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1998 activity of Leonid meteor shower

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Abstract. A group of five observers have participated in visual, photographic and MST radar observations of Leonid meteor shower during 15-20 November 1998 at National MST Radar Facility (NMRF), Gadanki (13.47° N, 79.18° E) near Tirupati. The peak activity of the shower occurred at 00:00 hours UT on 17 November with a maximum rate of 450 per hour in visual and 1250 per hour in radar observations. These rates are very less compared to the rates observed during 1966 return of the shower. Simultaneous observations of Es occurrences during the shower period showed a spread of about 20-30 Km around 90 Km height region. Most of the Leonid meteor radar echoes occurred around 100 km range.

Key words : Leonid meteor shower, MST Radar, Sporadic E (Es)

1. Introduction

A spectacular celestial display of Leonid meteor stream associated with the comet 55P/Temple-Tuttle was expected to occur in the early hours of 18 November, 1998. Vast publicity through modern mass media was given around the globe highlighting this splendid fiery celestial event. Professional scientists, amateurs and general public of all the countries eagerly watched the skies on the night of 17/18 November 1998 to witness the splendour of this great Leonid meteor shower. Photographic and radio observations of the event were also carried out along with the naked eye observations at some places.

Soon after the discovery of the comet 55P/Temple-Tuttle in 1865 with similar orbit of Leonids with an orbital period of 33.25 years, it was established that this comet is the most likely parent of the Leonid meteors (Lovel 1954). The Leonid meteor storm is caused by a swarm of meteoroids in the vicinity of the comet. Most storms appear to have occurred when the node of the cometary orbit is inside the Earth's orbit and the earth reaches the closest point after the comet has passed through the node. The most recent perihelion passage of the comet occurred on 28th February, 1998. In the past 200 years four such spectacular Leonid meteor storms were observed in 1799, 1833, 1866 and 1966 (Kresak 1993) when the activities of the showers had a zenithal hourly rate (ZHR) in excess of 6,000. Lenoid Meteoroid stream has not been subject to major planetary perturbations as it were prior to 1898, a storm similar to that observed in 1966 was expected to be seen in the years towards the end of this century (Brown and Jones 1993). In view of these findings, a systematic observational programme of Leonid meteor shower was undertaken by this group of observers involving visual, photographic and MST radar observations at the National MST Radar Facility (NMRF) Gadanki (13.47° N, 79.18° E) near Tirupati in Andhra Pradesh.

2.Observations and results

The visual observations of meteors have been carried out by a group of five well trained observers during 15-20 November, 1998. The paths of meteors observed were plotted on meteor plotting charts to determine the radiant position of the shower and the individual magnitudes of the meteors observed were also estimated. From these observations the Zenith hourly rates (ZHR) of the Leonid shower were determined following the standard International Meteor Visual Observational Method. From the observed meteor magnitudes the mass index 's' was estimated each night during 15-20 November, 1998 from the slopes of the distribution curves of number of meteors observed as a function of magnitude by assuming the number of meteors having magnitudes between m and m+dm be represented by $dN \alpha\, m^{-s}\, dm$ (Mckinley, 1961).

A 35 mm ASAHI PENTAX camera with f ratio of 1.4 was fixed in a direction aligned with N_{20} beam of MST radar to photograph the meteor trails. A 35 mm 36 exposure role of Kodak colour film ASA 400 was used in the camera. Exposures were given every 10 minutes successively starting from 01:00 hours. The sky conditions were very good where 5th magnitude stars were visible with naked eye.

The Doppler Spectra of the amplitude variations for meteor trails and Sporadic E layers have simultaneously been recorded continuously throughout the nights of Leonid activity along with the above visual observations. The Doppler spectra of the meteor echoes have been continuously recorded with beams E_{20}, W_{20}, N_{20}, S_{20} and Z_x followed by N_{13} for sporadic E. The observations were taken from 21:00 hours to 06:00 hours each night continuously during 15-20 November, 1998. The hourly rates of occurrence of meteors on each night were estimated from the counts of the offline display of the Doppler spectra of the meteors with SNR > 10dB.

Fig 1. shows the typical MST radar doppler echo of a bright Leonid meteor recorded through N_{20} beam along with the trail photographed (Meteor No. 5 in Fig. 2) with the above camera. The radiant position of the Leonid shower obtained with the plots of meteor paths on star chart on 16/17 November 1998 is shown in Fig. 2. The radiant of the shower estimated is $\alpha = 150\pm3°$ and $\delta = +22\pm1°$.

The meteor rates thus obtained of simultaneous visual and radar observations during November 15 to 20, 1998 are presented in Fig. 3. It is noticed that a broad peak of bright meteors occurring on the night of November 16/17 and a sharp peak of faint meteors on the night of November 17/18 as reported by the other observers. These observations are similar to that recorded in the 1966 return but with very much reduced rates (MacIntosh and Millman 1970). Fig 4 shows the diurnal variations of the Leonid shower on No. 16/17 1998 with a peak activity at 00:00 hours UT.

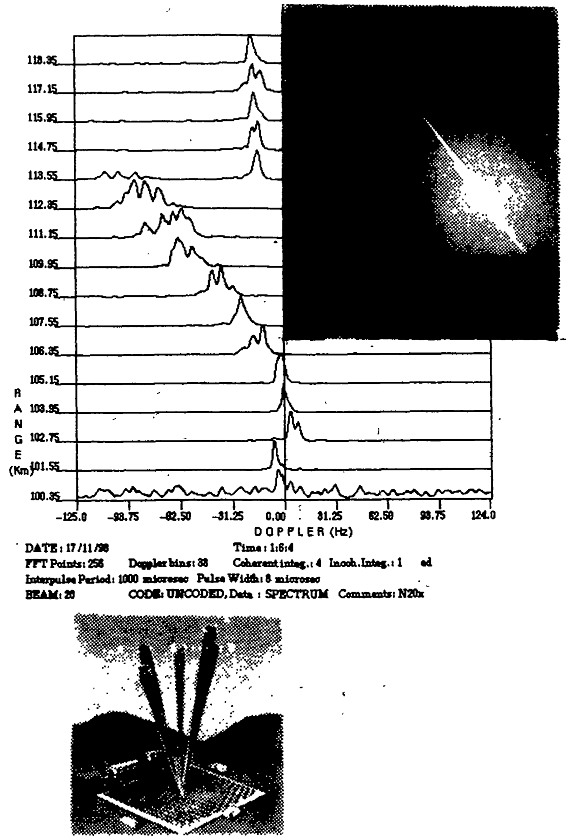

Figure 1. Typical MST radar echo of a bright Leonid meteor of –4 magnitude and its photographic image

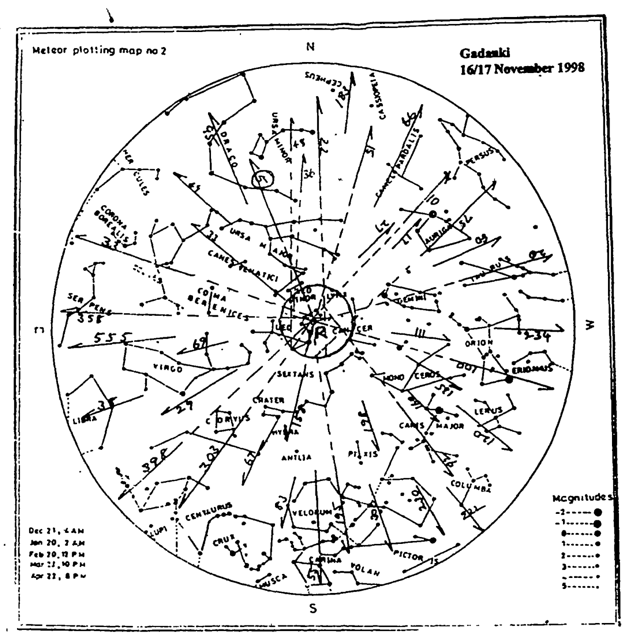

Figure 2. Radiant position of Leonid meteor shower on 16/17 November 1998

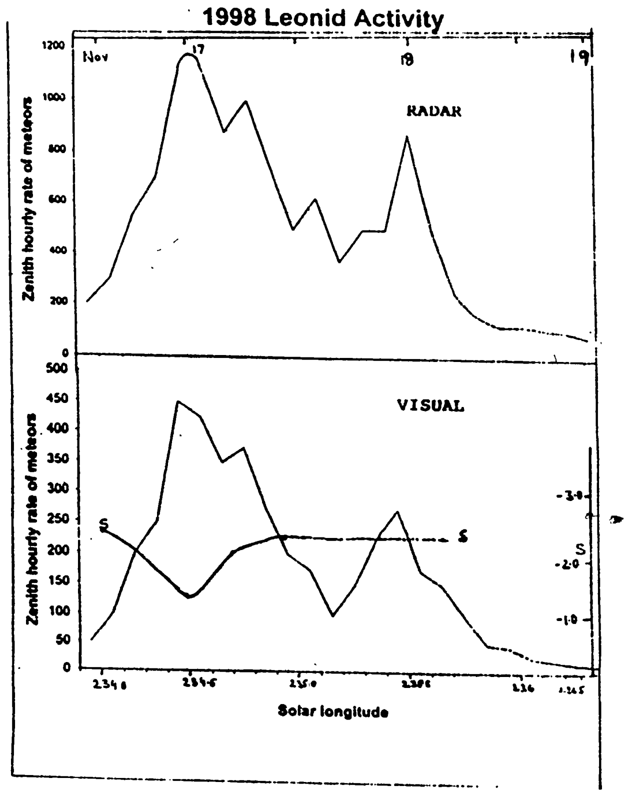

Figure 3. Variation of mean hourly rate of Leonid shower as a function of solar langitude

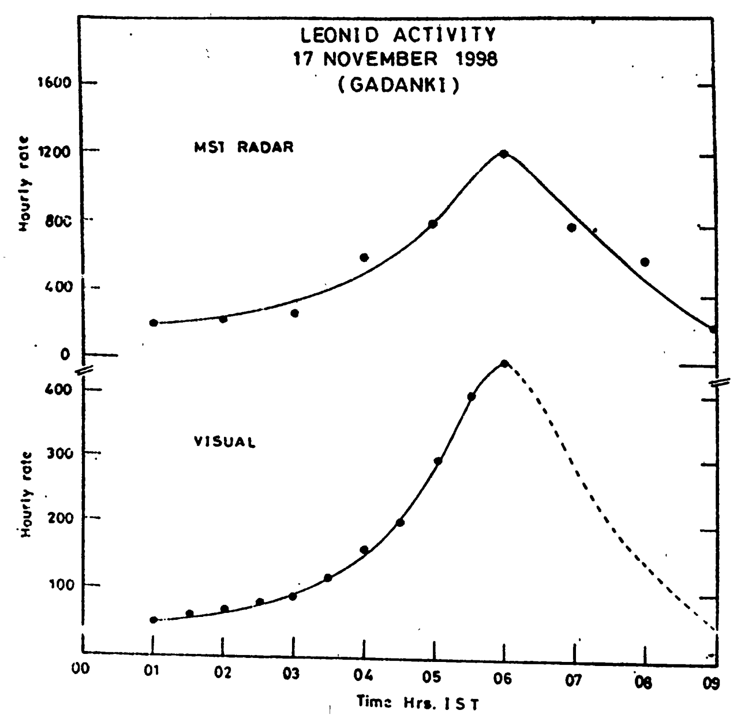

Figure 4. Diurnal variation of meteor rates on 16/17 November 1998

Doppler spectra of sporadic E was recorded simultaneously through N13 beam in every scan of meteor observation throughout this period of investigation. It has been noticed that two district strata of sporadic E occuring around 100 Km and 92 Km altitudes respectively with high percentage of occurrences during the night of peak activity of Leonid meteor shower.

3. Discussion and Conclusions

From the above observations of the activity of 1998 Leonids, it is found that the shower is characterised by a strong and broad background component with a maximum activity of ZHR ~ 450 (visual) and 1250 (radar) around λ_0=234.5° (November 16/17). This 'background component' of the stream was resulted from several revolutions of the comet 55P/Temple-Tuttle around the sun. Gravitational perturbations due to planets and solar radiation pressure have affected the motion of smaller particles more than that of large sized particles, resulting the 1998 Leonid fireballs observed at Gadanki which gave rise to a lower mass index s = 1.6.

On the other hand, the 'storm component' exhibited a relatively weak enhancement of activity of ZHR ~ 250 (visual) and 900 (radio) at λ_0 = 235.5° (November 17/18) with relatively high value of mass index s=2.2. This was resulted due to two or three latest revolutions of the comet 55P/Temple-Tuttle which had its recent apparition on 28 February, 1998. This is very close to 1998 predicted peak activity of the shower which disappointed the meteor observers all over the globe.

The radar, visual and photographic records of 1966 Leonids (MacIntosh and Millman 1970; Brown and Jones 1997) indicated an activity profile similar to that of 1998 Leonids. Judging from these phenomenological facts, we may expect 1999 Leonid activity to show a similar profile of meteor activity of 1966 and 1998 Leonids. However, the actual 1999 peak rate of Leonid activity is hardly predictable.

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