Daily measurements at high spectral (0.1 nm) resolution began with the launch of the Solar Radiation and Climate Experiment (SORCE) in 2003. The next generation of measurements from the Extreme Ultraviolet Sensor (EUVS) on the Geostationary Operational Environmental Satellite 16 (GOES-16) will add high time cadence (every 30 seconds) to the observational Mg II irradiance record. We present a comparison of the two measurements during the period of overlap.

S3-P46	IAUS340_384	Syed Ibrahim M	Poster

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Title: Estimation of coronal magnetic field using type II band splitting

Abstract: We report on the analysis of a Coronal Mass Ejections (CME) and a band-splitted type II radio burst associated with B7.0 X-ray flare occurred on 18 March 2010. For this, we analyzed multi-wavelength observations like, radio observations from the Culgoora and Wind/WAVES in combination with SOHO/LASCO data to retrieve the association of solar activities such as CME, type II burst and flare. The results from the analysis are, (i) the onsets of flare and CME coincide with each other around 23:00UT, (ii) an EUV event is reported in SECCHI around 23:03UT, (iii) the type II burst occurred during (23:11 - 23:18UT), the decay phase of solar flare in the frequency range 120 – 35 MHz with a drift rate of ~0.15 MHz/s, (iv) the estimated type II speed (550 km/s) is nearly similar to the CME speed (488 km/s), and (v) there is a temporal sequence in the occurrence of events in the order: onsets of flare, type II burst and CME. Since this type II burst has well defined band splitting, the density jump at the shock, Alfven Mach number, plasma frequency using Newkirk model, shock speed, velocity and the coronal magnetic field strength at different heights have been calculated.

S3-P47	IAUS340_243	T. E. Girish	Poster

Authors: V.G Haritha1, P.E.Eapen2,G.Gopkumar1 and T.E.Girish1 1 Department of Physics,University College,Trivandrum 695034,INDIA 2 Department of Physics,S.G.College,Kottarakkara, Kerala, INDIA

Title: ON THE CHARACTERISTICS OF GEOMAGNETIC STORMS OBSERVED DURING THE PAST 415 YEARS

Abstract: Long term changes in geomagnetic activity helps to probe past solar activity cycles. In this paper we will present our investigations on the characteristics of geomagnetic storms deduced from direct and proxy observations for the years 1601-2016 AD. The data sources for this study include i) Geomagnetic declination observations from European observatories during the years 1784-1825 ii) Geomagnetic H observations from European and Indian observatories during the years 1840-1956(iii) Geomagnetic aa indices from 1844 onwards iv) Aurora observations during the years 1600-1890.We have studied sunspot cycle (around 11 years) and secular (related to Gleissberg solar cycle) changes in the characteristics of geomagnetic storms for the above period covering about four centuries. The solar sources of geomagnetic storms will be also discussed in this context.

S3-P48	IAUS340_78	Tripathi Durgesh	Poster

Authors: Durgesh Tripathi, IUCAA, PUNE Sami Solanki, MPS, Germany, Kyung Hee University, Korea Pradeep Kayshap, University of Maria Curie-Sklodowska, Poland Hardi Peter, MPG, Germany

Title: IRIS Observations of Quiet-Sun and Coronal Holes in Mg II k

Abstract: At coronal temperatures, quiet Sun (QS) can easily be distinguished from Coronal holes (CHs). However, this is not possible at chromospheric temperatures and transition regions. Here we have used the k line of Mg II observed by the Interface Region Imaging Spectrometer (IRIS) and corresponding line of sight magnetic field to understand the similarities and differences in the QS and CH at the chromospheric level and their possible relationship with the magnetic field. We find that the CH emission in k3 and k2v of Mg II line, originating in the chromosphere, is significantly different to that in QS for the regions with similar magnetic field strengths. However, the wing emission from QS and CH is remarkably similar. We further find that the difference in intensities increased with increasing magnetic field and decreased with increasing spectral resolution. For a spectral resolution of 11A, the difference completely vanished. These findings are important for the supply of mass and energy from chromosphere to the corona as well as provides the essentials ingredients for the modeling of solar spectral irradiance.

S3-P49	IAUS340_200	Zender Joe	Poster

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Title: SOLARSEG: Segmentation of Photospheric Magnetic Elements Corresponding to Coronal Features to Understand the EUV and UV Irradiance Variability

Abstract: The magnetic field plays a dominant role in the solar irradiance variability. Determining the contribution of various magnetic features to this variability is important in the context of heliospheric studies and Sun-Earth connection. Aims. We studied the solar irradiance variability and its association with the underlying magnetic field for a period of seven years (January 2011 - January 2018). We used observations from the Large Yield Radiometer (LYRA), the Sun Watcher with Active Pixel System detector and Image Processing (SWAP) on board PROBA2, the Atmospheric Imaging Assembly (AIA), and the Helioseismic and Magnetic Imager (HMI) on board the Solar Dynamics Observatory (SDO). The Spatial Possibilistic Clustering Algorithm (SPoCA) is applied on the EUV observations obtained from the AIA to segregate coronal features by creating segmentation maps of the Active Regions (ARs), the Coronal Holes (CHs) and the Quiet Sun (QS). Further, these maps are applied on the full-disk SWAP intensity images and the full-disk HMI line-of-sight (LOS) magnetograms to isolate the SWAP coronal features and photospheric magnetic counterparts, respectively. We then computed full-disk and feature- wise averages of EUV intensity and LOS magnetic flux density over ARs/CHs/QS. The variability in these quantities is compared with those of LYRA irradiance values. We present the results of our studies obtained so far.

Session 4. Total Solar Irradiance and Spectral Solar Irradiance

S4-P1	IAUS340_338	M S Baburaj	Poster

Authors: M.S.Baburaj1 , C.Sunil kumar Morais2, K.S.Sony3 and T.E.Girish3 1 Department of Physics, Christian College,Kattakada, Trivandrum ,INDIA 2 Ph.D research scholar in Physics,M.S.University,Tirunelveli,INDIA 3 Department of Physics, University College,Trivandrum 695034,INDIA

Title: ON THE VARIATIONS OF SURFACE SOLAR RADIATION IN TRIVANDRUM CITY DURING THE YEARS 1837-2011

Abstract: Trivandrum city is the only location in India near geographic equator for which long term meteorological records are available since the first half of 19th century. Actinometer observations of solar radiation from Trivandrum Observatory is carried out for the years 1837-1840 . The bright sunshine duration observed in Trivandrum city during the years 1933-2011 is found to show statistically significant anticorrelation with rainfall variations and correlation with surface temperature changes. During the long period spanning nearly 175 years from 1837-2011 surface total solar irradiance in Trivandrum is inferred to be maximum during the years 1865-1882 which coincides with prolonged drought conditions in several parts of south peninsular India.

S4-P2	IAUS340_81	Naidu Ashwini S	Poster

Authors: S.N.Ashwini,K.Jyothi,S.Divya,D.V.Manish,G.E.Hemamalini & R.Kariyappa,Image Processing Group, Departments of ECE & Physics,Vemana Institute of Technology, Koramangala, Bangalore-560034

Title: Extraction of Coronal Features from Spatially Resolved Images of 174A observed from PROBA2/SWAP to Understand EUV Irradiance Variability

Abstract: Extraction of different coronal features and determination of their contribution to EUV Irradiance Variability are important in heliophysics,the earth's climate and space weather applications. The main coronal features such as active regions(ARs),coronal holes(CHs),and background Regions(BG) have been extracted from full-disk calibrated images of 174Å observed from PROBA2/SWAP instrument.The SVM algorithm in MATLAB is applied to extract the different features. The cumulative intensity values of all the features have been derived. The contribution of these features to full-disk integrated EUV Irradiance Variability are estimated and found that the active regions contribute upto 60% and whereas the background and the coronal holes will be around 38% and 2% respectively. In addition, these results suggest that the variations in both intensity and area of the various coronal features have to be taken into account in Irradiance models.

S4-P3	IAUS340_274	P. Venkatakrishnan	Poster

Authors: P Venkatakrishnan, Physical Research Laboratory

Title: Solar Activity and Climate Change

Abstract: Solar ultraviolet radiation controls the ionization degree of the earth's upper atmosphere. Variation of uv radiation has been directly measured only for about 2 decades. The sunspot number is an important index that is used as a proxy for getting indirect estimates of earlier changes in the ultraviolet radiation. There has been a recent revision suggested for the method of measuring the sunspot number. In this paper, we will examine the implications of adopting the new sunspot number for the task of estimating and reconstructing the historical evolution of the solar ultraviolet flux. These implications will be used to re-examine the role of solar activity on climate change.

S4-P4	IAUS340_219	Seema C S	Poster

Authors: Seema C S,Prince P R University College, Thiruvananthapuram,Kerala

Title: A wavelet analysis of F2 layer critical frequency over solar cycle23

Abstract: The characterization of spatio-temporal inhomogeneities occurring in F2 layer of ionosphere is remarkable since these variations are direct consequences of electrodynamical coupling between magnetosphere and solar events. The molecules and atoms in the F2 region of the ionosphere are energized and ionized by solar extreme ultraviolet radiation and by energetic electrons of solar and magnetospheric origin. The ions produced then undergo chemical reaction with neutrals, recombine with electrons, diffuse to higher or lower latitudes according to their weight or are transported by neutral wind effects. The temporal and spatial variations of the F2 layer which occur with a period of several days or even years mainly owe to geomagnetic and meteorological activities. The hourly data of F2 layer critical frequency (foF2) during solar cycle 23 over eight ionosonde stations which falls within same longitudinal span are evaluated using Continuous Wavelet Transform (CWT) to estimate the ionospheric variations. In the analysis, Morlet wavelet is used to transform continuous time series data into a two dimensional time -frequency space explaining the dominant modes of variability. The quasi triennial, annual, semiannual, 27 day and diurnal variations of foF2 are clearly evident in the wavelet power spectra in all the stations. Quasi triennial oscillations which show a clear latitudinal dependence is more evident in Southern stations. A strong quasi biennial oscillation (QBO) is also noticed in higher latitudes which was not observable in equatorial latitude. The present study reveals that the semiannual variations are more obvious over the annual variation in the equatorial and low latitude stations while the annual variations are prominent in higher latitudes. 27 day variations are stronger in lower latitudes in both hemispheres. The diurnal variations of foF2 are stronger during solar active years in all stations.

S4-P5	IAUS340_243	T. E.Girish	Poster

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Title: Solar activity changes during polonged Sunspot minima as Inferred from Indian Monsoon Rainfall Variations

Abstract: Several studies have found good correlation between characteristics of Indian monsoon rainfall and solar activity indices. Solar output including total solar irradiance and solar wind during Maunder minimum (1650-1700) is suggested to be lower than modern spacecraft period averages. Proxy observations related to Indian monsoon rainfall during the 17th century suggest several years of normal monsoon rainfall during the Maunder minimum period. Limited series of rainfall in India during the Daltons minimum period (1790-1830) also suggest a similar result. Observations of solar transient phenomena such as 30 MeV solar proton events during Maunder and Daltons minima periods suggest that bursts of strong solar activity is occasionally present during these prolonged sunspot minima periods. The available models of spectral irradiance of the Sun during Maunder minima may require revision to explain the above results. . Solar-terrestrial observations during recent deep sunspot minima periods (1901-1902 and 2008-2009) will be discussed in detail this context

S4-P6	IAUS340_78	Tripathi Durgesh	Poster

Authors: A. N. Ramaprakash (1); Aafaque Khan (1); Avyarthana Ghosh (1,2), Subhamoy Chatterjee (3); Dipankar Banerjee (3); Pravin Chordia (1); Achim Gandorfer (4); Natalie Krivova (4); Dibyendu Nandi (3); Chaitanya Rajarshi (1); Sami K. Solanki (4) 1) IUCAA, Pune, India 2) CESSI, IISER-Kolkata, India 3) IIA, Bangalore, India 4) MPS, Goettingen, Germany

Title: The Solar Ultraviolet Imaging Telescope on board Aditya-L1

Abstract: The solar spectral irradiance (SSI) measurements performed using Sun-as-a-star observations have shown that the solar radiation below 400 nm changes by about 60%, though it only consists of about 8% of the total solar radiation. However, the reason behind such changes is not fully understood. One of the most important wavelength region to study the solar spectral irradiance (SSI) is 200-400 nm due to its major role in the chemistry of Oxygen and Ozone in Earth's stratosphere. The Solar Ultraviolet Imaging Telescope (SUIT) onboard Aditya-L1 mission of the Indian Space Research Organization (ISRO) to be launched in 2020, will provide full disk images of the Sun in the wavelength range of 200-400nm using 11 science filters. Such observations shall provide us with an opportunity to measure spatially resolved SSI in various narrow as well as broad wavelength range and help us pinpoint the cause of the SSI variation within this range. This is central to our understanding of the Sun-climate relationship.

S4-P7	IAUS340_179	Yamini	Poster

Authors: Yamini K. Rao1, P. Kayshap2, A. K. Srivastava1, K. Wilhelm3, and B. N. Dwivedi1 1Department of Physics, Indian Institute of Technology (Banaras Hindu University), Varanasi, India. 2Group of Astrophysics, UMCS, Lublin, Poland. 3Max-Planck-Institut fur Sonnensystemforschung, Gottingen, Germany.

Title: Multi-line Spectroscopic Analyses of the Dynamical Cool Loops Using Interface Region Imaging Spectrometer (IRIS) Observations

Abstract: IRIS high-resolution observations provide a unique opportunity to study the dynamics and evolution of the cool transition-region (TR) loops, which are poorly understood. An active-region is observed by IRIS on 2017 March 25, which consists of low-lying cool loop system. IRIS spectroscopic observations cover the broad range of temperature from the solar photosphere to the lower solar corona. We conduct this study to understand the dynamics/evolution of these loops in the various layers of the solar atmosphere. Footpoints of these loop threads are either dominated by very high blue-shifts or red-shifts. These loop threads also have the chromospheric counterparts as they are visible in middle of the solar chromosphere. Radiances, Doppler-shifts and line widths are also investigated from photosphere to the lower solar coronal temperatures in this loop system. Si IV line profile is very complex and broad at the footpoints of these loops, which suggest the occurrence of transient events. We observe the variation of Doppler flows with height in the area of loop footpoints, which may be the result of siphon flows or transient events.

Session 5. Solar - Stellar Connection

S5-P1	IAUS340_182	Das Srijan Bharati	Poster

Authors: Srijan Bharati Das (BS-MS, 5th year, CESSI, IISER-Kolkata.); Dr. Dibyendu Nandi (Head of Center, CESSI, IISER-Kolkata)

Title: The Evolution of Activity of Solar-Like Stars with Age.

Abstract: Earlier studies exploring the connection between the unsigned magnetic flux and stellar age have produced strongly correlated empirical relations. With the advent of newer and more advanced observational techniques, a repository of other stellar properties have become available. This study focuses on compiling a list of solar-like stars and gathering information about the stellar age and X-ray luminosity from available literature to explore the evolution of stellar activiy with age. Other stellar parameters like the Dynamo number, Rossby Number, Rotational period and convective turnover timescale are instrumental in understanding the magnetohydrodynamic processes in stellar interiors. It is suspected that a relation exists between the stellar age (and hence the magnetic flux or activity), and the above dynamo parameters. We explore the above database of stellar activity to establish whether such a relationship exists.

S5-P2	IAUS340_188	Gurumath Shashanka R	Poster

Authors: Shashanka R. Gurumath (Department of Physics, VIT University, Vellore, India), Hiremath K. M. (Indian Institute of Astrophysics, Bengaluru, India) and, Ramasubramanian V. (Department of Physics, VIT University, Vellore, India)

Title: Influence of planets on the magnetic activity of sun like stars

Abstract: By considering the physical properties of Sun-like G stars and their exoplanets, present study examines whether presence of planets near the host stars enhances their stellar activity. In order to attain this goal, chromospheric R_HK index data-a proxy for the magnetic activity-for the stars with and without planets is considered. With the reasonable constraints on the exoplanetary data, we obtained a power law decay relationship between the magnetic activity of host stars and their ages. Similar analysis of sun like stars without detected exoplanets, from the BCool survey data, also yields a similar power law decay relationship with similar magnitudes of the exponents. Both these results strongly suggest that there is no difference in magnetic activity of the sun like stars with and without presence of planets. In order to confirm this result, further we also examine an association between the host stars R_HK index that have exoplanets and their respective exoplanetary masses. We find that magnitude of R_HK (hence magnetic activity) of the host stars is independent of presence of planetary mass in its vicinity. That means planets do not play any major role in enhancing the stellar magnetic activity.

S5-P3	IAUS340_122	Hiremath K M	Poster

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Title: A possible solution for the Faint Young sun paradox

Abstract: According to standard solar evolution model, roughly 4 billion years ago, the Sun was about 30% less luminous. With the similar green house gases during that era, Earth and hence probably Mars would freeze. Yet geological and biological evidences of the Earth and ancient climate of the Mars suggest other way. This condition of apparent contradiction is called Faint Young Sun paradox. One of the solution for this paradox is, during Early epoch of the solar system formation, sun is massive compared to present mass. Aim of present study is to examine,from the sun like stars that have exoplanets, whether sun was really massive or not during early epoch. For this purpose, sun like stars that have exoplanets are considered and their mass loss is estimated from the mass versus age relationship. From this relationship a power law relationship between rate of mass loss versus mass of different stars is obtained and rate of mass loss of the sun is estimated to be ~ 10^{-11} M_sun/year. By evolving rate of mass loss of the host stars from present epoch to initial epoch, around 50 million years, probably when planets were formed, total mass lost by the stars and hence by the sun is estimated and mass loss correction to the present stellar masses are applied. Initial mass of the Sun during the early epoch is estimated to be ~ (1.061\pm0.006) solar mass. Interestingly this initial high mass (high luminosity) of the sun is adequate to explain the Faint young sun paradox. That means during that epoch, Earth was not frigid and Mars probably was inherited with water.

S5-P4	IAUS340_296	Huiqin Yang	Poster

Authors: Huiqin Yang (1,2) , Jifeng Liu(1,2) , Qing Gao(1), Xuan Fang(3， 4), JinCheng Guo(5) Affiliation: 1 Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China 2 University of Chinese Academy of Sciences, Beijing 100049, China 3 Laboratory for Space Research, University of Hong Kong, Pokfulam, Hong Kong, China 4 Department of Earth Sciences, University of Hong Kong, Pokfulam, Hong Kong, China 5 Department of Astronomy, Peking University, Beijing 100871, China

Title: The flaring activity of M dwarfs

Abstract: Flare events are mainly due to magnetic reconnection and thus are indicative of stellar activity. The Kepler Space Observatory records numerous stellar activities with unprecedented high photometric precision in flux measurements. It is perfectly suitable for carrying out a statistical study of flares. Here we present 540 M dwarfs with flare events discovered using Kepler long-cadence data. The normalized flare energy, as defined by the ratio to bolometric stellar luminosity, Lflare/Lbol, is used to indicate the flare activity. We find that, similar to the Xray luminosity relation, the Lflare/Lbol versus Prot relation can also be described with three phases, supersaturation, saturation, and exponential decay, corresponding to an ultra-short period, a short period, and a long period. The flare activity and the number fraction of flaring stars in M dwarfs rise steeply near M4, which is consistent with the prediction of a turbulent dynamo. The size of starspots are positively correlated with flare activity. The Lflare/Lbol ratio has a power-law dependence on LHa/Lbol, a parameter indicative of stellar chromosphere activity. According to this relation, a small enhancement in chromosphere activity may cause a huge rise in flare energy, which suggests that superflares or hyperflares may not need an extra excitation mechanism. Through a comparison study, we suggest that flare activity is a more suitable indicator for stellar activity, especially in the boundary region. However, contrary to what is expected, some M dwarfs with strong flares do not show any light variation caused by starspots. Follow-up observations are needed to investigate this problem.

S5-P5	IAUS340_208	Ismaiel Mohamed	Poster

Authors: Mohamed Ismaiel

Title: Case study on complex Forbush decrease caused by interacting and non-interacting passing CME

Abstract: Using Neutron Monitors data for 10 stations distributed over the high \(\phi\geq55 N\ \textrm{and}\hspace{1mm}\phi\geq55 S\), and mid \(45 N \geq\phi\geq 30 N\) latitude regions, study the sudden short time drop in cosmic rays intensity known as Forbush decrease caused by solar energetic events such as flares, flares associated with CME, or ICME. This work is case of study on the complex FD on 5-6 Aug 2011, during the ascending of the first peak of solar cycle 24. Caused by two consecutive M-class flares, one associated with fast CME of 1315 Km/s led to FD of amplitude \(\sim\) 4\%, recorded by high latitude stations showed dependence on latitude rather than rigidity. Mid stations had no response to the second flare. However, suffered another FD probably caused by crossing of 610 Km/h non-interacting ICME associated with earlier flare, investigated by its effects on Earth's magnetic field components.

S5-P6	IAUS340_206	Julian David Alvarado Gomez	Poster

Authors: Julian D. Alvarado-Gomez (Harvard-Smithsonian Center for Astrophysics), Jeremy J. Drake (Harvard-Smithsonian Center for Astrophysics), Ofer Cohen (University of Massachusetts at Lowell), Sofia P. Moschou (Harvard-Smithsonian Center for Astrophysics), Cecilia Garraffo (Harvard-Smithsonian Center for Astrophysics).

Title: Investigating Transient Events in Active Stars

Abstract: The stellar magnetic fields dominate the environment around late-type stars. They are responsible for driving the coronal high-energy radiation, the development of stellar winds, and transient events such as flares and coronal mass ejections (CMEs). While considerable progress has been made for the first two processes, our understanding on the eruptive behavior of active stars is still limited. This information is critical as these phenomena can have a strong or even catastrophic impact on planetary systems, particularly, during the early stages of evolution where they can become the dominant factor in determining the properties around low mass stars. In this context, the initial results of a joint observational and numerical project, aimed at studying the properties of eruptive phenomena in active stars are presented. The first aspect comprises the analysis of simultaneous observations of X-ray and white light flares of young stars, acquired with the Chandra and Kepler telescopes. On the numerical side, we present 3D MHD simulations of CMEs in active stars using one of the latest models employed for space weather forecast in the solar system. These results are discussed in the solar-stellar context, considering the observed properties of the magnetic fields in which they develop.

S5-P7	IAUS340_295	Kaiming Cui	Poster

Authors: Yang Huiqin, Gao Qing, Liu Jifeng

Title: Long-term rotational main-sequence variables in Kepler SAP light curve

Abstract: The relationship between stellar activity and stellar rotation period is a vital method to study the origin and evolution of the stellar magnetic field. Traditional detection method for the long-term rotational period in Kepler field was restricted by PDC light curve data, which removed the long time scale variation by its cotrending basis vector(CBV). Therefore, it's hard to find more slow rotators with PDC data. We design a new method to detect the long-term period objects and remove the false positive objects based on SAP light curve. In our results, hundreds of main-sequence objects with period larger than 70 days could be found.

S5-P8	IAUS340_382	Lehtinen Jyri	Poster

Authors: Jyri J. Lehtinen [1,2] Maarit J. Käpylä [1,2] Thomas Hackman [3] Teemu Willamo [3] [1] Max Planck Institute for Solar System Research [2] ReSoLVE Centre of Excellence, Aalto University [3] University of Helsinki

Title: Doppler imaging active longitudes at the Nordic Optical Telescope

Abstract: It is known from photometric studies that the spot activity of active late type stars becomes strongly nonaxisymmetric, forming long lived active longitudes, once the rotation rate of the stars exceed a critical limit. This transition can be understood in terms of dynamo models as a changing preference for axisymmetric and nonaxisymmetric dynamo modes as a function of rotation rate. The spatial information given by the photometric studies has, however, only a limited resolution. It is thus vital to study the evolution of the stellar surface features with the higher resolution provided by the Doppler imaging method to gain further understanding of the stellar dynamos. We present results from our extended and partly spectropolarimetric Doppler imaging time series, spanning nearly 25 years, gathered at the Nordic Optical Telescope using the SOFIN and FIES high resolution spectrographs. The long time span of the data set and the surface resolution provided by the Doppler imaging give us a unique view into the evolution and the fine structure of the active longitudes, supplementing the view gained from time series photometry. We study in particular the migration patterns of the active longitudes and their relation to the azimuthal dynamo waves that are seen in numerical dynamo models.

S5-P9	IAUS340_152	Mishra Sudheer Kumar	Poster

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Title: The growth of magnetic Rayleigh-Taylor instability into the outer solar atmosphere and in the low inter-planetary space

Abstract: We analyze the observation from the Solar TErrestrial RElations Observatory (STEREO)-A/COR-1 of an eruptive prominence in the intermediate corona on 7 June 2011 at 08:45 UT. This eruptive prominence possesses magnetic Rayleigh-Taylor (MRT) unstable plasma in the form of finger structures in COR-1 FOV. The spatial evolution of magnetic Rayleigh-Taylor instability is discussed in the form of finger structures in outer atmosphere and low inter-planetary region. The Spherical Symmetric Polynomial Approximation (SSPA) technique has been used to measure the mass density in the observed finger structures and the corresponding dark region below lying of it. We approximate that the mass density in each bright finger is greater the corresponding dark region below lying of it evolved within 2.8-3.8 solar radii. The instability is developed due to higher dense finger structures rest on the top of less denser dark region and initiate a wave perturbation. The MRT instability grew when the wave perturbation that are parallel to the magnetic field while they propagate at the density interface. We speculate that the plasma blobs (finger structures and dark region below lying of it) is suspended by the magnetic component of Lorentz force against the gravity. Using linear stability theory, the minimum value of magnetic field is estimated as 17-38 mG to suppress the growth of MRT in the observed finger structures. As the MRT fingers moves in outer corona upto 6-13 solar radii, due to relative motion of fingers secondary Kelvin-Helmholtz instability developed. The mushroom-like structures have been diagnose in the same MRT plasama segment in STEREO-A/COR-2 FOV. In the low inter-planetary region upto 20 solar radii the non-linear phase of MRT instability grew and mushroom-like structures are influenced by fingers breakup, and turbulent mixing. These plasma structure are fragmented into various small-scale localized plasma spikes most likely due to turbulent mixing.

S5-P10	IAUS340_66	Namekata Kosuke	Poster

Authors: Authors: Kosuke Namekata (speaker, 1), Takahito Sakaue (1), Kyoko Watanabe (2), Ayumi Asai (1), Hiroyuki Maehara (3), Yuta Notsu (1), Shota Notsu (1), Satoshi Honda (4), Takako T. Ishii (1), Kai Ikuta (1), Daisaku Nogami (1), Kazunari Shibata (1), Affliations: (1) Kyoto University, Japan, (2) National Defense Academy of Japan, (3) National Astronomical Observatory of Japan, (4) University of Hyogo, Japan

Title: Statistical Study of Solar White-light Flares and Comparison with Superflares on Solar-type Stars

Abstract: Recently, many "superflares" on solar-type stars were discovered by long-term monitoring observations with the Kpler spacecraft (Maehara et al. 2012). The superflares emit 10-10,000 times stronger radiation in "white-light" than the maximum solar flares. A statistical study of superflares found a correlation between the energy (E) and duration (t): $t \propto E^{0.39}$, similar to those of solar hard/soft X-ray flares: $t \propto E^{0.2\text{-}0.33}$. This indicates a universal mechanism of energy release of solar and stellar flares, i.e., magnetic reconnection (Maehara et al. 2015). A direct comparison of solar flares and suerpflares in "white light" emission can give us more information about the energy release mechanism of superflares. We then carried out a statistical research on 50 solar white-light flares with SDO/HMI and examined the t-E relation. As a result, the t-E relation on solar white-light flares ($t \propto E^{0.42}$) is similar to that on stellar superflares ($t \propto E^{0.39}$). However, the durations of stellar superflares are one order of magnitude shorter than those extrapolated from solar white-light flares. We present the following two interpretations for this discrepancy. (1) In solar flares, the cooling timescale of white light may be longer than the reconnection one, and the decay time can be determined by the cooling time. (2) The distribution can be understood by applying a scaling law ($t \propto E^{1/3}B^{-5/3}$) derived from the magnetic reconnection theory. In this case, the observed superflares are expected to have 2-4 times stronger magnetic field strength than solar flares.

S5-P11	IAUS340_317	Pandit Drabindra	Poster

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Title: Solar Activities and its Impact on Space Weather

Abstract: Sun is an active star its magnetic field fluctuates from fraction of second to on long period of time. The solar wind, coronal mass ejection, solar prominence, solar flares, solar particle and solar filament are the direct result of solar magnetic activity providing connection to the effects on the interplanetary space, Earth's magnetosphere and ionosphere. The intensity of irruption of these phenomena from the Sun's surface depends upon its phases. The extreme events affect technology both in space and on the ground. Data obtained from series of observation can help to predict solar activity and its safekeeping of the space technology. The impact of solar activities on the environmental conditions in near-Earth space or in the interplanetary space is studied by geomagnetic indices and solar wind parameters. Our study showed that strong geomagnetic disturbances have high impact on space weather than weak disturbances. We have also studied the cross correlation between interplanetary magnetic field (Bz) with solar wind parameters- solar wind velocity (Vsw), plasma pressure (Psw), proton density (Nsw) and proton temperature (T) and IMF Bz with geomagnetic indices (Kp, Dst and AE) and found good correlation.

S5-P12	IAUS340_391	Petrus C Martens	Poster

Authors: Petrus C Martens and Rafal A. Angryk, Georgia State University (resp, Physics & Astronomy and Computer Science)

Title: Data Handing and Assimilation for Stellar Cycle Prediction

Abstract: The solar-stellar informatics cluster at Georgia State University (GSU) is an interdisciplinary group between the departments of Physics & Astronomy and Computer Science. A major objective of this rapidly expanding group is preparing solar and stellar data sets for the prediction of solar flares and the solar cycle and the related activity. The first requirement for such an undertaking is a clean and balanced databases. While the meaning of clean is pretty obvious, balanced is a more subtle concept. Suppose one wants to predict the occurrence of periods of low solar activity, like the Maunder or Dalton minima, or extended solar minima, like we recently experienced around 2010, and also in 1913. The challenge is then to find a roughly equal amount of instances of very similar data prior to such events, that did not lead to solar or stellar periods of low activity or extended minima. Only then can the sophisticated methods recently developed for data mining in computer science be applied in preparing forecasts. Classifier algorithms may then be able to predict extended minima or Maunder-like minima. That is an approach that has not been attempted yet, and is well worth attempting. I will review our approach and methodology.

S5-P13	IAUS340_175	Sreejesh PS	Poster

Authors: 1. Sreejesh PS,Department of Physical Sciences IISER Kolkata 2. Annapurni Subramaniam,IIA 3. Dibyendu Nandy, Center of Excellence in Space Sciences India (IISER Kolkata),Department of Physical Sciences IISER Kolkata 4. Koshy George,IIA

Title: Understanding the ultraviolet energy budget of exoplanet host stars

Abstract: The Ultraviolet (UV) energy budget of exoplanet host stars is a very essential parameter in shaping up the planetary atmospheres as well as habitability. A systematic study of UV budget of the planet host stars is attempted here using the data archive of the GALEX Ultraviolet telescope. Using the gphoton tool, we created light curves of planet-hosting stars which have sufficiently large time coverage in the GALEX observations. The light curves are searched to look for flare like signatures, which is an indication of the presence of magnetic fields. We also derive the UV energy budget for a large number of planet hosting stars and estimate the UV flux as a function of spectral type.

S5-P14	IAUS340_312	Buzasi Derek	Poster

Authors: D. L. Buzasi (Florida Gulf Coast University)

Title: Building a Large Solar Analog Sample Using K2

Abstract: Two complementary approaches have been adopted for studies of the Sun, the first centered on in-depth studies of the Sun itself, and the second focusing on the study of solar analogs, stars which are like the Sun and thus might shed light on characteristics of its composition, structure, activity, planetary system, evolution, and future. The utility of the study of solar analogs is broad, ranging from finding night-time proxies for the Sun for calibration purposes to their use as snapshots of the evolutionary history of the Sun. Their study has helped to establish that chromospheric activity is key to understanding stellar rotation, activity, and dynamos. However, difficulties arise in placing the Sun in context among its analogs, due to the simple fact that the catalog of good solar analogs is so brief, particularly for less-active stars. We have begun a project aimed at providing a large consistent set of well-vetted solar analogs in order to address these questions. We make use of the K2 mission fields to obtain precise photometric time series of approximately 2000 solar analogs, supplemented by asteroseismology and ground- and space-based spectroscopic data for the brighter and more promising candidates. From this data we will derive rotation periods, spot coverages, and flare rates for a well-defined, well-calibrated, and statistically meaningful sample of solar analogs. We present early results from this long-term program.

Session 6. Solar Behavior over Centuries

S6-P1	IAUS340_242	Aranya S	Poster

Authors: S.Aranya1, T.E.Girish2, G.Gopkumar2, N.G.Nisha3 and V.Vipindas2 1 Department of Physics, SN College, Sivagiri, Varkala 695145,INDIA 2 Department of Physics, University College, Trivandrum 695034, INDIA 3 Department of Physics, Govt College for Women, Trivandrum 695014 ,INDIA.

Title: CHARACTERISTICS OF SOLAR PROTON EVENTS OBSERVED NEAR EARTH AND STELLAR ACTIVITY VARIATIONS

Abstract: We suggest that the characteristics of solar proton events observed near earth (which is an important manifestation of solar activity) can help us to understand different kinds of stellar activity variations. We could find two types of solar proton events (SPE) with distinct solar origin. The occurrence of 10 MeV SPE is found to to be cyclic and closely follows sunspot activity variations during the recent six solar cycles. We have long term data on the 30 MeV SPE which is inferred back in time up to the year 15 from nitrate measurements in polar ice . Girish and Gopkumar (2010) explained the characteristics of 30 MeV SPE in association with secular changes in the efficiency of the solar dynamo and solar equatorial rotation rate variations .The fluence of 30 MeV solar proton observed in association with the Carrignton event of September 1859 is the largest of its kind during the past 470 years and will be shown to be associated with an abnormal increase in solar rotation. Even though solar rotation is inferred to slow down during Maunder minimum period, transient increases in the same could have caused occurrence of 30 MeV SPE events during the years 1667 and 1682. In a similar way changes in stellar rotation may be helpful in understanding extreme stellar activity changes in stars with inferred cyclic magnetic activity. Relevant examples in this context will be discussed in detail.

S6-P2	IAUS340_291	B Ravindra	Poster

Authors: Ravindra B Indian Institute of Astrophysics, Bengaluru Javaraiah J Indian Institute of Astrophysics (formerly)

Title: Study of long term variations in hemispheric asymmetry of solar activity

Abstract: Sunspots and other features on the sun exhibits hemispheric asymmetry. We study the long term asymmetry parameters in sunspot numbers and area from Kodaikanal white-light data sets. The absence or presence of double peak in each solar cycle, dominant hemispheric activity and a phase relationship between the hemispheres activity results will be presented. A comparison of the results with other data sets will also be made. The wavelet analysis results on the data sets will also be presented.

S6-P3	IAUS340_35	Banerjee Dipankar	Poster

Authors: Dipankar Banerjee, Sudip Mandal & Bidya Binay Karak

Title: Latitude Distribution of Sunspots: Analysis Using Sunspot Data and a Dynamo Model

Abstract: In this work, we explore the evolution of sunspot latitude distribution and explore its relations with the cycle strength. With the progress of the solar cycle, the distributions in two hemispheres from mid-latitudes propagate toward the equator and then (before the usual solar minimum) these two distributions touch each other. By visualizing the evolution of the distributions in two hemispheres, we separate the solar cycles by excluding this hemispheric overlap. From these isolated solar cycles in two hemispheres, we generate latitude distributions for each cycle, starting from cycle 8 to cycle 23. We find that the parameters of these distributions, namely the central latitude (C), width (δ), and height (H), evolve with the cycle number, and they show some hemispheric asymmetries. Although the asymmetries in these parameters persist for a few successive cycles, they get corrected within a few cycles, and the new asymmetries appear again. In agreement with the previous study, we find that distribution parameters are correlated with the strengths of the cycles, although these correlations are significantly different in two hemispheres. The general trend features, i.e., (i) stronger cycles that begin sunspot eruptions at relatively higher latitudes, and (ii) stronger cycles that have wider bands of sunspot emergence latitudes, are confirmed when combining the data from two hemispheres. We explore these features using a flux transport dynamo model with stochastic fluctuations. We find that these features are correctly reproduced in this model. The solar cycle evolution of the distribution center is also in good agreement with observations. Possible explanations of the observed features based on this dynamo model are presented.

S6-P4	IAUS340_254	G. L. Jayalekshmi	Poster

Authors: Jayalekshmi G. L. and Prince P. R.,Department of Physics, University College, Thiruvananthapuram 695034, Kerala, India

Title: Distribution of hemispheric solar activity during various phases of solar cycles

Abstract: Solar activities in the northern and southern solar hemispheres cannot be considered as identical. North-south (N-S) asymmetry is exhibited by solar activity parameters, like sunspot number, sunspot area, CMEs, number of filaments, number of coronal holes etc. The asymmetry can influence various solar phenomena and hence by itself is an indicator of solar activity. Since hemispheric asymmetry is one of the significant parameters related to the action of solar dynamo, details of the same can be applied in the upcoming dynamo models. The study attempts to find out nature of hemispheric activity during different solar cycles. An individual solar cycle consists of four different phases - minimum, ascending, maximum and descending. Comparison of hemispheric activities at the above phases is found out for solar cycles 12 to 23. Sunspot activity of solar cycles, 14-16 and 18-20 shows northern hemisphere domination. Asymmetry of solar activity shows extremum values during the cycles 17 and 19. Lowest and highest levels of N-S asymmetry are mainly observed during minimum and descending phases respectively of solar cycles. A change of phase is found to be existing between the asymmetries at solar maxima and minima, starting from solar cycle 16 onwards. Also, for cycles 18-20, the behaviour of the asymmetry is observed to be peculiar and different from that of the other cycles. Analysis of periodic behaviour of N-S asymmetry proves that formation of asymmetry mainly occurs in 8.8 years periodicity and the level of asymmetry is noticed very high during the cycles 18-22.

S6-P5	IAUS340_122	Hiremath K M	Poster

Authors: Hiremath, K. M^{1} and Rozelot, J. P.^{2} 1. Indian Institute of Astrophysics, Koramangala, Bengaluru-560034, India 2. University of Nice, Grasse-06130, France

Title: Neraly century scale variations of Sun's radius and Earth's orbital distance

Abstract: From 1923-2011, Kodaikanal digitized white light picture calibrated data is used to estimate radius of the sun uniquely. We find that, for nearly century scale data, sun's radius is decreasing 5 milli arc sec per century. Long term century scale decrease of the sun's radius, even if it is feeble, needs to be altered substantially either energy budget or thermal structure of the sun. Hence, if we accept radius of the sun to be constant, only way to explain this long term decrease of sun's radius is due to increase of orbital distance of the Earth from the sun which in turn obviously could be due to combined effect of accretion and mass loss of the sun and, variable universal gravitational constant G. Translating decrease of Sun's radius into Earth's orbital distance we find that there is a secular increase of Earth's orbital distance from the sun by 1.565 meter/century.

S6-P6	IAUS340_276	J. Javaraiah	Poster

Authors: Formerly in Indian Institute of Astrophysics, Bengaluru-560034

Title: Long-term variations in solar activity and planetary configurations

Abstract: Planetary configurations may have influence on solar activity. We have analyzed the data of yearly mean international sunspot number (R_Z) during the period 1600–2015 and the data on orbital positions of the giant planets in each 10-day interval during the period 1600–2099. We find that 1) the power spectrum of R_Z and that of the average of the absolute differences among the orbital positions of the giant planets are qualitatively similar, 2) on longer time scales the low/high solar activity is at least weakly associated with the less/large spread in the orbital positions of the giant planets, 3) the Maunder minimum, Dalton minimum, and the current grand minimum (may cover cycles 24–26) seem to be associated with the troughs of the~179-year cycles of the average of the absolute differences among the orbital positions of the giant planets, 4) role of Jupiter in the solar activity variation is primary and all the other planets may play a role of perturbation on the role of Jupiter causing the variations in the lengths of solar cycles and other short- and long-term variations in solar activity, and 5) the length of a solar cycle, *i.e.* the time elapsed between the maximum epochs of two consecutive cycles, is equal to the product of the orbital period of Jupiter (11.86 year) and the number of revolutions of Jupiter take place in order to Jupiter align with other giant planets at these epochs in some specific configurations.

S6-P7	IAUS340_158	Kseniya	Poster

Authors: Vasilyeva V.V. 1, Tlatova K.A. 1, Tlatov A.G. 1,2 1Kislovodsk Mountain Astronomical Station of the Pulkovo Observatory, Kislovodsk, Russia tlatov@mail.ru 2Kalmyk State University, Elista, Russia

Title: Properties of prominences in 14-24 cycles of activity

Abstract: Digitization of solar prominences Kodaikanal Observatory (India) on photographic plates in the CaIIK line for the period 1907-1960 was performed. These data were supplemented by data such as daily observations of prominences Kislovodsk Observatory (1957-2017), digitization of prominence sketches by the spectrohelioscopes network (1922-1934) and prominences on synoptic charts (1887-1898, 1904-1915). Comparative analysis of the velocity drift of high-latitude prominences to the poles in activity cycles are performed. Connection between the velocity drift and the power of the activity cycle has been established. Analysis of the height prominences distribution are performed. The maximum of the heights distribution is about 30 Mm. Also there is a second maximum for a height of ~60 Mm.

S6-P8	IAUS340_123	Mishra Roshan Kumar	Poster

Authors: 1. Roshan Kumar Mishra, Department of physics, St.Xavier's College, Maitighar, Kathmandu, Nepal. 2. Binod Adhikari, Department of physics, St.Xavier's College, Maitighar, Kathmandu, Nepal and Department of physics, Patan Multiple Campus, Patan Dhoka, Lalitpur, Nepal.

Title: Characteristics of Solar Wind Parameters and Geomagnetic Indices during Solar Flares

Abstract: Active sun is characterized by a compelling short-lived flash of solar eruption like solar flare, coronal mass ejections (CMEs), high-speed solar winds and solar energetic particles along with the colossal release of energy and mass. Solar flares are spectacular explosions on sun's surface with a solar luminosity of about 3.827×1033 $ergss^{-1}$, which can transform the magnetic energy of the sun to plasma motions, to acceleration of plasma, for heating up of the plasma and also giving out more light in the solar atmosphere. The phenomena of solar flare are elucidated by several models based on magnetic reconnection. Sudden perturbations, short life time, occur in the geomagnetic field corresponding with solar flare are solar flare effects. This paper proposes a new method to evaluate solar wind parameters and geomagnetic indices based on wavelet analysis during the solar flares. The crucial role of IMF-Bz (interplanetary magnetic field)is examined for the three solar flares events. The key result obtained from our study is the substantial dependence of solar flare intensity on IMF-Bz together with solar wind velocity. We also observed the duration of solar flares and their effect on ionospheric and ground-based parameters.

S6-P9	IAUS340_275	Pandit Rutvik	Poster

Authors: Rutvik Pandit, Himanshu Pandit SRM University, Chennai

Title: Calculation of rate of decrease of heliosphere and calculating increase in orbital period of planets due to CME and solar flares

Abstract: In recent years the size of heliosphere has decreased, by knowing the shrinkage of heliosphere with the help of data gathered over the years the rate of shrinkage of heliosphere can be calculated. The sun is losing mass continuously and the majority of mass is released by two phenomenon first the nuclear fusion inside the core of the sun in which energy mass conversion takes place and secondly due to coronal mass ejections and solar flares. although this mass is negligibly small in comparison to the overall mass of the sun but has a significant impact over large period of time on planets and celestial bodies present in solar system due to this loss of mass the gravitational force of the sun reduces which in turn increases the orbit size of planets and the orbital time of the planets also increases with increase in size of the solar system. By considering the above two factors a formula can be devised by which approximate distance of planets or celestial body from heliosphere at any given time can be calculated. References [1] Dr. Tony Phillips, Solar Wind loses power, hits 50-years low. [2] J. D. Richardson, K. I. Paularena, A. J. Lazarus, and J. W. Belcher, Evidence for a solar wind slowdown in the outer heliosphere.

S6-P10	IAUS340_165	Pant Vaibhav	Poster

Authors: Vaibhav Pant, Ankur Chauhan, Dipankar Banerjee and N. Gopalswamy

Title: Kinematics of Fast and Slow Coronal Mass Ejections in solar cycles 23 and 24

Abstract: We perform a statistical study of the kinematics of slow and fast Coronal Mass Ejections (CMEs) in solar cycles 23 and 24. We investigate the distribution of the width of slow and fast CMEs using Coordinated Data Analysis Workshops (CDAW) and Computer Aided CME Tracking (CACTus) catalogs. We find that the width distribution of slow and fast CMEs follow different power laws. We also study the width distribution by isolating the limb CMEs extracted from CDAW catalog and found that results are similar to non limb CMEs. We also study the variation of occurrences of CMEs with solar cycles 23 and 24 using CDAW and CACTus catalogs. We find that while the occurrence rate of fast CMEs follow the sunspot numbers, slow CMEs do not follow this trend, at least in cycle 23. We also find that solar cycle 24 produces more slow and poor CMEs which may be due to the weak polar and heliospheric field in solar cycle 24.

S6-P11	IAUS340_62	Priya T G	Poster

Authors: Priya T G, Jiangtao Su, Jie Chen, Deng Yuanyong, Robert Erdelyi

Title: Study of running penumbral waves in H-alpha data

Abstract: We present results from the investigation of 5-min umbral oscillations in a single-polarity sunspot of active region NOAA 12132. The spectra of TiO, Hα, and 304 Å are used for corresponding atmospheric heights from the photosphere to lower corona. Power spectrum analysis at the formation height of Hα - 0.6 Å to Hα center resulted in the detection of 5-min oscillation signals in intensity interpreted as running waves outside the umbral center, mostly with vertical magnetic field inclination > 15° . A phase-speed filter is used to extract the running wave signals with speed vph > 4 km/s ,from the time series of Hα - 0.4 Å images, and on investigation found 24 events of 3-min umbral oscillations in a duration of one hour. Interestingly, the initial emergence of the 3-min oscillations are noticed closern to or on umbral boundaries and these 3-min oscillations are observed as propagating from a fraction of preceding RPWs. These fractional wavefronts rapidly separates from Running Penumbral Waves (RPWs) and move towards umbral center, wherein they expand radially outwards suggesting the beginning of a new umbral oscillation. We found that most of these umbral oscillations further develop into RPWs. We speculate that the waveguides of running waves are twisted in spiral structures and hence the wavefronts are first seen at high latitudes of umbral boundaries and later at lower latitudes of umbral center. We aim to look into the similar events in the other ARs and find for its occurance in the long dataset.

S6-P12	IAUS340_161	Schmieder Brigitte	Poster

Authors: Brigitte Schmieder LESIA, Observatoire de Paris

Title: Geoeffective events through the solar cycles

Abstract: Extreme solar storms are well known in the historical databases. Since the modern era, it has been possible to associate clearly geomagnetic disturbances with solar events (flares, SEP, CMEs). In the recent solar cycles the geoeffective events (number and strength) are decreasing . As an exemple we will show, in one recent solar maximum activity year, how many flares, CMEs were geoeffective. Based on observations and theory, we will review the main ingredients for the built up of the electric current, free energy in active regions to get X-ray class flares and large Interplanetary Corona Mass Ejections and what we can predict in the near future.

S6-P13	IAUS340_191	Valliappan Senthamizh Pavai	Poster

Authors: Senthamizh Pavai Valliappan, Rainer Arlt

Title: Cycle-averaged tilt angles of sunspot groups over centuries

Abstract: The tilt angle of a sunspot group is the angle between the axis joining the group polarities and the E-W direction. It is basis of magnetic buoyancy needed for the flux tube emergence and an important parameter in surface flux transport models (SFTM) in which it provides the source term for the poloidal magnetic field. The solar cycle properties seem to be related to the tilt angles, and the cycle-averaged tilt angles vary from one cycle to another. Hence the study of tilt angles over many cycles can help us in understanding its relation to the solar cycle properties. The tilt angles of sunspot groups obtained from modern data are available since 20th century. Further tilt angle values for sunspot groups in the past centuries can be obtained from the analysis of historical sunspot drawings. The solar observation drawings, covering parts of 17th - 19th century, by Scheiner, Hevelius, Staudacher, Zucconi, Schwabe, and Spoerer were analyzed for the tilt angles of sunspot groups. The observations by Hevelius cover the part of solar cycle before the Maunder minimum. The average tilt angle before the Maunder minimum was not low as one of the suspected reason for a following grand minimum, whereas a low average tilt is seen for a period of three to four cycles after the Maunder minimum. Except for the solar cycles after the Maunder minimum, cycle-averaged tilt angle values of other cycles are similar to the values 20th century data.

S6-P14	IAUS340_298	Wagner Daniel	Poster

Authors: Daniel Wagner Prof. Dr. Ralph Neuhäuser Astrophysical Institute and University Observatory,Friedrich-Schiller-University, Schillergaesschen 2-3, D-07745 Jena, Germany

Title: Variation of the auroral oval size and offset

Abstract: The understanding of the behaviour of the auroral oval is crucial for the correct reconstruction of its size and location during past centuries by using historical aurora sightings. Therefore we investigated the size of the oval as well as the offset from the geomagnetic poles for different magnetic activity levels described by the Kp-index. The Spin-Scan Auroral Imager (SAI) mounted on the Dynamics Explorer 1 satellite provides image data from 1981 to 1991 which was used for this purpose. Geometrical analysis of each image, transformed to quasi-dipole coordinates (QD coordinates), gives the center of the oval and its radius. To minimize the uncertainties, the results in different Kp-intervals were averaged. The results show a linear dependence between Kp-index and radius and a nearly constant shift of the oval center towards the midnight sector of around 4°. We will try to use historical aurora observations to check reconstructions of the Earth magnetic field, which are otherwise possible only with archeological methods - the Earth magnetic field in turn is relevant for estimations of solar activity from radioisotopes.

S6-P15	IAUS340_176	Waheed Malik Abdul	Poster

Authors: 1. Department of Physics, Islamic University of Science and Technology, Awantipora, Pulwama, J & K-192122. 2.Space Science Laboratory, Department of Physics, Barkatullah University, Bhopal – 462026, M.P., India. 3. AISECT University, Bhopal, M.P.

Title: The Dynamics of High Latitudinal Magnetosphere in Relation to Solar Energetic Particles

Abstract: In this paper the relationship between Solar Proton Events and the higher latitude electrodynamic system has been explored. Those solar proton events have been taken into consideration for which peak flux values of >100 pfu have been observed for >10 MeV solar proton. Spectral analysis of those solar proton events has been done and a relationship has been explored to be existed between the spectral indices and PC indices which are representative of highly variable higher latitudinal current systems. Fairly good correlative results have been found between the spectral indices of solar protons and PC indices both with the Gradual as well as Impulsive Solar Protons. Studies have also been made in understanding the relationship between the flux value for > 10 MeV solar protons and its rate with PC index and its rates, respectively. We got fairly good relation in time has been found to exist for the same.

Session 7. Solar and Stellar Dynamo

S7-P1	IAUS340_149	Basak Arnab	Poster

Authors: Arnab Basak (1) and Dibyendu Nandy (1,2) (1) Center of Excellence in Space Sciences India, Indian Institute of Science Education and Research Kolkata, Mohanpur-741246, West Bengal, India. (2) Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata, Mohanpur-741246, West Bengal, India.

Title: Study of starspots in fully convective stars using three dimensional MHD simulations

Abstract: The mechanism of formation of starspots in cool stars is fundamentally different from the formation of spots in the sun. Observations as well as numerical simulations have shown that starspots are usually formed as high-latitude patches extended over wide areas. Using a fully spectral magnetohydrodynamic code, we try to simulate polar starpsots produced by self-consistent dynamo action in rapidly rotating convective shells. We carry out high resolution simulations and investigate various properties related to the starspot formation using different approximations.

S7-P2	IAUS340_82	Cherkos Alemayehu Mengesha	Poster

Authors: Alemayehu Mengesha Cherkos, Addis Ababa University , Institute of Geophysics Space Science and Astronomy

Title: Effect of viscosity on propagation of MHD waves in astrophysical plasma

Abstract: We determine the general dispersion relation for the propagation of magnetohydrodynamic (MHD) waves in an astrophysical plasma by considering the effect of viscosity with an anisotropic pressure tensor. Basic MHD equations have been derived and linearized by the method of perturbation to develop the general form of the dispersion relation equation. Our result indicates that an astrophysical plasma with an anisotropic pressure tensor is stable in the presence of viscosity and a strong magnetic field at considerable wavelength.

S7-P3	IAUS340_114	Hazra Gopal	Poster

Authors: Gopal Hazra (IISc) and Mark Miesch (HAO)

Title: Incorporating Surface Convection into a 3d Babcock-Leighton Solar Dynamo Model

Abstract: The observed convective flows on the photosphere (e.g., supergranulation, granulation) play a key role in the Babcock-Leighton (BL) process to generate large scale polar fields from sunspots fields. In most surface flux transport (SFT) and BL dynamo models, the dispersal and migration of surface fields is modeled as an effective turbulent diffusion. Recent SFT models have incorporated explicit, realistic convective flows in order to improve the fidelity of convective transport but, to our knowledge, this has not yet been implemented in previous BL models. Since most Flux-Transport (FT)/BL models are axisymmetric, they do not have the capacity to include such flows. We present the first kinematic 3D FT/BL model to explicitly incorporate realistic convective flows based on solar observations. Though we describe a means to generalize these flows to 3D, we find that the kinematic small-scale dynamo action they produce disrupts the operation of the cyclic dynamo. Cyclic solution is found by limiting the convective flow to surface flux transport. The results obtained are generally in good agreement with the observed surface flux evolution and with non-convective models that have a turbulent diffusivity on the order of 300 km^2/s. However, we find that the use of a turbulent diffusivity underestimates the dynamo efficiency, producing weaker mean fields than in the convective models. Also, the convective models exhibit mixed polarity bands in the polar regions and the explicitly computed turbulent electromotive force bears little resemblance with the diffusive flux.

S7-P4	IAUS340_84	Kutsenko Aleksandr	Poster

Authors: Aleksandr Kutsenko, Crimean Astrophysical Observatory RAS; Valentina Abramenko, Crimean Astrophysical Observatory RAS

Title: Flux emergence rate of active regions as a probe for turbulent dynamo action

Abstract: We analyzed the flux growth rate of several dozens of emerging active regions (ARs). To compute the magnetic flux we used line-of-sight magnetograms acquired by the Helioseismic and magnetic Imager onboard the Solar Dynamics Observatory. The flux growth rate was calculated as a time derivative of the total unsigned flux of an AR. We found that after the onset of the emergence the flux growth rate amounts to some maximal value and remains quasi-constant during a certain interval. This interval is unique for each AR. To compare weak and strong ARs we introduced a normalized flux growth rate determined as the flux growth rate divided by the maximal flux accumulated by an AR. We found that most of the ARs form two subsets: the ARs with a relatively high normalized flux emergence rate form the ‘rapid’ emergence subset. The second subset consists of ‘gradual’ emergence events and it is characterized by a low normalized flux emergence rate. Preliminary results suggest that the ARs from the ‘rapid’ emergence subset exhibit on average higher twist than those from the ‘gradual’ emergence subset. This is consistent with the numerical simulations performed by other authors. The observed difference can be a manifestation of the turbulent dynamo action that generates additional magnetic flux and twist via turbulent motions as the magnetic structure makes its way up to the solar surface.

S7-P5	IAUS340_318	Tripathi Bindesh	Poster

Authors: Bindesh Tripathi, St. Xavier's College, Tribhuwan University, Nepal. Soumitro Banerjee, Department of Physical Sciences, Indian Institute of Science Education and Research, Kolkata, India. Dibyendu Nandy, Center of Excellence in Space Sciences India, IISER Kolkata, Mohanpur 741246, West Bengal, India. Department of Physical Sciences, Indian Institute of Science Education and Research, Kolkata, India.

Title: Modeling grand minima using hysteresis in a time delay solar dynamo model

Abstract: We explore a reduced Babcock-Leighton (BL) dynamo model based on delay differential equations. This model reveals hysteresis, which can be directly related to the recent inference that a grand minimum phase is a distinct mode of solar activity. We study the coupled nonlinear delay differential equations of the model using numerical bifurcation analysis and find that grand minima episodes can be triggered by a stochastically varying poloidal source. We show how the mean field alpha-effect considered previously recovers the cycle while preserving the hysteresis, but only for a very narrow range of parameters (i.e., this is a non-robust feature). Moreover, the BL model with magnetic noise as an additional poloidal field source, over a wide range of parameters, exhibits a bimodal distribution of toroidal field energy confirming two modes of solar activity. It also shows intermittency and reproduces phase space collapse, a signature of the Maunder Minimum. Thus we conclude that the magnetic noise due to turbulent dynamo action (or other sources) plays a vital role even in Babcock Leighton dynamo models.

S7-P6	IAUS340_251	Varnana M Kumar	Poster

Authors: Varnana M Kumar1, Thara N Sathyan1, Nisha N.G3 ,Aranya.S2 and Girish T.E1 1 Department of Physics, University College, Trivandrum 695034, INDIA 2 Department of Physics, SN College, Sivagiri,Varkala 695145, INDIA 3 Department of Physics, Govt College for Women, Trivandrum 695014, INDIA.

Title: Inferring stellar activity variations near habitable extrasolar planets using dynamical effects

Abstract: Knowledge of variability of the activity of host stars of extra solar planets is important to judge its space weather environment and habitability. Angular momentum distribution in the star-planetary systems may influence of the periods of cyclic stellar activity. For example sunspot cycle period is close to the sidereal orbital period of Jupiter which carries significant portion of solar system angular momentum. We will cite examples of different manifestations of solar activity variability related to angular momentum exchanges between Sun and the planetary system or vice versa. Three types of stellar activity are now detected in stars with nearby planets i) periodic or cyclic changes in activity (ii) Maunder minima type stable activity pattern (iii) abrupt and extreme changes in stellar activity. The types of stellar activity and angular momentum distribution are studied in detail for 52 star-planetary systems where potentially habitable extrasolar planets are now identified by astronomers. It is found that transient and abrupt changes in stellar activity is more probable in M stars like Proxima Centauri whose dynamical environment and associated angular momentum exchanges are likely to be more complex than our solar system apart from strong tidal effects in these stars.

S7-P7	IAUS340_364	Viviani Mariangela	Poster

Authors: Viviani, M.(1), Warnecke, J.(1),(2), Käpylä, M. J.(1),(2), Käpylä, P. J.(3),(2),(1),(4), Olspert. N.(2), Lehtinen, J.(1),(2), Brandenburg, A.(4),(6),(7),(8) (1)Max Planck Institute for Solar System Research, Göttingen, Germany, (2) ReSoLVE Centre of Excellence, Aalto, Finland, (3) Leibniz Institute for Astrophysics Potsdam, Potsdam, Germany, (4) NORDITA, Stockholm, Sweden, (5) Department of Astronomy, Stockholm University, Stockholm, Sweden, (6) JILA and Department of Astrophysical and Planetary Sciences, University of Colorado, Boulder, USA, (7) Laboratory for Atmospheric and Space Physics, Boulder, USA.

Title: Solar-like stars at various rotation rates: a comparison between observations and simulations

Abstract: Many observational studies have attempted to characterize the behavior of stellar activity and dynamos as function of rotation rate. From long-term photometric data sets a limiting activity measure for the stars showing active longitudes (i.e nonaxisymmetric fields) has been derived. At the same time, the magnetic activity cycle length is changing. When the cycle length is normalized to the rotation period, stars seem to fall on different branches (called Inactive, Active and Superactive branch), depending on their rotation rate. However, the existence and origin of these branches is controversial. Global 3D magnetoconvection models have advanced to a level where solar-like solutions can be routinely obtained and integrated long enough even to study the long-term cycles hence the observational issues described in Lehtinen poster can be addressed. These models are applicable to other solar-like stars by varying the rotation rate, and we have recently performed such a study. We find that solar-like axisymmetric solutions change to nonaxisymmetric ones at rotation rates only slightly higher than the solar one. Our transition occurs earlier than what is indicated by observations. Moreover, in the models the dynamo mode transition is accompanied by a change from anti-solar (faster poles, slower equator) to solar-like (fast equator, slower poles) differential rotation. Our study covers models that should belong to all the branches, but we clearly recover only the superactive branch behavior, while the active population seems to be merged with the superactive population.

Session 8. Predictions and Predictability of Solar Cycle

S8-P1	IAUS340_71	Adhikari Binod	Poster

Authors: 1Department of physics, Tri-Chandra Multiple Campus, Ghantaghar, Kathmandu, Nepal.
2Department of physics, St.Xavier's College, Maitighar, Kathmandu, Nepal

Title: Analysis of Sunspots Number during Solar Cycle 21 and 22

Abstract: Many solar indices are investigated based on faculae, flares, coronal holes, and electromagnetic radiation in various bands such as 10.7 cm radio flux, sunspots, the total solar irradiance, coronal mass ejections, geo-magnetic activity, galactic cosmic ray fluxes and ice cores. Among these, sunspot number is considered as a best index of solar activity because of its availability and reliability. The sunspot number series has been studied for more than a century, but new interesting feature is being discovered even recently. To analyze the sunspot number, here we used the data of the daily, monthly and yearly mean sunspot number. From our analysis, we have found that the maxima of yearly mean sunspot number, monthly mean sunspot number and daily mean sunspot number during solar cycle 21 are 220.1, 266.9, and 428 respectively, while those during solar cycle are 211.1, 284.3, and 410 respectively. Similarly, we have also displayed the behavior of standard deviation of sunspot number as time series graph and reported their maxima and minima values. Therefore, in one sentence, this work aims to make us enable to understand the physics behind the sun, sunspot number, solar activity and their relations with our climate, their influences on this earth and so on.

S8-P2	IAUS340_83	Bhargawa Asheesh	Poster

Authors: Asheesh Bhargawa and A. K. Singh, Department of Physics, University of Lucknow, Lucknow - 226 007

Title: Forecasting Solar Activity Parameters for 25th Solar Cycle using Rescaled Range Analysis

Abstract: The ability to forecast periods of intense solar activity may provide the better understanding to scientists and researchers. Actually the 11-year cycle of solar activity is delineated by the rise and fall in the numbers and surface area of sunspots. Some other solar activity indicators like 10.7 cm radio flux, solar magnetic field, proton flux and Alfven Mach number also vary in association with the sunspots. We have analyzed about 40 years solar data for above mentioned parameters and have also performed the statistical test for persistence of solar activity based on the value of the Hurst exponent (H) which is widely used for the measurement of long-term memory of time series. We have adopted re-scaled range analysis for estimation of Hurst exponent and have described the efficiency of this methodology as well as prediction content for the next solar cycle. We have conducted the test for the persistence of sunspot numbers, 10.7cm radio flux and the solar magnetic field for last forty years data (years 1976 – 2016) and calculated H-index as 0.86, 0.82 and 0.64 respectively. Further we have calculated maximum number of counts for sunspot numbers, F10.7cm index and solar magnetic field as 102.8±24.6, 137.25±8.9 and 6.82±1.6 (nT) respectively. Using the simplex projection analysis, we have forecasted that the solar cycle 25th would start in the year 2021 (January) and would last up to the year 2031 (September) with its maxima in June 2024.

S8-P3	IAUS340_45	Bhatt Nipa J	Poster

Authors: Nipa J Bhatt1 and Rajmal Jain2 Affiliation 1Dept of Physics, C. U. Shah Science College, Ahmedabad – 380014, India. 2Research Cell, Kadi Sarva Vishwavidyalaya, Gandhinagar – 382015, India

Title: Reassessing the Predictions of Sunspot Cycle 24

Abstract: The space weather is largely affected due to explosions on the Sun viz. solar flares and CMEs, which, however, in turn depend upon the magnitude of the solar activity i. e. number of sunspots and their magnetic configuration. Owing to these space weather effects, predictions of sunspot cycle are important. Bhatt et al. (2009) employed the precursor technique (using geomagnetic indices) for the prediction of sunspot cycle 24. The predictions were made using the long term dataset of the relative sunspot number (International Sunspot Number), as well as average geomagnetic activity index aa from 1868, considering 2008 as the year of sunspot minimum. Owing to the extended solar minimum in 2009, we re-examined our prediction model and found that (i) The annual maximum amplitude of cycle 24 = 71.2 ± 19.6 (observed: 79) and (ii) A smoothed monthly mean sunspot number maximum in January 2014±4 months (observed in February 2014) which are now in good agreement with the observations. Recent research has shown that there are many inconsistencies in the old dataset of International sunspot number which has been used as a basis for many predictions till now. The newly calibrated international sunspot number reduces many discrepancies and is available from Solar Influences Data Center (SIDC) website. We re-assess our predictions in the light of this new improved version of international sunspot number. Our prediction method appears to be a reliable indicator for the predictability of the following solar cycle. References: Bhatt, N.J., Jain, R. & Aggarwal, M.: 2009, Sol. Phys. 260, 225

S8-P4	IAUS340_205	Dhuri Dattaraj	Poster

Authors: Dattaraj Dhuri, Tata Institute of Fundamental Research

Title: Prediction of solar flares from photospheric magnetic field using machine learning

Abstract: Solar flares are eruptions on the surface of Sun caused by the rapid restructuring of magnetic field lines in active regions. The radiation and charged particles released in the process pose a threat to space and ground based communication instruments. Understanding mechanism leading to solar flares and their prediction is an outstanding problem in the field. Helioseismic and Magnetic Imager (onboard NASA's Solar Dynamic Observatory) makes available high resolution solar vector-magnetic-field data with 12 minutes cadence. We use this data to train machine learning algorithms for prediction of solar flares with accuracy greater than 85%. We analyse performance of trained machine learning algorithms to shed light on underlying physics responsible for triggering solar flares.

S8-P5	IAUS340_446	Exnerová Martina	Poster

Authors: Martina Exnerová

Title: Solar Activity Service and Reports from the Ondrejov Observatory

Abstract: There is a long tradition of the solar patrol service at the Ondrejov observatory (AV CR) for more than 80 years based on own optical and radio observations. Sunspot drawings and synoptic optical continuum images are systematically produced daily, depending just on weather and technical conditions. Morever, forecasts of the week solar activity are made since 1978 and distributed for several public institutions in the Czech Republic. They are broadcasted on the national radios and TVs and they are mostly highly appreciated by the public. During the last few years we also determine a probability of the flare activity for each individual NOAA region. We also produce daily forecasts of solar activity using both the synoptic and our own H-α detail data. During last months we improved the technical facility of the solar patrol. The details and prospects are given in the poster.

S8-P6	IAUS340_254	G. L. Jayalekshmi	Poster

Authors: Jayalekshmi G. L. and Prince P. R., Department of Physics, University College, Thiruvananthapuram 695034, Kerala, India

Title: Prediction of upcoming grand episodes of solar activity

Abstract: Sunspots are active regions on the surface of the Sun having strong magnetic fields. Sunspot numbers vary from a minimum to a maximum and back to a minimum with a typical period of 11 years (Schwabe cycle). This cycle is modulated on various longer timescales. Sunspot record is extended backwards by using proxy data derived from the abundance of cosmogenic isotopes. Activity level of the Sun shows grand episodes – Grand maximum and Grand minimum. Grand episodes are the reflection of irregularities in solar activity. Several dynamo models are trying to explain these long-time scale phenomena in sunspot numbers. Present study examines extended yearly averaged sunspot numbers during 1090 – 2009 using methods of wavelet transform and sinusoidal regression. Analysing time interval includes two grand maxima [Medieval maximum (1100-1250) and Modern maximum (1924-2009)] and four grand minima [Wolf minimum (1280-1340), Spörer minimum (1420-1530), Maunder minimum (1645-1715) and Dalton minimum (1790-1820)]. Interval in between grand episodes are regular oscillations. The latest corrected sunspot number fails to find modern maximum. Time-periodicity localization of non-stationary signals is an excellent property of wavelet analysis. Phase changes found from periodicity analysis clearly show the presence of upcoming grand episodes. The forthcoming grand episodes are suggested to be two grand minima that is likely to occur between the years 2100-2160 and 2220-2300.

S8-P7	IAUS340_260	Gopinath Sumesh	Poster

Authors: Department of Physics, University College, Thiruvananthapuram, Kerala, India

Title: Prediction of future evolution of solar cycle 24 using machine learning techniques

Abstract: Forecasting the solar activity cycle is of great importance not only for its effect on the climate of the Earth but also on the telecommunications, power lines, geophysical exploration, space missions and satellite safety. During all these years, a wide variety of techniques have been proposed in order to predict the characteristics such as amplitude, duration, structure etc. of the coming cycle for a few years ahead. The present solar cycle had achieved a great attention of several solar physicists to treat the problem of forecasting due to the unexpected deep solar minimum. As we know, several models have been arduously developed to predict the amplitude as well as the phases of activity of solar cycles, in relation with the deep minimum. In the present work, a machine learning technique using Artificial Neural Networks (ANNs) called as the Nonlinear Autoregressive Network with Exogenous Inputs (NARX) approach has been applied for the prediction of future evolution of the present solar cycle. The proposed model uses several inputs such as sunspot number (SSN), solar EUV flux, F10.7 cm radio flux, total solar irradiance (TSI) etc. to predict the 11-year solar magnetic cycle and make a comparison of forecasting ability using statistical quantifiers such as root mean square error (RMSE), average relative variance (ARV), R-value etc. The NARX neural network is generally known for its ability to outperform other neural network models and is far better than the ordinary linear regression models.

S8-P8	IAUS340_129	Jiang Jie	Poster

Authors: Jie Jiang (School of Space and Environment, Beihang University, Beijing, China Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences, Beijing, 100012, China)

Title: Predictability of the subsequent cycle at different phase of a cycle

Abstract: Both observations and theories indicate that the polar field at the cycle minimum determine the next cycle strength, which makes the reliable prediction of the strength of cycle n+1 at the minimum of cycle n feasible. The strong effects of the violent solar activities on modern technologies require people to know future solar cycle strength as early as possible. Hence here we investigate the predictability of the subsequent cycle at different phases of a ongoing cycle. When a solar cycle starts for a few years, we predict the future possible sunspot emergence of the ongoing cycle including the area, location and tilt angle of each sunspot groups based on the semi-empirical relations. Then we run the surface flux transport simulations with a number of such random flux sources to get the polar field evolution, especially the possible range of the polar field strength at the cycle minimum. The range of the subsequent cycle strength with giving probability can be obtained based on the correlation between the polar field and the subsequent cycle strength.

S8-P9	IAUS340_362	Patra Sankar Narayan	Poster

Authors: Sankar Narayan Patra, Amrita prasad, Soumya Roy, Koushik Ghosh, Subhash Chandra Panja

Title: Nonlinear Autoregressive Model (NARX) of Stationary Forbush Decrease Indices Based on Levenberg-Marquardt Feedback Algorithm

Abstract: Different ground-based detectors system like Neutron Monitors are continuously and efficiently measuring the Forbush Decrease. The galactic cosmic rays in fact are energy particles, predominantly protons and helium nuclei striking the Earth's atmosphere from outer space mostly with the 11- year Sunspot cycle and 22-year magnetic cycle. Forbush decrease is a rapid decrease in the observed galactic cosmic ray intensity pattern after coronal mass ejection. In the present paper we have analyzed the daily sampled discrete signal of stationary Forbush decrease indices from January, 1967 to December, 2003 generated in IZMIRAN, Russia. We have made an attempt to fit a suitable Levenberg-Marquardt backpropagation Nonlinear Autoregressive Neural Network model (NARX) with exogenous input for the present time variant process by means of a necessary number of process parameters like hidden layer neurons, output layer neuron, combination coefficient, previous and present values of Forbush Decrease(FD) Indices used parsimoniously. The study reveals that the present time series of FD is governed by a nonlinear autoregressive process with a trace of white noise. Short term predicted output matches properly with the targets output with a small mean square error of 0.000252.Our results perfectly show the existence of strong value at zero lag which may explain the complete uncorrelation between prediction errors (white noise). In this case, the correlations, except for the one at zero lag, fall approximately within the 95% confidence limits around zero, so the model seems to be adequate.

S8-P10	IAUS340_189	Sarp Volkan	Poster

Authors: V. Sarp and A. Kilcik Akdeniz University, Faculty of Science Department of Space Science and Technologies

Title: Nonlinear Prediction of Solar Cycle 25

Abstract: In this study, a nonlinear approach is applied to sunspot numbers from 1848 to 2017 in order to obtain the prediction of the minimum of solar cycle 24 and the maximum of solar cycle 25. For this purpose, we used simplex projection algorithm which depends on the embedding dimension of the sunspot data. In results of our analysis we found followings; i) starting time of the next cycle (the minimum of solar cycle 24) is expected at March 2019 with 10.8 smoothed monthly mean sunspot number. ii) Maximum of the next cycle is expected at June 2023 with 145.2 smoothed monthly mean sunspot number.