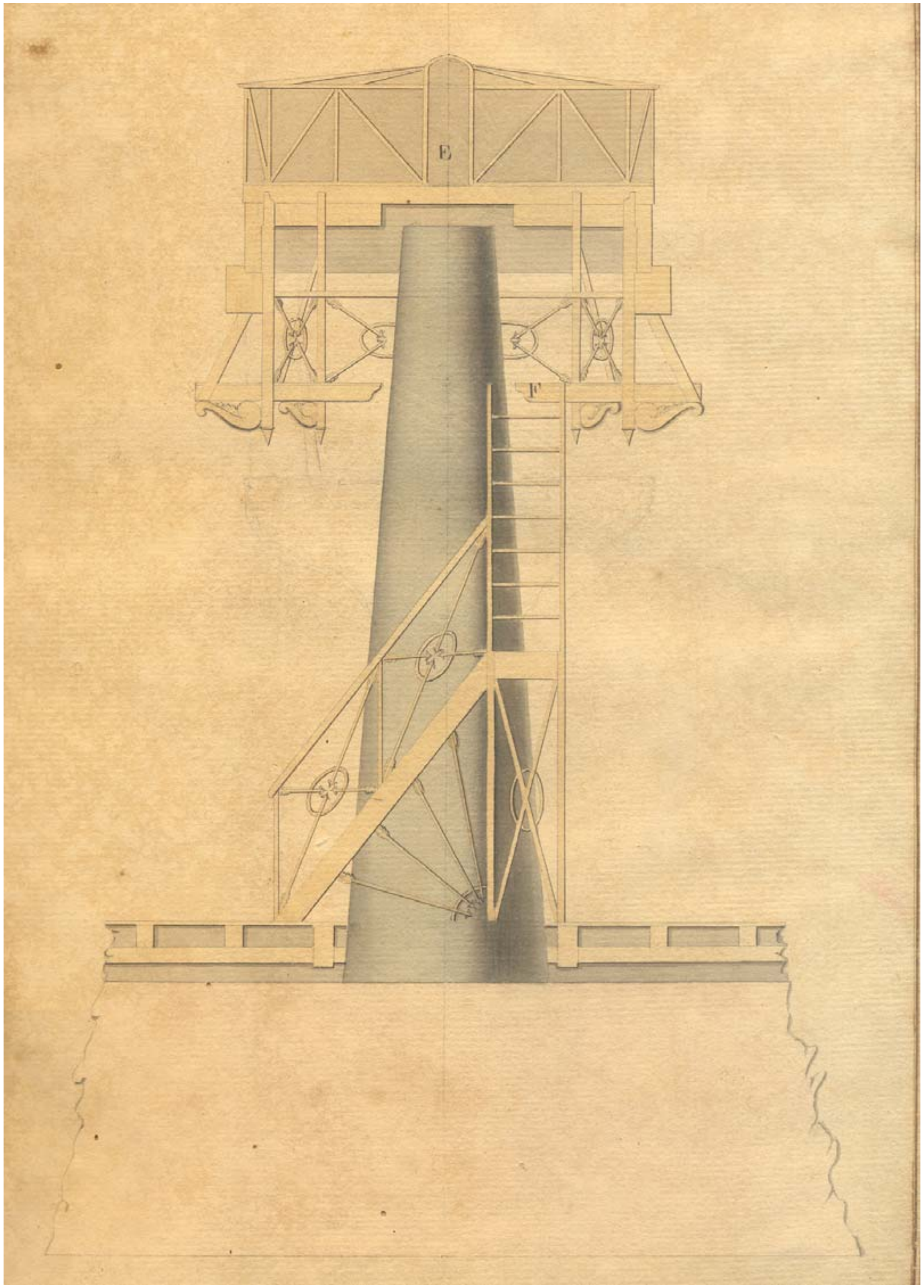


ASTRONOMY FROM IIA ARCHIEVES

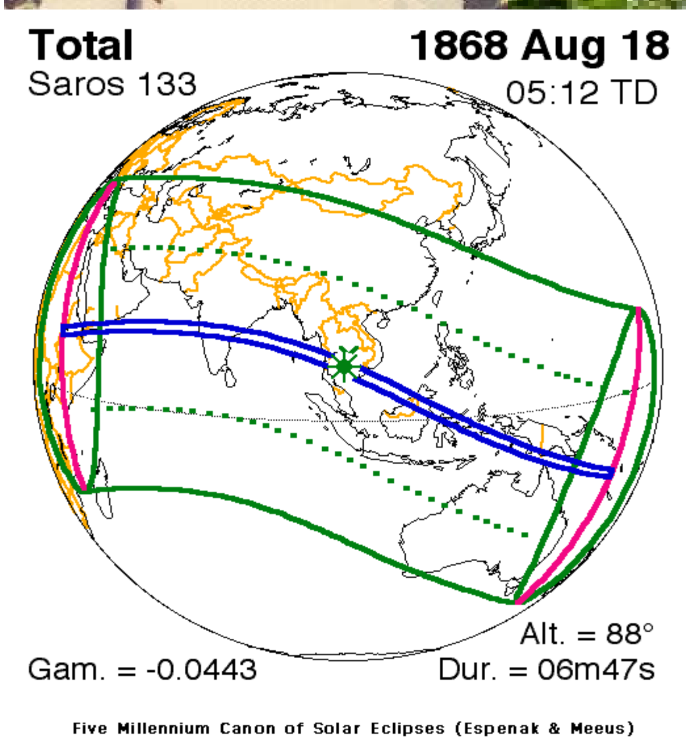
N.Kameswara Rao

Indian Institute of Astrophysics

Bangalore 560034

18 ft Granite pillar with an inscription in four languages dedicating the effort to the advancement of the science of Astronomy by East India Company

- Discovery of Helium
- Evershed and Solar Gravitational Redshift
- Comet 1882

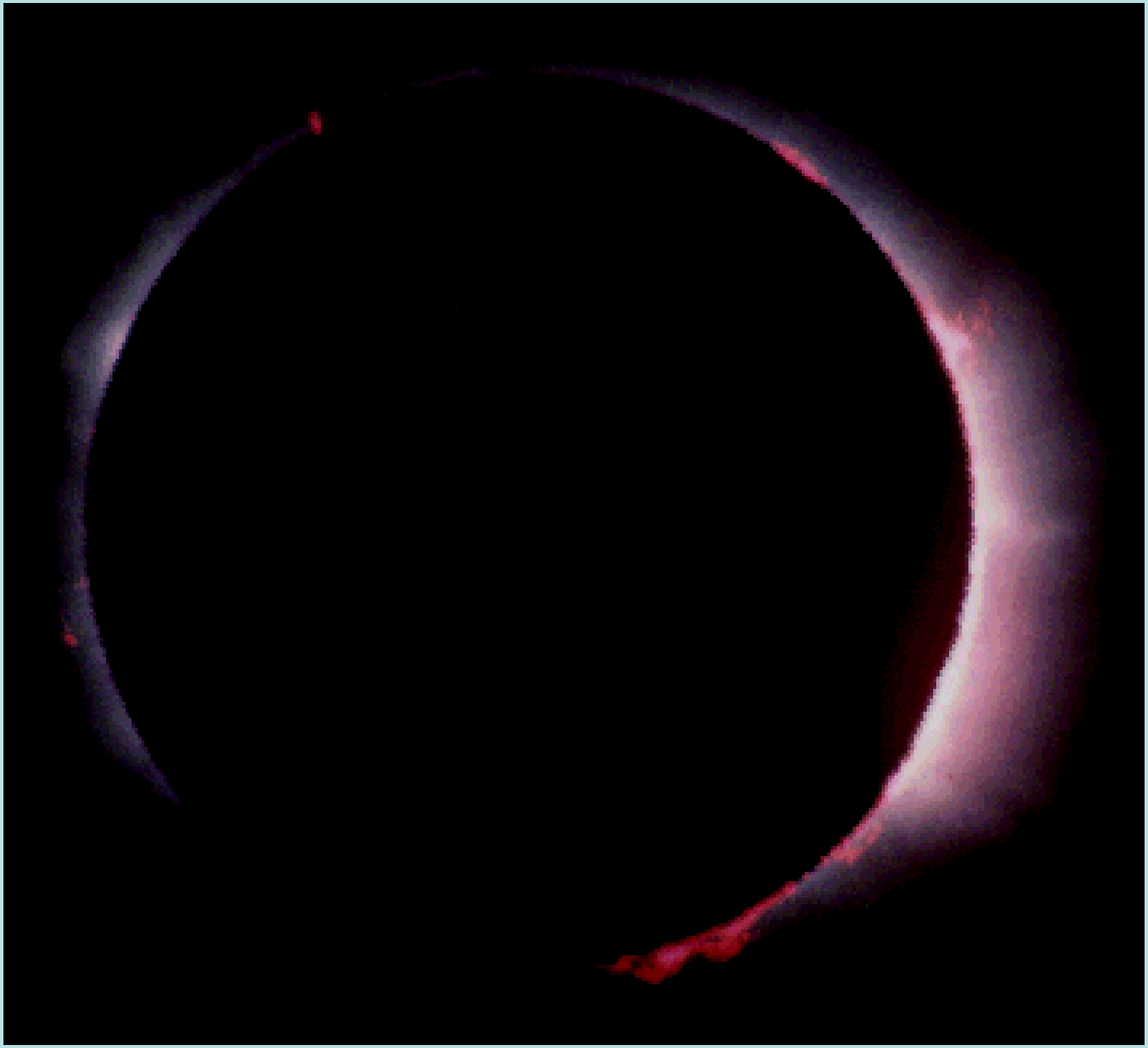

Total
Saros 133
1868 Aug 18
05:12 TD
Alt. = 88°
Gam. = -0.0443
Dur. = 06m47s
Five Millennium Canon of Solar Eclipses (Espenak & Meeus)


Solar physics is born on the tobacco fields of Guntur
- MKV Bappu

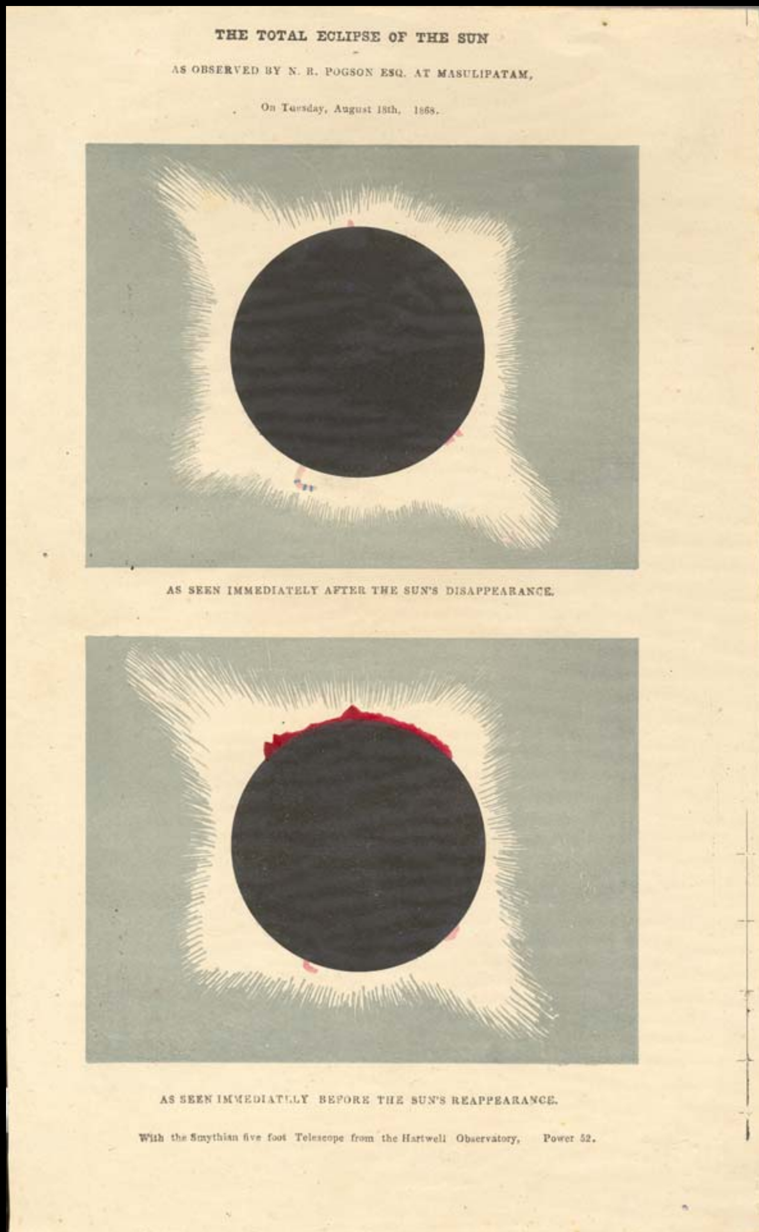
NORMAN ROBERT POGSON 1861-1891

In 1861, N. R. Pogson was appointed the government astronomer at Madras, India. When he arrived he had to work under harsh conditions. He found the instruments in a bad shape and there were no proper staff to assist him. In spite of all these he began a series of observations which terminated with his death 30 year later. He was credited with 50,000 observations most of which were published by Michie Smith after Pogsons death. During his stay in Madras he discovered several minor planets and detected large number of variable stars. He named his daughters after the minor planets he discovered. He was also well known for his work in comets and solar eclipses

Solar Eclipse Observations from Baikal -Tamilnadu

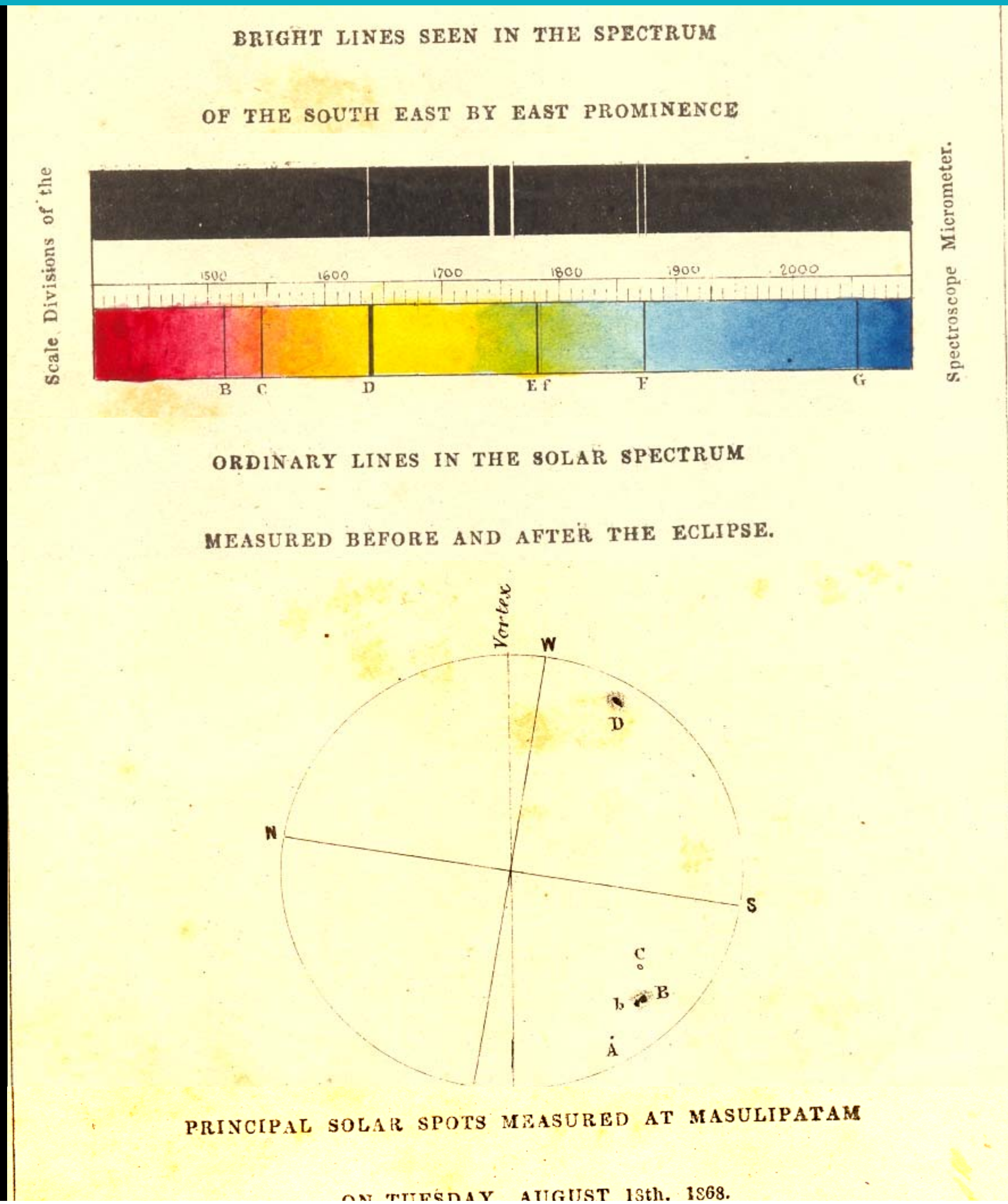


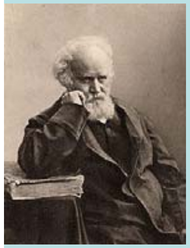
- The main question in 1868 was –
- What is the nature of red protuberances called Prominences



Hand-sketched picture of the sun during the total solar eclipse of 1868. Pogson painted the prominences he observed in red colour

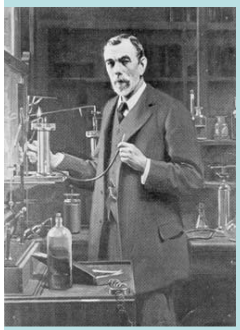
Detection of Helium





Pierre Jules Janssen: 1824-1907

Sir Joseph Norman Lockyer: 1836-1920



Sir William Ramsay: 1852-1916

cleveite

Lord Rutherford: 1871-1937

1868: A bright yellow line at 587.49nm in the spectrum of the chromosphere of the Sun

1868: A yellow line in the solar spectrum, labelled D3,, concluded it was caused by an element unknown on earth and labeled it: ηλιος (*helios*).

1895: Isolated helium by treating cleveite with mineral acids.

Actually looking for argon, but after removing N and O noticed a bright-yellow line that matched the D3 line seen in the Sun.

> Cleveite is an impure variety of uraninite. It has the composition UO2 with about 10% of the uranium substituted by rare earth elements. Helium is created by the alpha radiation of the uranium which is trapped (occluded) within the mineral

1907: Identifies alpha particle with He++ nucleus

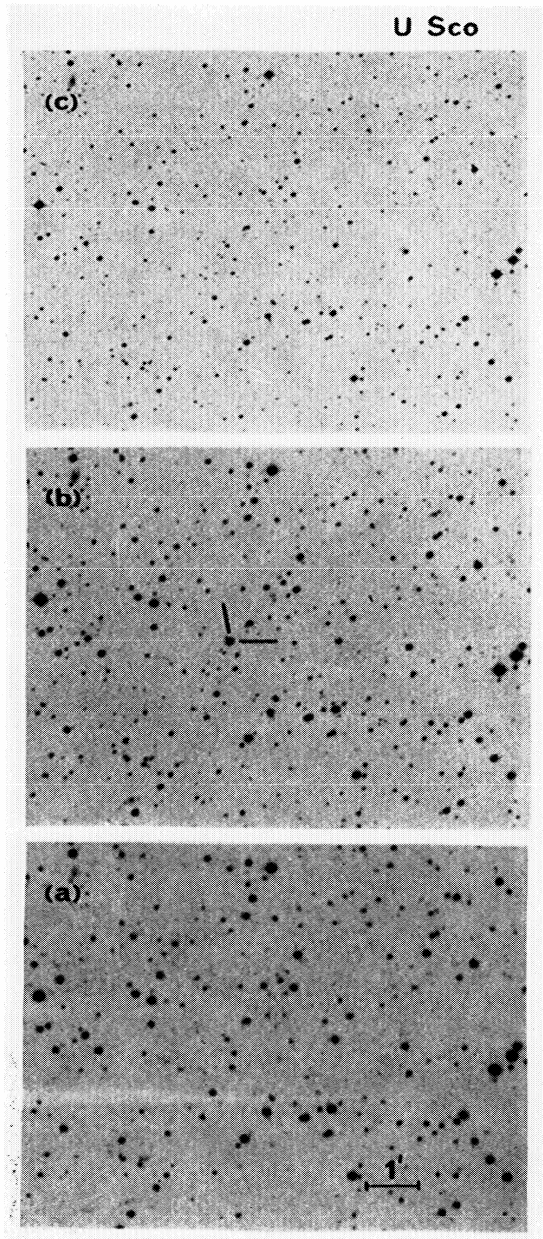


Plate 1. The field of U Sco. North is to the top and east to the left. The scale is shown. (a) is the Palomar O plate taken when U Sco was in quiescence, (b) is UKSTUIIIaJ 5177 taken on 1979 July 14, U Sco has $m_v = 15$ and is marked and (c) is UKSTUIIIaJ 5279 taken on 1979 August 15, when U Sco had almost returned to its quiescent level.

[facing page 64]

The Variable star (recurrent novae) discovered by Pogson in 1863

Again observed in 1979 July 14 in outburst

Importance of Archievel Observations

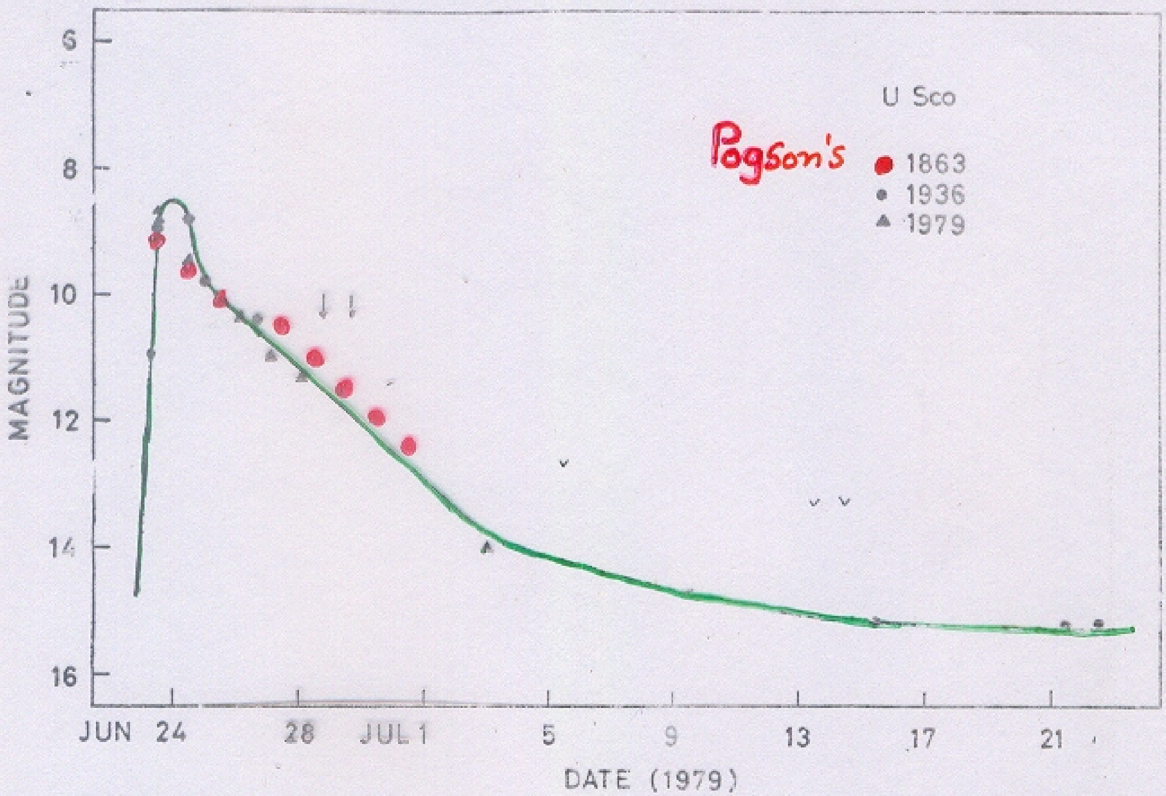


Fig. 1 The light curve of U Sco. Open circles are Pogson's observations of 1863 outburst. The V marks are Pogson's upper limits. Closed circles are the Harvard observations of the 1936 outburst. The filled circles are the visual estimates of the 1979 outburst published in the IAU Circulars. The abscissae are the dates of the present outburst while the observations of the previous outbursts are shifted to match the light curve. The arrows indicate the times of our spectrophotometric observations.

Pogson's observations plotted along the later observations during the outburst.

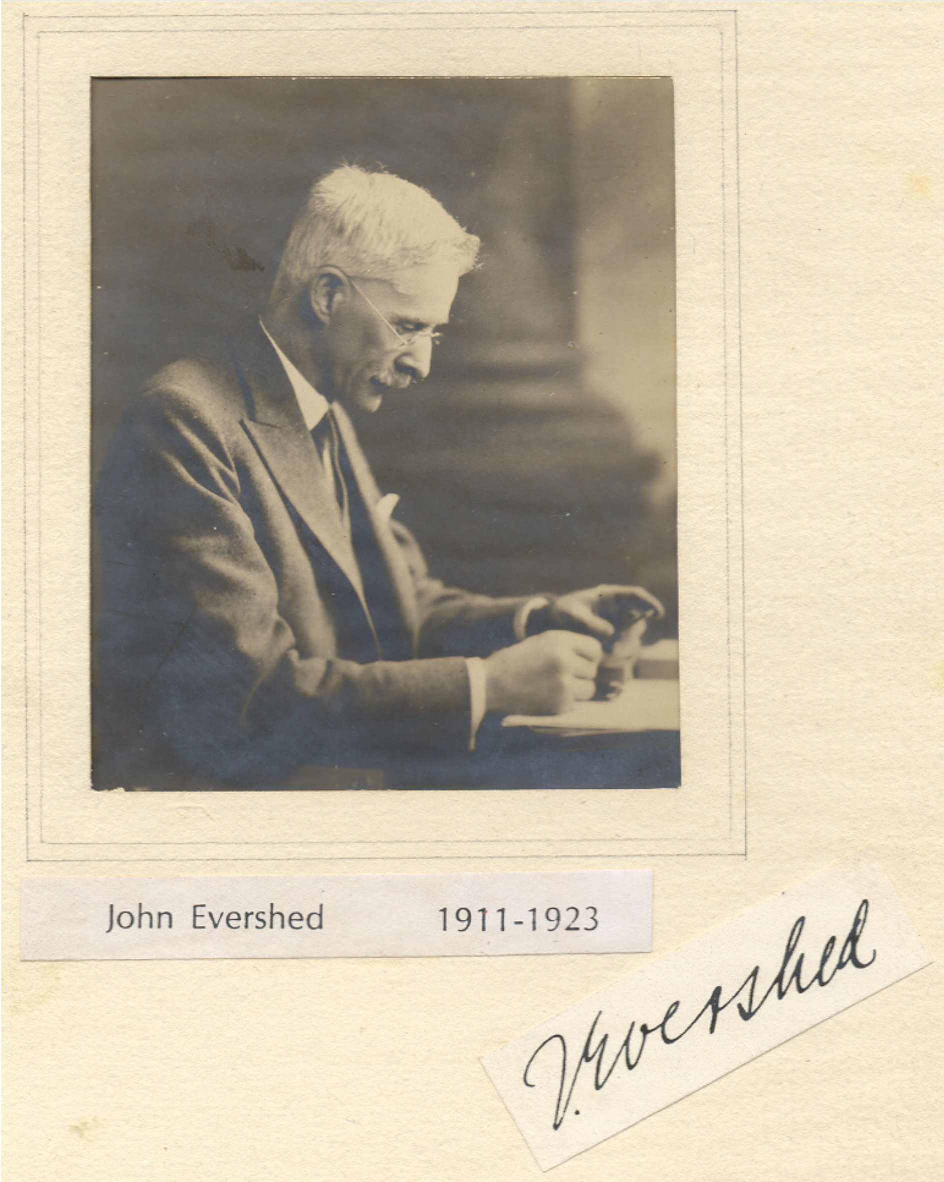
Kodaikanal Observatory with 8-inch and 6 – inch telescope domes

Einstein published his general theory of relativity in 1915,

- during days of first world war.
- It contained three predictions, all astronomical in nature.

- one of them explained a long-standing anomaly in Mercury's
- measured orbit .

- The other two were a shift toward the red of spectral lines emitted by
- large gravitating bodies;
- and the bending of path of light in a
- gravitational field, observable an outward displacement of stars in the
- vicinity of the eclipsed Sun. ..
- After the war ended, British astronomers (Eddington) verified the light-bending prediction in the 1919 may total solar eclipse.
- Within a few years astronomers showed that the third effect exists in the Sun;
- and in 1925 astronomers invoked the effect to prove the existance of
- incredibly dense stars called white dwarfs.



- Evershed (assisted by Narayan Iyer and Royds) was engaged from 1917 -23 in determining the gravitational redshift of spectral lines on sun disc (centre and limb)
- He devised several new techniques of measuring accurate spectral line positions (radial velocities)

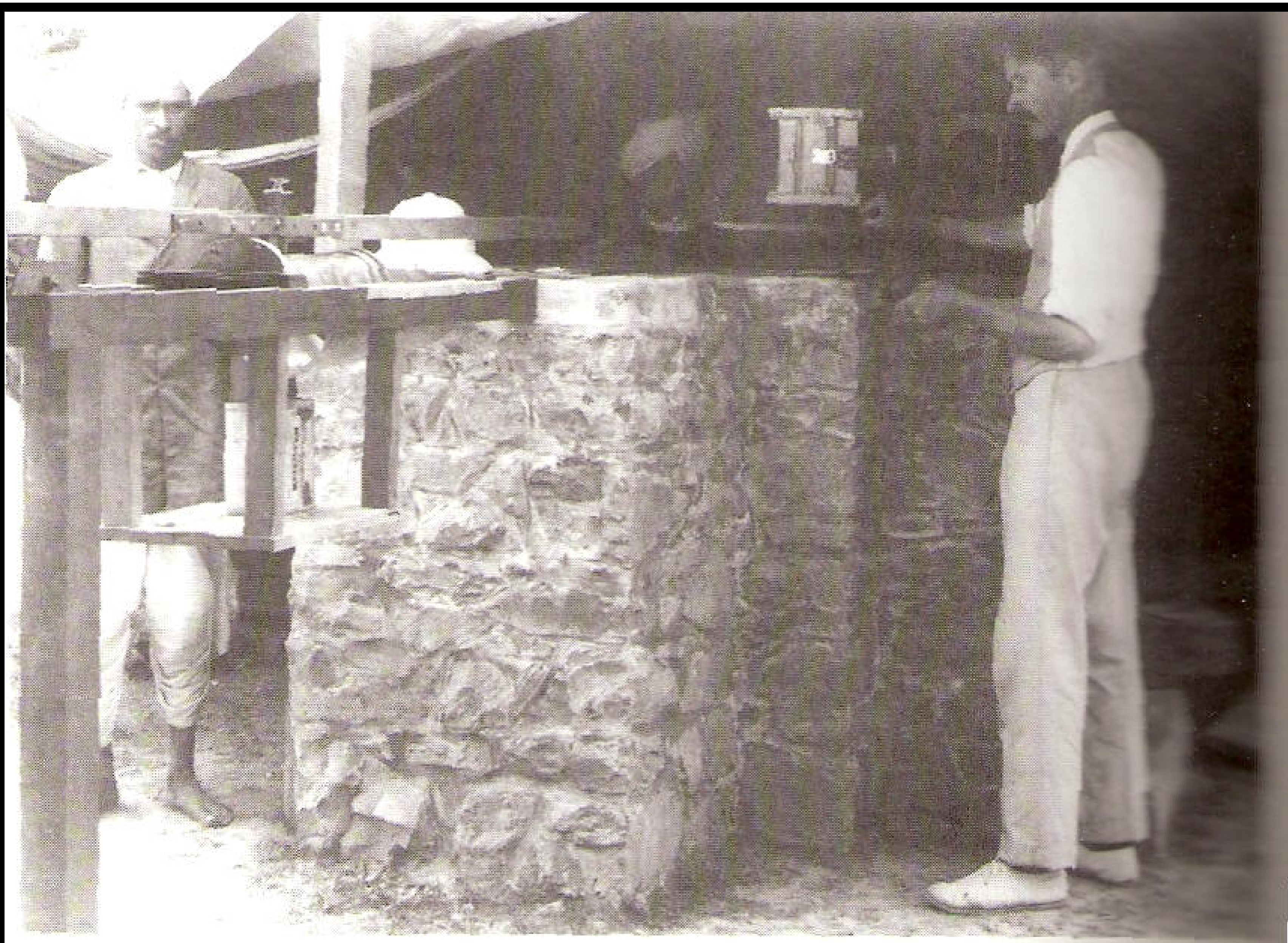
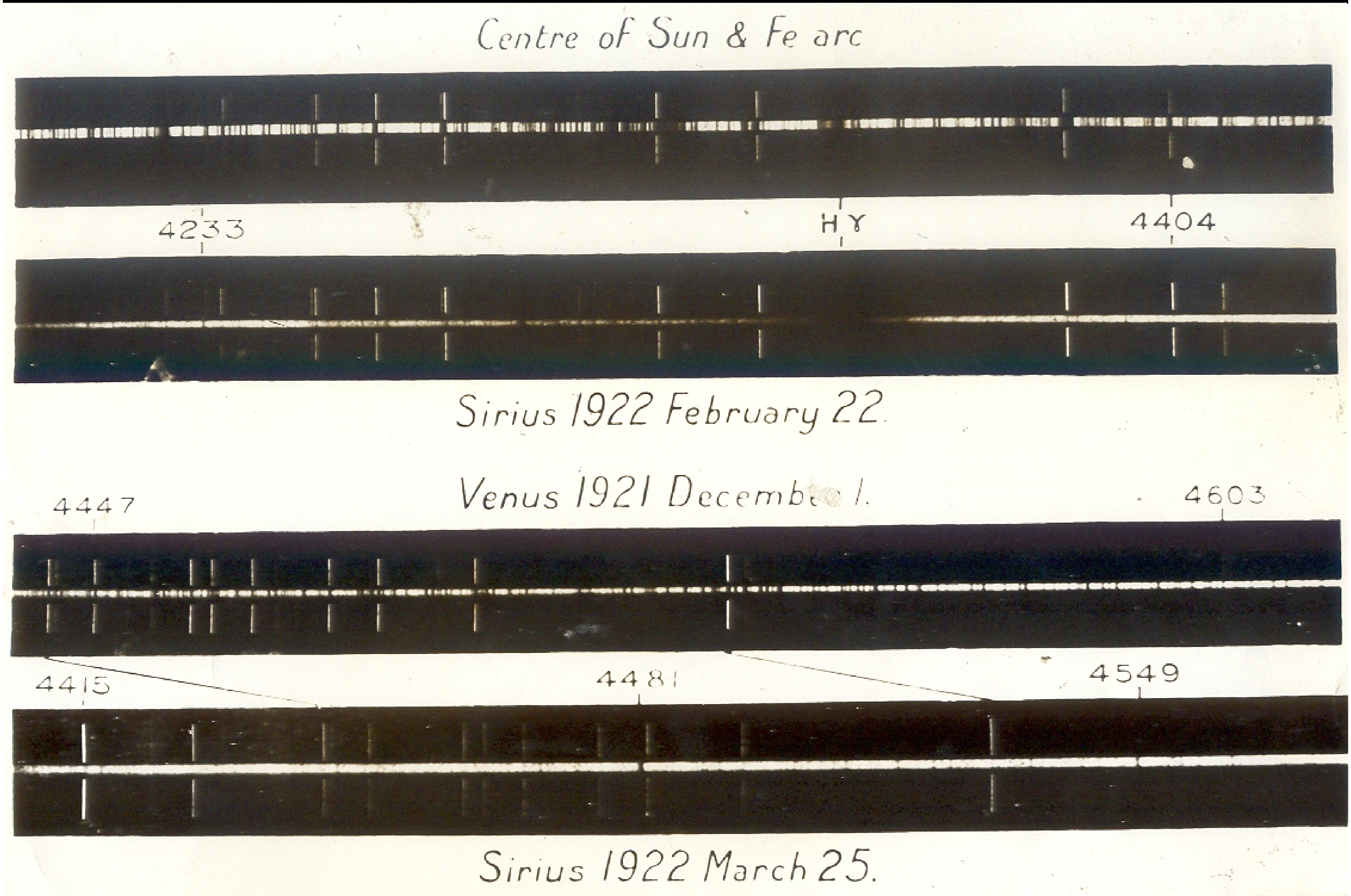
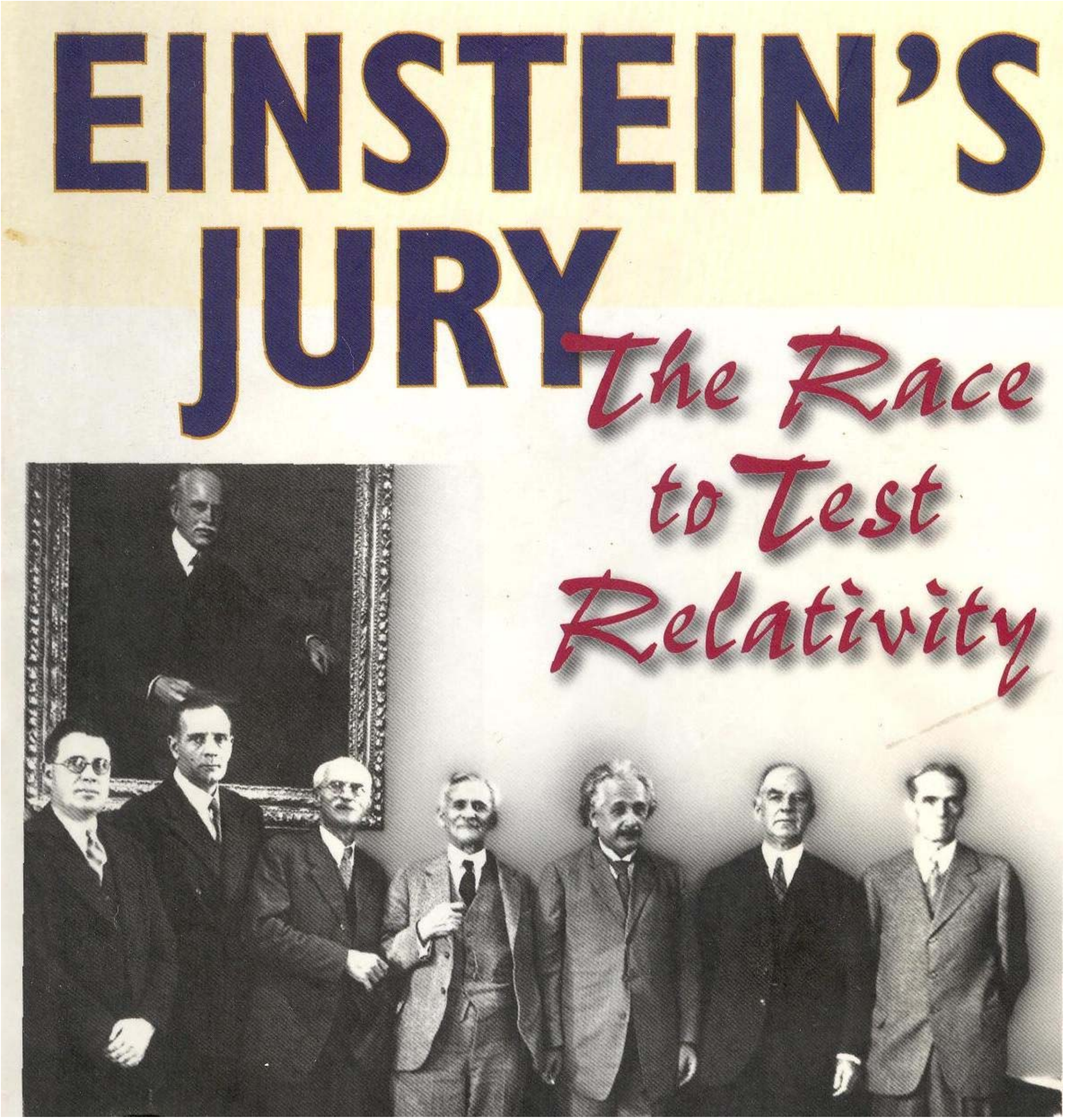


Figure 3.9. John Evershed at Kodaikanal Observatory in India, ca. 1909. [illegible]
director from 1911 to 1923. (Courtesy Indian Institute of Astrophysics [illegible]



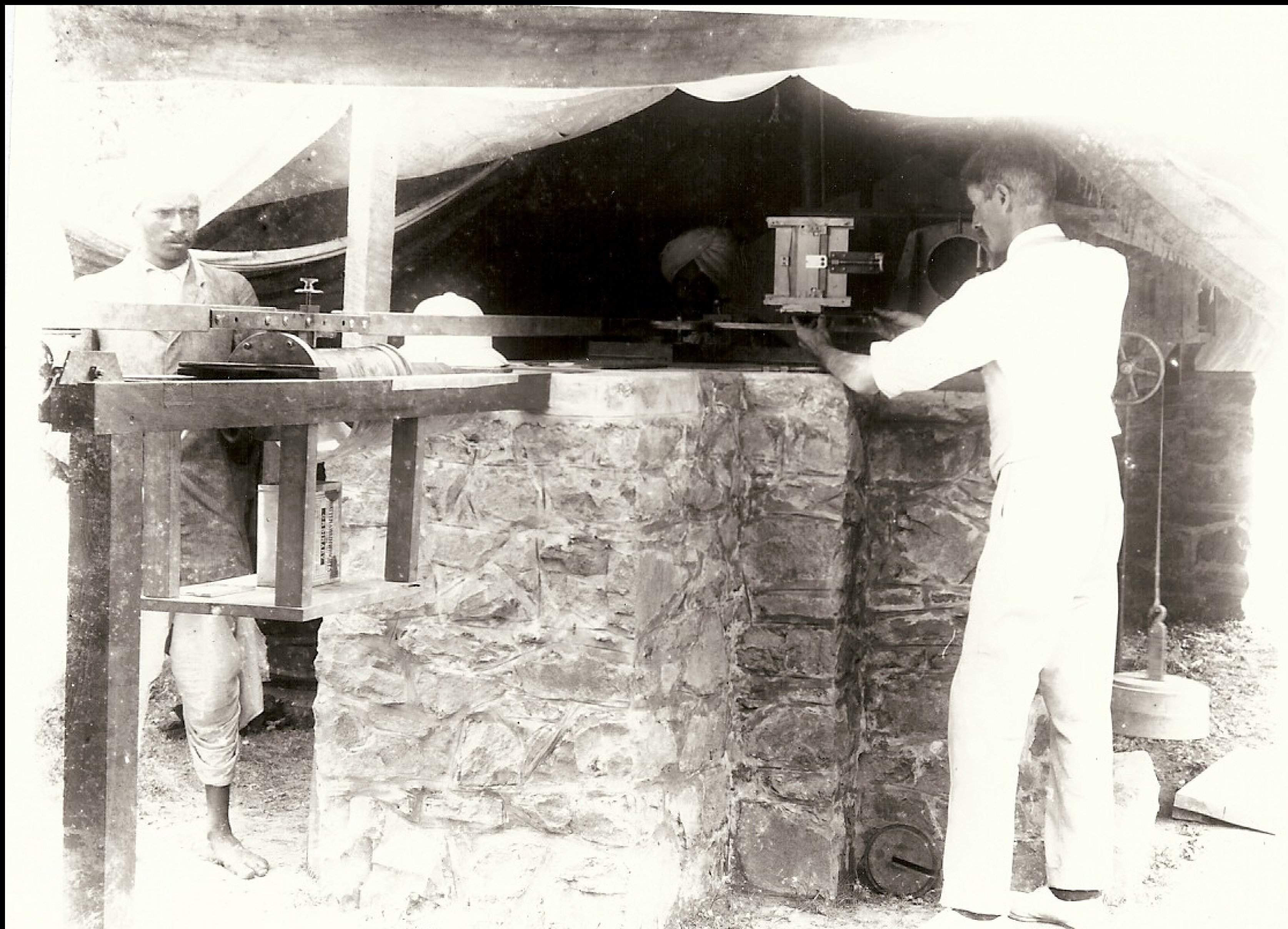
Centre of Sun & Fe arc
4233
H γ
4404
Sirius 1922 February 22.
Venus 1921 Decemb 1.
4447
4603
4415
4481
4549
Sirius 1922 March 25.

Jeffrey Crelinsten



Evershed declared finally in 1923

`Reviewing the evidence as a whole, there seem to be very little doubt that the Einstein effect is present in the solar spectrum .'



Eddigton's letter to Evershed -1937 Sept

OBSERVATORY
CAMBRIDGE

1937 Sept 12

Dear Mr Evershed

Since your paper 18 months ago I have thought a good deal about the factor 2 and the red-shift. I think that in the last few weeks I have begun to see the ~~factor~~ problem clearly; and I am now more or less convinced that Einstein's theory is wrong on this point, and the true ~~red~~ theoretical red-shift is twice his value as you find. It is an important matter; and I have got to think it over a bit more. Meanwhile you may be interested to know this; and I should, of course, like to know of any further ~~obser~~ developments on the observational side. I understand that Royds confirmed the double value at the eclipse; but I do not know how reliable his results are.

Yours sincerely

A.S. Eddington

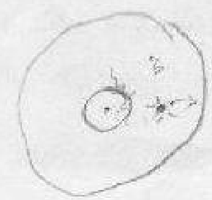
⊙	limb
013	006
12	5
14	15
13	8
10	13
13	17
10	14
12	14
13	13
14	15
	10
	12
	12
	12
	14
	15
	15

0124 ± 0003

01247

17)210(124
17
40
34
60
68

⊙ 0133



Evershed's letter to Eddignton - 1937 Sept

Sept. 15, 1937.

Dear Sir Arthur Eddington,

Thank you for telling me about your work on the red shift, and that you think after all a factor of 2 is required.

Your letter prompts me to make renewed attempts to get reliable values for the shifts. It is a difficult business, owing to the turbulence of the Sun. Royds' results from the eclipse spectra I think can be trusted as far as they go, which is not very far: what they really mean is that our previous measures in the particular region he photographed are very little affected by scattered skylight. We schemed the work thinking that eclipse spectra might give larger values of the limb shift, but apparently they agree well with measures made in ordinary sunlight, and give values when corrected for one atmosphere pressure in the arc varying from about 1.5 to 1.9 times the Einstein shift. I think more eclipse spectra should be obtained at large partial or annular eclipses as well as total ones.

My latest results here seem to show that the sodium D lines differ from the calcium and iron lines in giving smaller limb shifts. I get the following values: -

D_1 only (D_2 is affected by WV line on red edge)

	A
Centre of Sun	+ .0124 ± 0003
Limb of Sun	+ .0137 ± 0003
Einstein shift D_1	+ .01247

The D lines are very sensitive to pressure, and I have in this assumed that there is no pressure shift in the vacuum tube comparison spectra; but when the tube is hot, much sodium must evaporate and increase the pressure. It is possible therefore that a plus correction may have to be applied to the above.

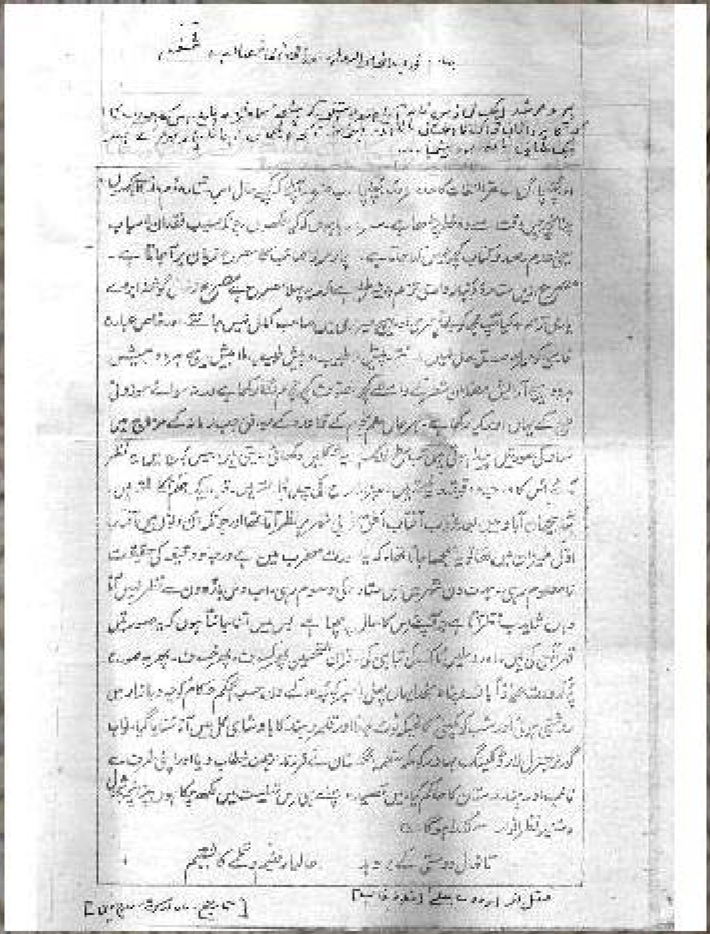
Yours sincerely,

J.E.

- Comets

Letter from H.A Sayed (sholapur Sept 2006)

Mirza Ghalib ----



Mirza Ghalib's letter to Nawab Anwar-ul-Daula 'shafaq'
((translated by Sri Mohan Lal Azad)

`.. Now I thought it my bounden duty to express my views about `the comet (dhum tara)' referred to …. I am in a fix as to what to write as nothing for sure could be said on this count ..

… In Shahjehanabad, after the sun set, it appeared on the horizon. As was the practice in those days, the Sun was looked upon as the `prime object', Comet's position and timings of its appearance were not given precedence, thus were ignored…

… For several days the Comet was the topic of talk amongst the city-dwellers. The Comet has not been visible for the last 10 – 12 days. …'

Comet Donati (1858)

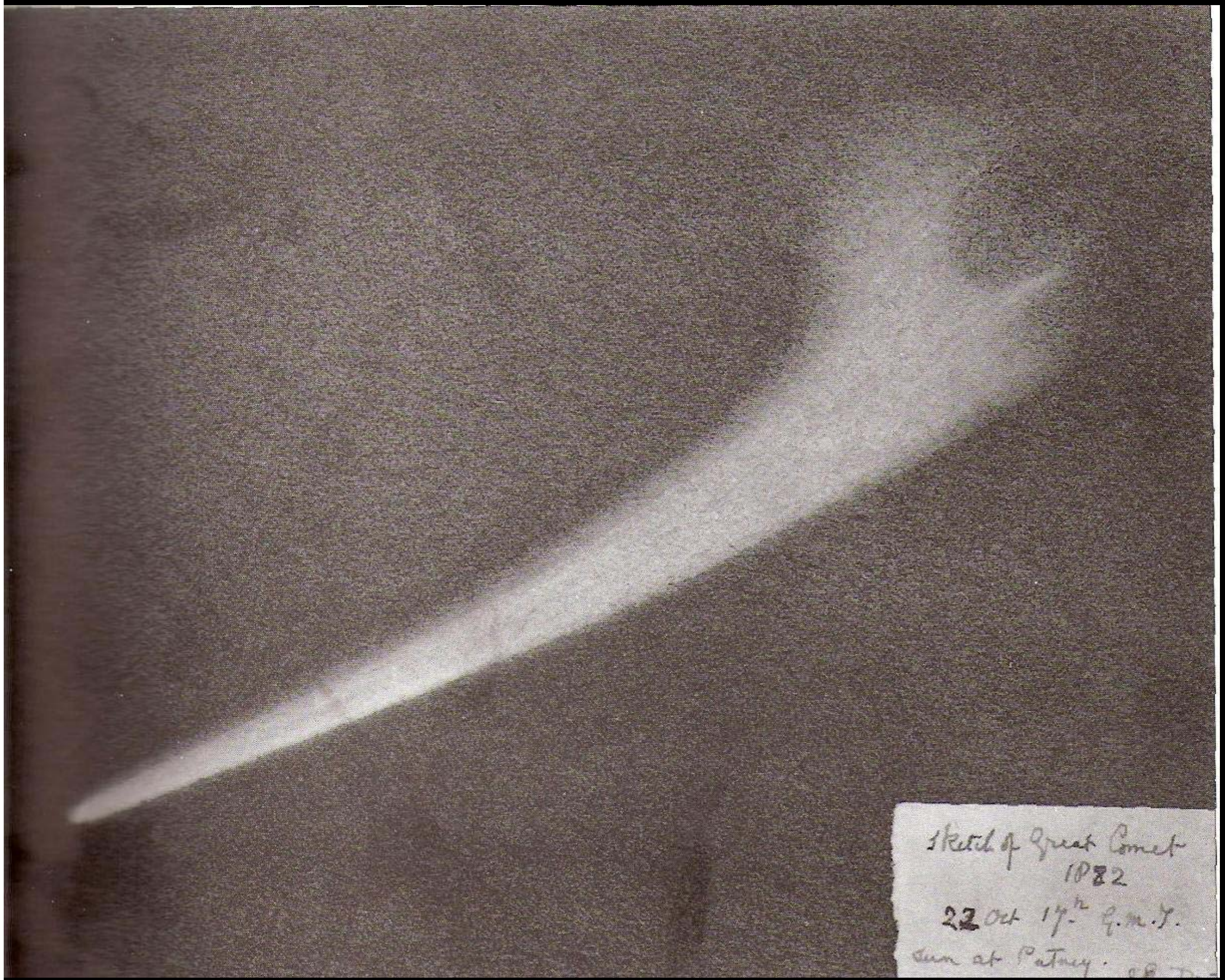
- painting from the book `Fire in the Sky'

Figure 131. Anonymous, *Victorian transparency of Donati's Comet over Balliol College and Trinity College, Oxford, near the Star Arcturus, 5 October 1858*, watercolor with pen and black ink, 197 × 280 mm, Maas Gallery, London.

- Donati's comet
- -5 Oct 1858 Oxford

THE GREAT SEPTEMBER COMET OF 1882 II(C\1882 R1) THAT TRANSITED OVER THE SUN - POGSON'S OBSERVATIONS FROM MADRAS OBSERVATORY

A drawing of the great comet of 1882 by John Brett Putney, UK



The huge post perihelion tail was `concave towards south and shaped like a tusk of an elephant. Observing the comet with the naked eye, at the seaside the whole tail took an hour to rise'

exclaimed Nursing Row (1883) from Vizag in 1882 October 7.

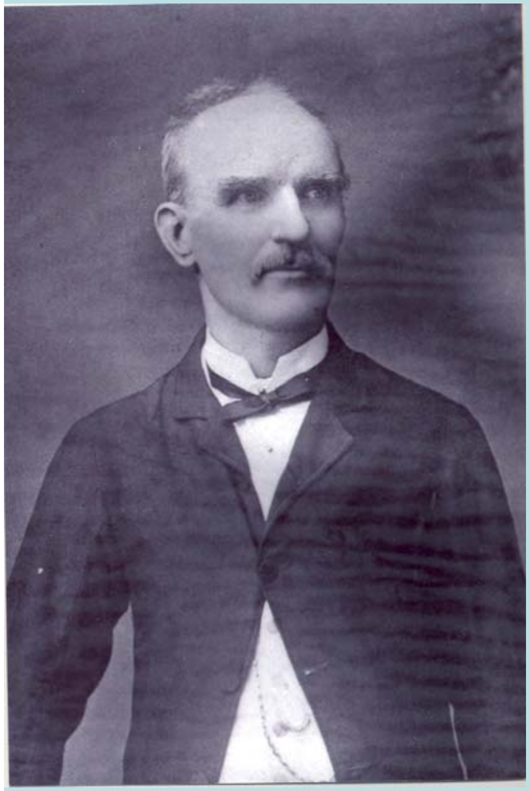
- The great comet of 1882 (designated as C\1882 R1) was one of the most brilliant sun grazing comets of nineteenth century that launched a major astronomical project `Carte du ciel' of photographing the sky (Gingerich 1992, Ashbroock 1961).

- The comet had many firsts to its credit: one of them being that display of anti- tail (or sun-ward tail) for the first time.

- Ashbrook(1961) comments it appeared several decades too soon for its unusual phenomena to be studied with modern techniques.

- The comet was independently discovered by several observers in the southern hemisphere. The perihelion was on 17th September when the conjunction with the sun happened (comet was at a distance of 305,000 miles from the sun's surface). Elkin (1883) described the event in great detail ` I actually observed it to disappear among the undulations of the sun's limb.

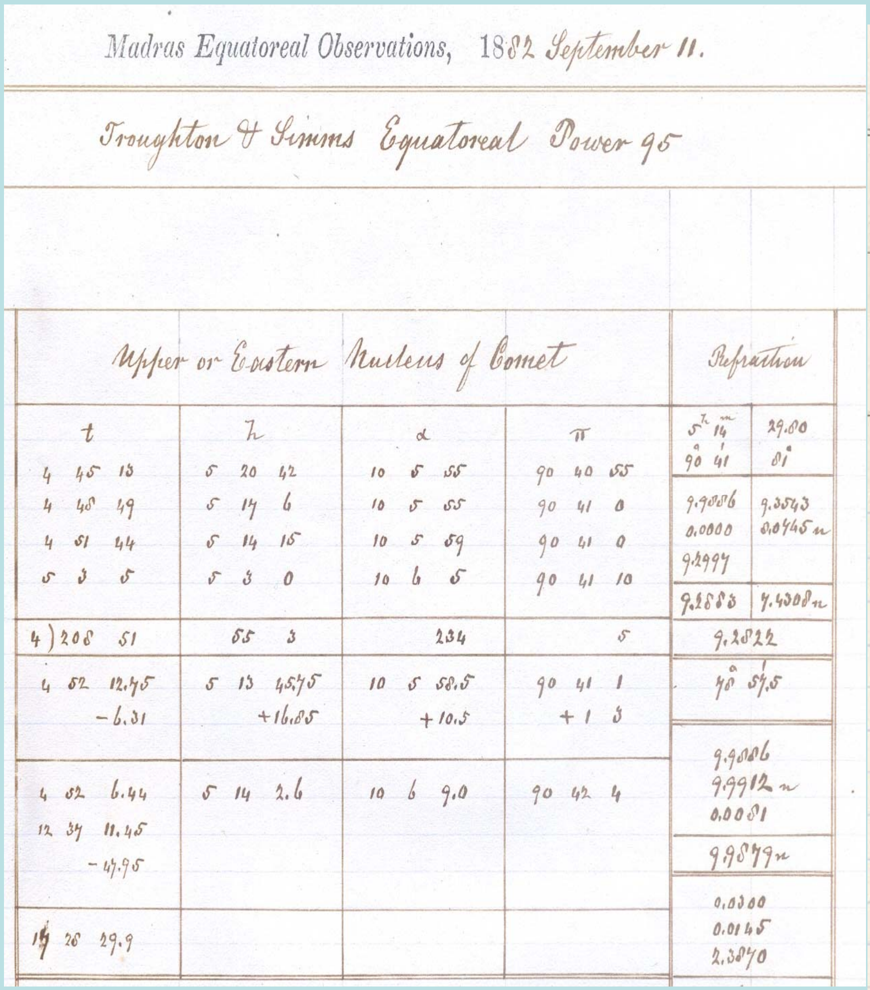
First Comet to be photographed



Madras Observations: The Madras observations were started by N.R.Pogson , then Director of Madras Observatory, quite early, even before perihelion on 11th September1882. N.R Pogson was a well known observer, who established the magnitude scale. He has observed several comets earlier and the famous one being the rediscovery or recovery of the lost comet of Biela in 1872 (Pogson 1872).

Madras Observatory during 1860-1890

- Pogson used the 8-inch Troughton and Simms telescope for his observati-ons.
- He started observing (may be independently) and measured the position of
- `Upper or Eastern Nucleus' of the comet. Although no detailed account of the
- observations are available the above statement suggests that he observed more
- than one nucleus (lower or western).He measured positions of the upper or
- eastern nucleus from 11 September onwards when ever the sky permitted him
- using several comparison stars.

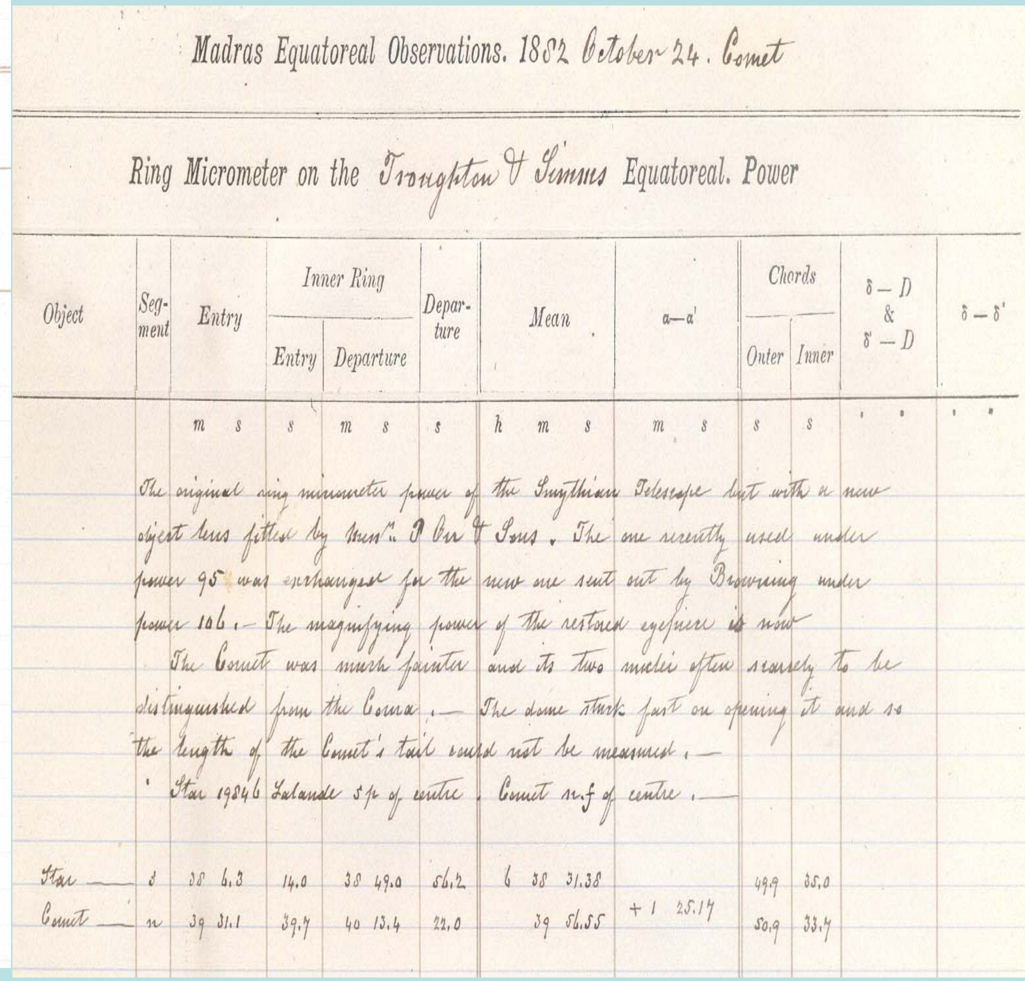


Madras Equatoreal Observations, 1882 September 11.

Troughton & Simms Equatoreal Power 95

Upper or Eastern Nucleus of Comet

t	h	α	π	Refraction	
				5h 14m / 90° 41'	29.80 / 81°
4 45 13	5 20 42	10 5 55	90 40 55		
4 48 49	5 17 6	10 5 55	90 41 0	9.9886	9.3543
4 51 44	5 14 15	10 5 59	90 41 0	0.0000	8.0445 n
5 3 5	5 3 0	10 6 5	90 41 10	9.2997	
				9.2883	7.4308 n
4) 208 51	55 3	234	5	9.2822	
4 52 12.75	5 13 45.75	10 5 58.5	90 41 1	78° 57.5'	
− 6.31	+ 16.85	+ 10.5	+ 1 3		
4 52 6.44	5 14 2.6	10 6 9.0	90 42 4	9.9886 / 9.9912 n / 0.0081	
12 37 11.45				9.9879 n	
− 47.95					
17 26 29.9				0.0300 / 0.0145 / 2.3870	



Madras Equatoreal Observations. 1882 October 24. Comet

Ring Micrometer on the Troughton & Simms Equatoreal. Power

Object	Segment	Entry	Inner Ring Entry	Inner Ring Departure	Departure	Mean	α − α'	Chords Outer	Chords Inner	δ − D & δ' − D	δ − δ'
		m s	s	m s	s	h m s	m s	s	s	' "	' "
Star	3	38 6.3	14.0	38 49.0	56.2	6 38 31.38		49.9	35.0		
Comet	n	39 31.1	39.7	40 13.4	22.0	39 56.55	+ 1 25.17	50.9	33.7		

The original ring micrometer power of the Smythian Telescope but with a new object lens fitted by Messrs. P Orr & Sons. The one recently used under power 95 was exchanged for the new one sent out by Browning under power 106. — The magnifying power of the restored eyepiece is now

The Comet was much fainter and its two nuclei often scarcely to be distinguished from the Coma. — The dome stuck fast on opening it and so the length of the Comet's tail could not be measured. —

Star 1984 6 Lalande s.p. of centre. Comet n.f. of centre. —

The observations cover up to November 1st.

On October 24th he comments that the comet was much fainter and its

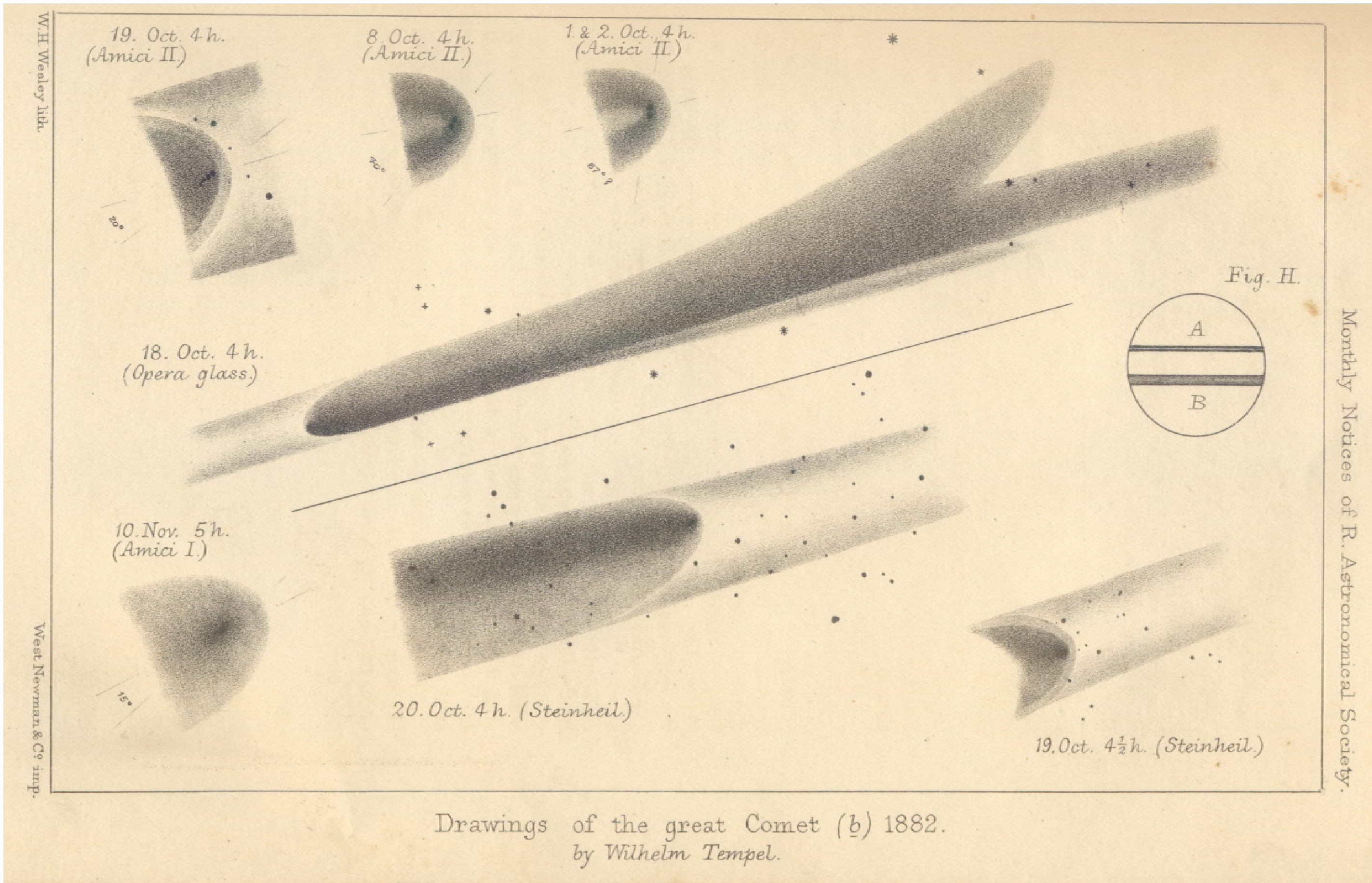
`two nuclei often scarcely to be distinguished from the Coma and the dome stuck fast on opening it and the length of comet's tail could not be measured'.

He clearly saw two nuclei. The observations stopped after November 1st. It was known that some comets split after perihelion. Biela's comet , a periodic comet of 6.6 yrs was single before 1846 but split nto two after perihelion passage in 1846. On its return in 1852 the fragments appeared as twin comets and disappeared all together in later years.

The Puzzle

- Pogson's records suggest that the Great comet 1882 II had split even before perihelion. However David Gill of the Cape Observatory strongly asserts that it is not the case (Gill 1883).
- Writing in MNRAS Gill states ` In reply to the question which you ask on behalf of the society viz. whether before perihelion the Great Comet of 1882 showed a duplex or compound nucleus, the observations recorded by Mr. Finlay and Dr. Elkin on September 7 and 8 and printed in Monthly Notices prove clearly that no duplicity could be detected with our optical means on these dates. Dr. Elkin describes the nucleus as sharp, well defined disk 10" or 15" in diameter as strongly condensed in the centre'

..`A short glimpse I obtained confirmed the view. weather was unfavorable till 17th, the day on which the disappearance of the comet on the sun's limb has been noted.

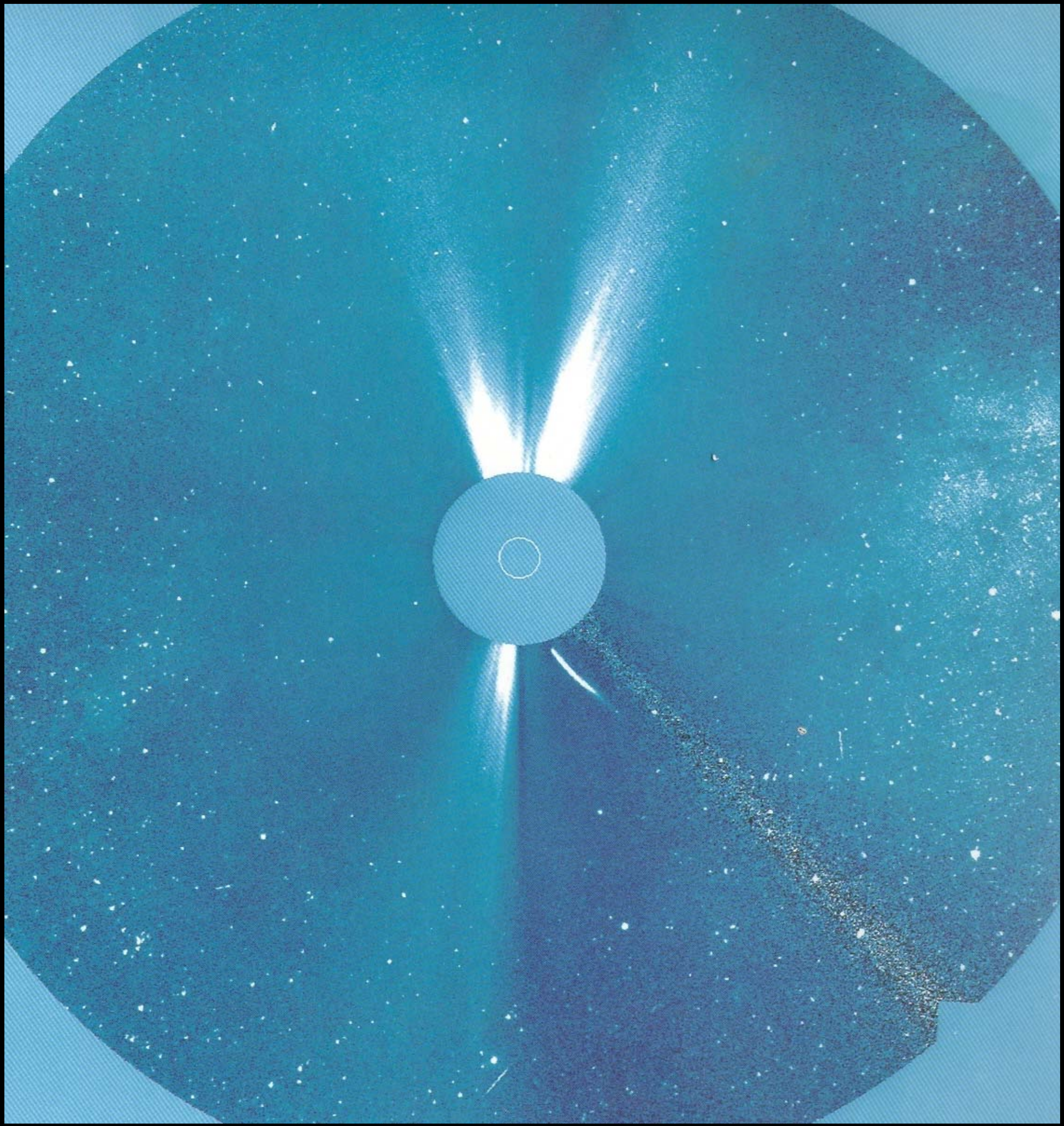


Gill asserts that till September 28th (inclusive) the nucleus was single. However on September 30th the nucleus is seen to be split. It was remarked by Finlay `there seems to be two balls of light in the head '(of the comet). Drawings by Temple (1883) do show two bright nuclei on 1st and 2nd October. Several observers had noticed multiple nuclei after 1st of October.

What was that Pogson measured from 11th September?

- Regarding Pogson's observation: could the geographical separation between Madras and Cape Town offer a different line of sight to the comet displaying different perspective?
- At a distance of 0.5 a.u a cometary object of 10 km that could in principle provide different facets to geographical locations separated by 6400 km. (At a distance of 0.5 a.u the earth's radius subtends an angle of approx. 18", twice the solar parallax.) Could this be the probable cause?
- Pogson did not publish his observations. He also did not reduce some of these observations. We could not trace any drawings of the comet by him which would have clarified the picture.
- His reluctance to publish might be some thing to do with the attitude of then government which not only rejected his request for a trained European assistant but also admonished him for not publishing the routine meridional observations regularly done at Madras.

A comet hits the Sun – as observed by SOHO ‘s coronagraph 1996



Comets like the Great Comet 1882 II, comet du Toit (C/1945VI) and Ikeya- Seki (C/1965S1) are now called Kreutz Sungrazers and thought to belong to parent comet known as X/1106C1.

SILPACAM (!)

- Regarding the appearance of Comet 1882II ,Nursing Row (1883) mentions that

- Our Hindoo astronomers (astrologers?) predicted the appearance of a comet in the southern hemisphere in their printed calendar - no other particulars except that it would possess a bright copper colour like the rising moon and a long tail. The name given to their predicted comet is “Silpacam”'.

- Table 1. Measurement of positions of the upper nucleus of the Comet 1882

Date		L.S.T	L.M.T	R	N.P.D
		h m s	h m s	h m s	o ' "
Sept	11	4 52 6.44	17 28 29.9	10 06 9.0	90 42 04
	16				
	23	5 28 35.4	17 17 42.2	10 58 14.3	92 54 22
	24	5 55 55.7	17 41 2.1	10 54 06.8	90 33 51
	25	5 27 55.4	17 09 10.5	10 51 54.3	94 08 32
	26	5 48 22.2	17 25 38.0	10 49 31.0	94 41 35
	27	5 37 49.2	17 11 10.9	10 46 59.1	95 14 45.5
	30	5 36 42.1	16 58 16.1	10 40 28.0	96 33 30
Oct	4	5 43 5.9	16 48 55.3	10 33 21.05	98 44 04
	8	6 29 25.7	17 19 23.9	10 28 43.6	100 28 43
	16	6 06 1.75	16 24 36.5	10 17 51.4	104 00 6.5
	17	6 51 31.3		10 1 29.8	
	19	7 4 56			
	24	6 54 39.5			

- **References:**

- Ashbrook, J. 1961, Sky & Tel. 22, 331
- Gill, D. 1883, MNRAS, 43, 318
- Gingerich, O. 1992, ` The Great Copernican chase' Sky Publishing Corporation, Cambridge and Cambridge University press , p 189
- Nursing Row , 1883, MNRAS, 43, 32
- Olson, J.M & Pasachoff, J.M , 1998 , `Fire in the Sky' , Cambridge University press , p
- Pogson, N.R. 1872, MNRAS, 33, 116
- Temple 1883, MNRAS 33

ASPECTS OF DEVELOPMENT OF OBSERVATIONAL ASTRONOMY IN INDIA

Prof. N. Kameswara Rao
Dr. A. Vagiswari
Dr. Christina Birdie
Prof. A.V. Raveendran

INDIAN INSTITUTE OF ASTROPHYSICS
Koramangala, Bangalore -560034