Gaia Symposium: DR2 and Beyond

November 2 - 6, 2020
Indian Institute of Astrophysics
https://www.iiap.res.in/GAIA/

Abstract Book

All times are in Indian Standard Time (IST; UTC +5:30)

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2 November 2020 (Monday)

Time: **14:30 – 15:15**
Speaker: Gerry Gilmore (Institute of Astronomy, University of Cambridge)
Title: **Gaia - some science highlights**
Abstract: ESA's Gaia astrometry mission is delivering a revolution in our view of the Milky Way Galaxy, its structure and its evolution, even after release of only a small part of what will eventually be available. I will give an overview of recent results with a focus on the early evolution of the Galaxy's structural components - halo, thick disk, thin disk. These show how the combination of Gaia and ground-based stellar spectroscopy is producing a quantitative and consistent description of the history of our Galaxy.

Time: **15:15 – 16:00**
Speaker: Jos de Bruijne (European Space Agency)
Title: **Gaia: mapping 1 billion stars with 1 billion pixels**
Abstract: In this presentation, I will tell the story of Gaia, Europe's astrometry mission that is currently creating multi-dimensional astrometric, photometric, and spectroscopic maps of the Milky Way. From its unique vantage point in space, and making use of a carefully designed, ultra-stable measurement platform, Gaia's telescopes feed its billion-pixel focal plane with trillions of measurements of more than 1 billion objects. I will provide an overview of the history of the Gaia mission and will summarise how this remote-controlled robot makes its magic measurements.

3 November 2020 (Tuesday)

Time: **14:00 – 14:40**
Speaker: Caroline Soubiran (Laboratoire d'Astrophysique de Bordeaux)
Title: **The impact of Gaia on open cluster science**
Abstract: Open clusters are valuable objects to probe the history of the Milky Way's disc and to improve stellar evolutionary models. Investigations of these galactic building blocks have been boosted by the release of Gaia data. Novel methodologies dedicated to the determination of memberships and physical properties have been developed. Thanks to the large number of objects observed by Gaia and to the unprecedented precision and homogeneity of their derived parameters, including ages, the global characteristics of the open cluster population are revisited. A selection of recent results will be presented to illustrate the impact of Gaia in that field.

Time: **14:40 – 15:00**
Speaker: Blesson Mathew (Christ University)
Title: **Study of young stars in diverse environments using Gaia DR2**
Abstract: We made use of the unprecedented quality of Gaia DR2 data to study young stars in moving groups, star forming regions and clusters. The precise distance measurements have provided accurate estimates of mass accretion rates and disk dissipation time scales in Herbig Ae/Be stars. The membership probability and dynamics of young stars belonging to various moving groups were analyzed. We found evidence for clustering of low mass stars around Herbig Ae/Be stars, which were found to be bounded and co-moving. We also discuss our ongoing work on the formation of pre-main sequence stars in high galactic latitude, isolated environments. The future is bright due to the release of Gaia EDR3, wherein we plan to use this dataset to address star formation in isolated and clustered environments.

Time: **15:00 – 15:15**
Speaker: Gaurav Singh (ARIES)
Title: **Impact of GAIA DR2 in the study of Hot stellar population in Galactic Globular Clusters**
Abstract: GAIA DR2 has completely revolutionised our understanding of the Kinematics of Galactic Globular clusters (GGCs). It provides an unprecedented photometric and astrometric precision of all the stars down to G ~ 21 mag. The data is also complete up to G=18 mag, therefore quite useful for studying the hot stellar population. The population of interest here is the Blue straggler stars (BSSs), Horizontal branch (HB), extreme HB (EHB), etc. Using the Astro-photometric catalog of HST and GAIA-DR2, we have obtained the dynamical status of various GGCs using BSSs as the dynamical probe. Not only the dynamical status but it plays a very important role in our recent discovery of a BSS companion to an EHB star in the outskirts of the GGC, NGC 1851, which provides a pathway for the formation of EHB stars. However, GAIA DR2 data is affected by the systematics which are problematic at the fainter magnitudes. So with GAIA DR3 we are expecting a

much better catalog with higher astrometric and photometric precision and with the reduced systematic errors.

Time: **15:15 – 15:30**
Speaker: D. Bisht, University of science and technology of China
Co-authors: Qingfeng Zhu, Geeta Rangwal, R. K. S. Yadav, Alok Durgapal
Title: **The multicolour photometric and Gaia DR2 astrometric study of an intermediate age open cluster NGC 1348**
Abstract: The multi-band photometric data are collected from Gaia DR2, APASS, UKIDSS, Pan-STARRS1, 2MASS, and WISE surveys for the comprehensive analysis of open cluster NGC 1348. The extinction law is found to be normal using different colour-colour diagrams. Cluster members are identified by applying distances based on the Gaia DR2 parallaxes and the point vector diagram of the Gaia DR2 proper motions. Mean proper motion of the clusters in RA and DEC directions are estimated as 1.01±0.08 and −1.70±0.09 mas/yr. We calculated the main fundamental parameters (Age, distance, reddening, metallicity etc.) for this cluster. Galactic orbits and several orbital parameters are determined using Galactic potential models. Our study indicates that NGC 1348 has circular orbits (eccentricity~0). In addition to this, we also have studied the luminosity function, mass function and dynamical state of the target cluster for the first time. Mass function slope for the entire region of NGC 1348 is found to be comparable with the Salpeter's value. A comparison of dynamical age with cluster's age indicates that NGC 1348 is dynamically relaxed cluster. Main/important results will be explained later on at the time of talk.

Time: **15:30 – 15:45**
Speaker: Kaushar Vaidya, Birla Institute of Technology and Science Pilani
Co-authors: Khushboo K. Rao, Manan Agarwal, Souradeep Bhattacharya
Title: **Blue Straggler Populations of Open Clusters Using Gaia DR2**
Abstract: We have identified and characterized blue straggler stars (BSS) of seven open clusters using the astrometric, kinematic, and parallax information of sources available in the Gaia DR2. BSS, being the most massive objects of a star cluster, are considered to be a crucial link between the stellar dynamics and stellar evolution. Upon studying the normalized radial distributions of the BSS populations of these open clusters with respect to a reference population, the red-gaint branch stars, we find five of them to show bimodal radial distributions. For the first time for open clusters, we study the correlation between the location of minima ---presumably the boundary delineating the region of the cluster affected by the dynamical friction --- and the number of relaxations the central parts of the cluster has undergone. We obtain a positive value for the correlation, with the slope being consistent to the known globular cluster correlation, within the errors.

Time: **16:00 – 16:20**
Speaker: Coryn A.L. Bailer-Jones (Max Planck Institute for Astronomy)
Title: **Can we identify the parent stars of interstellar objects?**
Abstract: The first two interstellar objects (ISOs), 1I/'Oumuamua and 2I/Borisov, were discovered in 2017 and 2019 as they passed within a couple of astronomical units of the Earth and Sun. Using ground-based and HST data to reconstruct their hyperbolic orbits, together with Gaia-DR2 to trace back the positions of 7 million stars in the solar neighbourhood, we searched for stars that came closest to these ISOs in the past (Bailer-Jones et al. 2018, 2020). If a past encounter was both close and slow enough, then

such a star could be the stellar system from which the ISO was ejected. We indeed identified close encounters, in particular one at 0.07 pc for 2I/Borisov. But how likely is this to be the parent star? What factors do we need to take into account to determine this? And what are the prospects for a more confident detection using later Gaia data releases?

Time: **16:20 - 16:35**
Speaker: Yerra Bharat Kumar (NAOC)
Co-authors: B. E. Reddy, G. Zhao
Title: **Investigation of Li-rich puzzle in the era of GAIA**
Abstract: Only 1% of giants show high levels of lithium among low-mass red giants, so-called Li-rich puzzle, whose origin is not well understood. The critical issue is with the evolutionary phase that these stars belong to. We initiated a systematic survey using Hipparcos data, a decade back, which suggested Li-rich giants located at the red clump phase of the HR diagram. Our recent study using GAIA data revealed all red clump stars enhanced with lithium. In this talk, I will describe the journey from Hipparcos to GAIA in understanding the Li-rich puzzle.

Time: **16:35 - 16:50**
Speaker: Mayank Narang (TIFR)
Co-authors: P Manoj
Title: **Unveiling the photospheres of protostars with Gaia**
Abstract: The protostellar phase is the earliest phase in the process of star formation. During this phase, most of the star's final mass is accreted, and the protostellar disk is formed. However, the protostars are deeply embedded with a line of sight extinction Av ~50-100 and are only observable in the mid- to far-infrared wavelength range. However, if the protostar's cavity is inclined towards or the envelope mass is small and tenuous, it is possible to observe the protostar's photosphere in optical and near-infrared. In this work, we used a well-studied sample of protostars from the Herschel Orion Protostellar Survey (HOPS) to search for optical counterparts for these protostars in the Gaia DR2 survey. Out of the 330 sources in the HOPS catalog, we find Gaia counterparts for 59 sources within ~1.3” of the infrared position. We further complement the Gaia data with ALMA continuum observations at 0.87 mm. The ALMA positions are within 0.1” of the Gaia DR2 positions, thus ruling out the possibility of the optical emission being from a background object. Further, we show that the Gaia detected protostars are more evolved than the parent HOPS sample. We do this by calculating both the bolometric temperature, T_bol and envelope mass; M_env. The optically visible sources have larger T_bol and smaller M_env than the parent sample. We also calculate the inclination angle and show that while the T_bol and M_env are different between the two samples, the inclination angles are similar. This means that the sources are optically visible because of the tenuous envelopes and not due to a favorable geometry.

Time: **16:50 – 17:05**
Speaker: Piyali Saha (Indian Institute of Astrophysics)
Co-author: Maheswar Gopinathan
Title: **Investigation of Rocket Effect in Bright Rimmed Clouds using Gaia DR2**
Abstract: Bright-rimmed clouds (BRCs) are the ideal candidates to study radiation driven implosion (RDI) mode of star formation as they are potential sites of triggered star formation. Several young stellar objects (YSOs) have been identified towards a number of

BRCs that are likely to have been formed as a result of the compression caused due to the RDI process. We conduct a study to investigate any preferred orientations of the disks around YSOs associated with BRC 18 with respect to the ambient magnetic field and the direction of the energetic photons from the ionizing star. We also find the possible acceleration of BRC 18 away from the ionizing source as a result of recoil experience due to the evaporation of the gas towards the ionized medium from the surface facing it. We made R-band polarimetric observations of 17 YSOs identified in the vicinity of BRC 18 to infer the orientations of the disks around them. Using the distance and the proper motion measurements obtained from the Gaia DR2 of the sources identified as YSOs in the vicinity of the BRCs, we determined the projected motion of the YSOs and hence the BRCs on the sky plane by assuming that both are kinematically coupled. We found that the disk orientations of the YSOs are oriented randomly with respect to the projected magnetic field towards BRC 18. The relative proper motions of the YSOs associated with the BRC 18 are found to show a trend of them moving away from the direction of ionizing sources. Using BRC 18 as a prototype, we made our analysis for other BRCs also which showed a similar trend. We computed the offset between the angle of direction of ionization and relative proper motion of YSOs and found it to lie close to being parallel to each other. The Pearson's correlation coefficient is found to be 0.96 with pnull=1.09e-10. The Spearman's correlation coefficient is estimated as 0.95, with pnull=2.33e-09. Along with these, we also performed a k-s test on our samples. The computed statistic is 0.17 and the p-value is 0.94. All these results indicate that the YSOs and hence the BRCs are most likely accelerating away from the ionizing source due to the "Rocket Effect". In addition to these, we also found several sources lying in the vicinity of several BRCs that are kinematically associated with the previously known YSOs and therefore, could be YSO candidates unidentified in earlier studies.

4 November 2020 (Wednesday)

Time: **14:00 – 14:40**
Speaker: Joss Bland-Hawthorn (Sydney Institute for Astronomy)
Co-authors: Thorsten Tepper-Garcia
Title: **Galactic seismology: the evolution of the density waves and bending waves after Sgr impact**
Abstract: Our Galaxy, the Milky Way, is a benchmark for understanding disk galaxies. It is the only galaxy whose formation history can be studied using the full distribution of stars, from white dwarfs to supergiants. The oldest components provide unique insight into how galaxies form and evolve over billions of years. This is a veritable golden age for galactic archaeology with many large surveys now under way to map both chemistry and motions for stars in the Galaxy. Detailed 6D "phase space" information combined with chemistry for millions of stars heralds a new era in how we slice up the Galactic disc. This has already enabled the most remarkable discovery to emerge from ESA's Gaia satellite — the "phase spiral". This phenomenon, which was not foreseen, is direct evidence of giant waves crossing the disc. We discuss how the phase spiral is generated and what it may tell us about our history. We review the main science goals of Galactic seismology, and look at what the future may hold. These studies will continue to play a fundamental role far into the future because there are measurements that can only be made in the near field and contemporary astrophysics depends on such observations.

Time: **14:40 – 15:00**
Speaker: Deepak (Indian Institute of Astrophysics)
Title: **Understanding the evolution of the Galactic lithium in the era of the Gaia and large spectroscopic surveys**
Abstract: The highly accurate astrometric and photometric data from the Gaia survey is making it possible to find evolutionary phases and kinematics of a large sample of stars like never before. On the other hand, extensive spectroscopic surveys, like GALAH, APOGEE, LAMOST, etc., are providing chemical compositions of millions of stars. The combination of these spectroscopic surveys with Gaia is providing a perfect recipe to understand the formation and evolution history of the Milky Way. In this talk, we plan to discuss recent advances in the understanding of lithium (Li) evolution in the Galaxy based on data from the Gaia and GALAH surveys. The present amount of Li in the young metal-rich stars and the ISM is almost ten times higher than the amount of Li found in old, metal-poor stars and about three times higher than the theoretically predicted primordial Li abundance in the universe. This indicates a possible Li enrichment in the Galaxy. We will discuss the evolution of Li in the Galaxy based on Li abundance trends with respect to metallicity and other parameters. We also plan to discuss the evolution of Li in the low-mass red-giant branch stars and their possible contribution towards the Li enrichment in the Galaxy.

Time: **15:00 – 15:15**

Speaker: Shreeya Shetye, Institute of Astronomy and Astrophysics, Universite libre de Bruxelles

Co-authors: Sophie Van Eck, Alain Jorissen, Stephane Goriely, Lionel Siess, Drisya Karinkuzhi, Hans Van Winckel, Ana Escorza

Title: Determining the Luminosity of the Third Dredge-up via S-type stars: the promise of Gaia

Abstract: S stars are late-type giants whose spectra show distinctive molecular bands with as most noticeable characteristic the appearance of ZrO bands. They can be segregated in two classes: namely intrinsic and extrinsic. The intrinsic S stars on the Asymptotic Giant Branch (AGB), producing the s-process elements internally which are then transported to the stellar surface via third dredge-up (TDU). The intrinsic S stars are the first ones on the AGB to have undergone a third dredge-up. Understanding the AGB nucleosynthesis and the TDU episodes in function of evolutionary mass and metallicity involves several challenges. One such challenge is that on the AGB, the standard stellar evolution models produced TDUs for masses greater than 1.5Msun. However, there is a growing series of observations pointing at dredge-up occurring in lower mass stars (< 1.5 Msun). Here, for the first time thanks to a study of all intrinsic S stars in Gaia, we are able to systematically test the lower mass limit of TDU. The parameter study of intrinsic S stars along with their luminosity derived from the Gaia DR2 parallaxes has helped us marking the onset of the third dredge-up in the Hertzsprung-Russell (HR) diagram. The accurate parallaxes from Gaia DR2 combined with the well-constrained Teff also helps further constraining the masses and surface gravities of these stars. The positions of the intrinsic S stars in the HR diagram show that the TDU occurs in stars with masses as low as 1 Msun and [Fe/H] in the range of -0.2 to -0.5. Comparison with new, dedicated stellar evolution and nucleosynthesis models show that with some adjustments they are able to reproduce the s-process enhancements of these objects. Moreover, this study is a part of a larger investigation on S stars with Gaia DR2 parallaxes.

Time: **15:15 - 15:30**

Speaker: T. Ruiz-Lara (Kapteyn Astronomical Institute)

Co-authors: C. Gallart; E.J. Bernard; S. Cassisi

Title: Unveiling the secrets of our Galaxy with Gaia: Star Formation Histories from colour-magnitude diagram fitting

Abstract: Gaia has provided distances and photometry, and thus colour-magnitude diagrams in the absolute plane, for stars in an unprecedentedly vast volume of the Milky Way, encompassing significant fractions of the thin and thick discs, as well as the halo. This has allowed us, for the first time, to derive detailed star formation histories from direct modelling of these colour-magnitude diagrams, using the same techniques that have been proven successful for external galaxies in the Local Group. I will discuss our first results from the analysis of the 2 Kpc bubble around the Sun. We have precisely dated the first events involved in the formation of the inner Milky Way halo (Gallart et al. 2019, NatAstro) and found epochs of enhanced star formation (well constrained in time), associated to the various pericentric passages of the Sagittarius dwarf galaxy around our Galaxy (Ruiz-Lara et al. 2020, NatAstro). Additionally, I will outline ongoing and future plans to fully exploit current

and future Gaia data releases including the vertical distribution of ages in the Milky Way disc or the study of star formation histories of galactic substructures in phase space.

Abstracts of posters/ Short talks

Time: 15:45 - 16:55
(8+2 mins each)

Authors: Priya Hasan, Maulana Azad National Urdu University, Hyderabad, India.
Co-authors: S N Hasan
Title: New insights in Mass Segregation with Gaia
Abstract: In this paper, we have selected a sample of 9 clusters for which early mass segregation has been reported in literature. We use Gaia Data for stellar membership to minimise the errors in membership which could possibly lead to wrong results. We study mass segregation in these clusters using Gaia DR2 by finding the mass function $\phi(M) = dN/dM \propto M^{-\alpha}$ in different regions of the clusters and tracing the variation in the value of α as a function of the parameter $\tau = t_{age}/t_{relax}$ (where t_{age} is the age of the cluster and t_{relax} is the relaxation time of the cluster). We compare our results with earlier studies of mass segregation.

Authors: Manash Samal (PRL, Ahmedabad)
Co-authors: Swarali Patil (IISER, Thiruvananthapuram)
Title: Unveiling properties and evolutionary status of five Galactic open star clusters with GAIA
Abstract: Open star clusters before they are dynamically relaxed, represent natural laboratories for understanding star formation and stellar evolution theories. However, determinations of distance and kinematic properties of star clusters are significantly hampered by the contaminating field stars along the line of sight, which in turn affects the cluster properties such as age, luminosity/mass function, and dynamical status. Recent GAIA measurements have provided parallax and proper motion measurements of 1.3 billion stars in our Galaxy. In this work, using GAIA measurements along with a sophisticated approach, we obtained distance, properties and evolutionary status of six nearby open clusters. We argue that for these clusters, our estimates are more precise than other measurements tabulated in the literature. We also discuss that our method can be implemented to distant clusters to obtain precise cluster properties.

Authors: Saroon S (Indian Institute of Astrophysics),
Co-authors: Smitha Subramanian
Title: Gaia view of a Warp in the outer disk of the Large Magellanic Cloud
Abstract: Magellanic system is one of the closest (at a distance of ~ 55 kpc) examples of an interacting system of gas-rich dwarf galaxies (Large Magellanic Cloud and Small Magellanic Cloud), surrounded by gaseous sub-structures such as Magellanic Bridge,

leading arm and Magellanic stream. Detailed simulations of the Magellanic System suggest that the sub-structures around the Magellanic Clouds are the result of the mutual interactions between the LMC and the SMC. Simulations also predict stellar sub-structures. However the role of the Milky Way in the evolution of the Magellanic system is not well understood. A recent study identified an outer warp in the South-Western disc of the LMC and suggested that it could have formed during a collision between the LMC and the SMC. Due to limited spatial coverage of the data the previous study could not investigate the counterpart of this warp in the North Eastern region, which is essential to obtain a conclusive picture of the nature and origin of the warp. In this project we study the structure of the LMC disk and the nature of the outer warp using the Gaia DR2 data, which covers the entire Magellanic system. Preliminary results indicate the presence of a counterpart (for the South Western outer warp) in the North Eastern disc which is also in a direction away from us (U - shaped warp).

Authors: Ekta sharma (Indian Institute of Astrophysics)
Co-authors: Maheswar Gopinathan, Sami Dib
Title: Motion of clouds in Cepheus Flare region
Abstract: The motion of the clouds in the interstellar medium is an important factor in understanding their morphology and dynamics. Based on the GAIA DR2 proper motion measurements of young stellar objects embedded in the clouds, the motion of the molecular clouds in the sky has been studied. We selected Cepheus Flare region (containing a group of clouds L1147/1158, L1172/1174, L1228 and L1251) for this study having an active star formation. As suggested by simulations, there may be interaction of the clouds with the other forces like magnetic fields which are ubiquitous on all scales. In this talk, I will discuss the motion of the molecular clouds using the proper motion and the distance estimates of the young stellar objects associated with them using the Gaia DR2 data. Also, various correlations between the motion of the cloud with respect to the magnetic field and the clump orientations with respect to both magnetic field and the motion will be discussed.

Authors: Sadhana Singh (ARIES)
Co-authors: Jeewan C. Pandey, R. K. S. Yadav, and Biman J. Medhi
Title: Optical Linear Polarization toward the Open Star Cluster Casado Alessi 1
Abstract: We would like to present B-, V-, R-, and I-band linear polarimetric observations of 73 stars in the direction of open star cluster Casado Alessi 1 (hereafter Alessi 1) along with the basic parameters of the cluster estimated using Gaia photometric data. The polarimetric observations were carried out using the ARIES IMaging POLarimeter mounted at the 104 cm telescope of ARIES, Nainital (India) aiming to use polarimetry as a tool to investigate the properties and distribution of dust grains toward the direction of the cluster. We have used Gaia DR2 data to determine the basic parameters and membership of the cluster Alessi 1. Using the Gaia photometric data the age and distance of the cluster are estimated to be 0.8+/-0.1 Gyr and 673+/-98 pc, respectively. A total of 66 stars with a 26 arcmin radius from the cluster are identified as members of the cluster using the astrometric approach. Out of these 66 members, 15 stars were observed polarimetrically and found to have the same value of polarization. The majority of the stars in the region follow the general law of polarization for the interstellar medium, indicating that polarization toward the cluster Alessi 1 is dominated by foreground dust grains. The average values of the maximum polarization and the wavelength corresponding to the maximum polarization toward the

cluster are found to be 0.83+/-0.03 % and 0.59+/-0.04 micron, respectively. Also, dust grains toward the cluster appear to be aligned, possibly due to the galactic magnetic field.

Authors: Neelam Panwar (ARIES)

Title: Photometric and Gaia DR2 study of the young cluster Berkeley 59

Abstract: Berkeley 59 is a young cluster located at the center of the Cepheus OB4 stellar association and is surrounded by the HII region Sh2-171. It is a relatively nearby cluster and contains several massive stars (spectral type from O7 to B5). We investigated the memberships, distance, and proper motion of the Berkeley 59 using the high-precision astrometry and photometry from the Gaia R2. The color-magnitude diagram (CMD) of the cluster region reveals a pre-main-sequence population. The CMD and proper motion distributions show a clear separation between the cluster members and field stars. Using the Gaia DR2 data, we found that the cluster is at a distance of ~1.0 kpc.

Authors: Arun Roy (Christ University)
Co-authors: Blesson Mathew, Maheswar Gopinathan, Tapas Baug, Manoj Puravankara

Title: IL Cep - Herbig Be stars with a "cavity" and T Tauri clustering?

Abstract: The early type Herbig Be star IL Cep is a member of the Cep OB3 association. The~0.1 Myr star at 790 pc has created a "cavity" by gas dispersal in its surroundings. We identified 106 co-moving stars of IL Cep that are situated inside the "cavity" using high precision Gaia DR2 astrometry. The Gaia color-magnitude diagram confirms that the stars are coeval to IL Cep (~0.1 Myr). We analyzed the 2MASS and mid-infrared colors and classified 29 stars as class II objects and 1 star as a probable protostar. The average extinction of the region is estimated using the identified YSOs as AV= 3.5. The YSOs range from F6 - M3.5 which confirms that the subset is possible T Tauri stars. HD 216658, the brightest star that occupies the center of the"cavity" is identified as a foreground star using the Gaia DR2 astrometry. The star HD 216658, is 100 pc away from the "cavity" and not associated with the IL Cep, the "cavity" or the associated YSOs.

5 November 2020 (Thursday)

Time: **14:00 – 14:40**
Speaker: Amina Helmi (Kapteyn Astronomical Institute)
Title: **Views on the youth of the Milky Way with Gaia DR2**
Abstract: I will review our current understanding of the structure of the Galactic halo, and how it links to its formation and history as well as to that of other Galactic components. Much of what we know now was obtained largely thanks to the 2nd data release of the Gaia mission. I will also discuss new research directions in the context of future data releases and new facilities.

Time: **14:40 – 15:00**
Speaker: Sourav Chatterjee (Tata Institute of Fundamental Research)
Title: **Is Gaia the Best Black Hole Hunter?**
Abstract: Black holes capture the interests and imaginations of researchers and the general public alike. Especially, after the detection of gravitational waves from merging binary black holes by the LVK and Nobel awards, twice, to discoveries related to black holes within just four years, it is exciting to learn about how black holes form. Unfortunately, many uncertainties plague our understanding of the formation of stellar black holes. Theoretically solving these is still beyond the scope of current capabilities and observational constraints are still inadequate. This situation can be significantly improved via a large number of detections. I will talk about how Gaia, a survey not even designed for detecting black holes, may become instrumental in improving our understanding of stellar black holes.

Time: **15:00 – 15:15**
Speaker: Suchira Sarkar, Indian Institute of Science, Bangalore, India
Co-author: Chanda J. Jog
Title: **Non-isothermal vertical density distribution of stars in the Milky Way**
Abstract: The vertical density distribution of stars in a galactic disc is traditionally obtained assuming an isothermal vertical velocity dispersion of stars. But recent observed data from Gaia combined with the data from LAMOST, RAVE show that this dispersion increases with height from the mid-plane. We theoretically study the dynamical effects of such non-isothermal dispersion on the vertical distribution of the thin disc stars in the Galaxy. We apply a linear gradient of +6.7 km/s/kpc in the dispersion values, based on the vertical kinematics discussed in Hagen & Helmi (2018) which uses a combined dataset from TGAS and RAVE DR5. Guo et al. (2020) which uses a combined data from Gaia DR2 and LAMOST DR5, also shows a similar increase. We find that the mid-plane density is lower, and the scale height is higher in the non-isothermal case than the corresponding values for the isothermal distribution, by ~35% in the solar neighbourhood for a stars-alone disc. The non-isothermal distribution shows a wing at high z, in agreement with observations, and is fitted well by a double sech^2 , which could be mis-interpreted as the existence of a second, thicker disc, specially in external galaxies. Further, the total mid-plane density i.e, Oort limit value, calculated using the realistic multi-component system of stars ,gas in the field of dark

matter halo, is reduced by 16% in the non-isothermal model. For details of this work, see- Sarkar & Jog (arXiv:2009.10097,accepted for publication in MNRAS.)

Time: **15:15 - 15:30**
Speaker: Shourya Khanna, Kapteyn Astronomical Institute
Title: **Ridges, arches and vertical waves in the Milky Way kinematics**
Abstract: The dynamical history of the Milky Way is complicated. We see a lot of sub-structure, both in spatial density, and in kinematics. To complicate things further, the Galaxy has non-axisymmetric structures such as the bar and multiple spiral arms. Due to their large scale-lengths, the kinematic signatures of such features often overlap, making it difficult to relate to one culprit or another. In this talk, I'll share our findings of the new phase-space structure seen in the Galactic disc with Gaia DR2. In particular, we show that phase mixing of disrupting spiral arms (transient) can generate the substructure seen in the (R,V_φ) and (V_R,V_φ) planes. We also reveal coupling between planar and vertical motion, and demonstrate, using N-body simulations that such coupling can be generated both in isolated discs and in discs perturbed by an orbiting satellite like the Sagittarius dwarf galaxy.

Time: **15:45 – 16:25**
Speaker: Vasily Belokurov (Institute of Astronomy, University of Cambridge)
Title: **LMC - the elephant in the room**
Abstract: It turns out that we have underestimated the importance of the Large Magellanic Cloud in the dynamics of the Milky Way. I will discuss the most recent results based on the Gaia DR2 data pertaining to the mass of the LMC, its satellite population and its influence on our Galaxy.

Time: **16:25 – 16:40**
Speaker: Abinaya O. Omkumar (Indian Institute of Astrophysics)
Co-authors: Smitha Subramanian, Florian Niederhofer, Jonathan Diaz, Maria-Rosa L. Cioni, Dalal El Youssoufi, Kenji Bekki, Richard de Grijs, Jacco Th. van Loon
Title: **Gaia view of a stellar sub-structure in front of the Small Magellanic Cloud**
Abstract: Recent observational studies identified a foreground stellar sub-structure traced by red clump (RC) stars (~ 12 kpc in front of the main body) in the eastern regions of the Small Magellanic Cloud (SMC) and suggested that it formed during the formation of the Magellanic Bridge (MB), due to the tidal interaction of the Magellanic Clouds. Previous studies investigated this feature only up to 4.0 deg from the centre of the SMC due to the limited spatial coverage of the data and hence could not find a physical connection with the MB. To determine the spatial extent and properties of this foreground population, we analysed data from the Gaia data release 2 (DR2) of a ~ 314 sq. deg region centred on the SMC, which cover the entire SMC and a significant portion of the MB. We find that the foreground population is present only between 2.5 to ~ 5-6 deg from the centre of the SMC in the eastern regions, towards the MB and hence does not fully overlap with the MB in the plane of the sky. The foreground stellar population is found to be kinematically distinct from the stellar population of the main body with ~ 35 km/s slower tangential velocity and moving to the North-West relative to the main body. Though the observed properties are not fully consistent with the simulations, a comparison indicates that the foreground stellar structure is most likely a tidally stripped counterpart of the gaseous MB and might have formed from the inner disc (dominated by stars) of the SMC. A chemical and 3D kinematic study of the

RC stars along with improved simulations, including both tidal and hydro-dynamical effects, are required to understand the offset between the foreground structure and MB. (arXiv:2010.02687)

Time: **16:40 – 17:20**
Speaker: Alessandro Sozzetti (INAF)
Title: **Gaia and Exoplanetary Science: DR2, and Beyond**
Abstract: I will summarize the contributions to science of exoplanets made by Gaia absolute astrometry based on Data Release 2 (DR2). I will then outline the Gaia potential for ground-breaking results in exoplanetary science with the upcoming data releases, starting with DR3, expected to take place during the first half of 2022.

Time: **17:20 – 17:40**
Speaker: Manoj Puravankara (Tata Institute of Fundamental Research)
Title: **Kinematics of planet-hosting stars using Gaia DR2: Are Jupiter-hosting stars younger?**
Abstract: In addition to the five-parameter astrometric solution that it provides for more than 1.3 billion stars, Gaia DR2 also provides radial velocities for over 7.2 million stars, allowing us to compute 3D space velocities of stars and study kinematics of stellar populations. Of particular interest is the dispersion in the peculiar velocities (UVW velocities wrt the LSR) of stars, which is known to increase with age and is often used as a proxy for stellar age. We studied the kinematics of planet-hosting stars in the solar neighborhood (within 250 pc from the Sun) using Gaia DR2. Our analysis indicates that the velocity dispersion of stars hosting gas giants, on average, is lower than that for stars hosting smaller planets, suggesting that Jupiter-hosting stars are relatively younger. If confirmed, our results would provide a natural explanation for the observed dependence of planet mass on the host star metallicity and spectral type.

6 November 2020 (Friday)

Time: **14:00 – 14:40**
Speaker: Xavier Luri (University of Barcelona)
Title: **(Data)Mining the sky: Gaia EDR3 and the era of large surveys**
Abstract: In this talk I will present the early third release of Gaia data, scheduled for the 3rd of December 2020. The new dataset (see https://www.cosmos.esa.int/web/gaia/earlydr3) will bring several significant improvements with respect to Gaia DR2. Among other things: A factor 20% improvement in the parallax uncertainties A factor of 2 reduction of the uncertainty in the proper motions A new transit cross-match that provides a significant improvement in crowded areas and increases completeness 33 months of data significantly reduce the scanning law effects observed in Gaia DR2 when computing means and medians of parallaxes and proper motions Improved photometry with reduced uncertainties and systematics Besides these improvements, EDR3 will further increase the number of sources in the catalogue, almost reaching 1.7 billion (from 1.1 billion in DR2). These numbers make the full exploitation of the Gaia catalogue a challenging task, requiring the use of advanced analysis and computing techniques: it is a “Big Data” problem. In recent years it has become very common to hear statements on how Big Data, the availability of very large datasets, is revolutionising science. It is applicable to a wide variety of areas, but it is often forgotten that the breakthroughs achieved with these data do not only come from its volume, but specially from the capability to do meaningful data analysis with them. This capability requires the large processing capability of computers but also, and more critically, a proper understanding of the statistical properties of these samples and the ability to design statistical analysis tools to extract knowledge from the data. This is especially crucial in the case of Gaia and in this talk I will also discuss the challenges faced by the astronomical community to fully exploit its scientific potential. These challenges range from the basic need to understand the properties of the data (data censorships, variable transformation, random errors, systematics) to the design and implementation of analysis tools appropriate to handle them.

Time: **14:40 - 15:00**
Speaker: Kaushal Sharma (Aryabhatta Research Institute of Observational Sciences)
Title: **Galactic Astronomy using Artificial Intelligence: Exploring the Gaia Data**
Abstract: Astronomical surveys hold the key information to uncover the physical laws and patterns in the universe. But the task becomes challenging if the positional and kinematical information is missing for different galactic components. The Gaia mission, a successor of the Hipparcos satellite, complements other studies and surveys by providing this crucial piece of information along with other astrophysical properties such as effective temperature, surface gravity, metallicity, etc. Besides using the Gaia science products for various targeted studies, a huge amount of information remains hidden due to the unimaginably large volumes of data. The sheer volume of this data requires non-traditional approaches for efficient handling and precision measurements as good as obtained with the traditional methods. In the past two decades, Artificial Intelligence/Machine Learning (AI/ML)

techniques have been considered for this role, and they have displayed promising results for various galactic studies related to its structure, formation, and evolution. The talk will highlight the potential of ML methods through different science cases using the Gaia data and the advancements in the AI domain that are expected to help in achieving the mission goals with the existing and upcoming data releases.

Time: **15:00 - 15:15**

Speaker: Vikrant Jadhav (Indian Institute of Astrophysics)

Co-authors: Clara M. Pennock, Annapurni Subramaniam, Ram Sagar and Prasanta Kumar Nayak

Title: **Machine learning based cluster membership using Gaia DR2 astrometry**

Abstract: Traditionally, the spatial location, space velocities and colour-magnitude diagram are used to find cluster members. We present a novel supervised machine learning technique (using probabilistic random forest) to determine cluster membership and demonstrate it in six open clusters. We created and tested more than 22 feature-combinations using Gaia DR2 astrometric, photometric and statistical data. The stars are classified as members, candidates and field stars using two such combinations. Multiple such features-combinations can also be used to detect stars with peculiar colour-magnitude diagram locations. The generic method works in clusters of various stellar densities, age and reddening and is ready to be applied on Gaia EDR3.