Leonid meteor shower: activity and magnitude distribution

V. Porubčan[1], G. Cevolani[2], L. Neslušan[3] and J. Svoreň[3]

[1] *Astronomical Institute of the Slovak Academy of Sciences, Interplanetary Matter Division, Dúbravská cesta 9, 842 28 Bratislava, The Slovak Republic*

[2] *FISBAT Institute, CNR, Via Gobetti 101, 40129 Bologna, Italy*

[3] *Astronomical Institute of the Slovak Academy of Sciences 059 60 Tatranská Lomnica, The Slovak Republic*

Received: February 2, 1998

Abstract. Leonid meteor shower activity observed in 1995-1996 by a forward scatter radio system along two baselines is analysed and discussed. The overdense echo maxima of echo duration $\geq$8 s exhibit multiple peaks consistent with similar backscatter radio and visual data, with three peaks at the solar longitude 235.36°, 235.49° and 235.57° in 1995 and two peaks at 235.07°, 235.27° (2000.0) in 1996. The mass distribution exponent s derived for both Leonid returns shows a higher representation of larger particles in the 1996 return (s=1.56) with respect to the 1995 return (s=1.69).

Key words: meteor shower - Leonids - mass exponent - forward scatter system

1. Introduction

The Leonid meteor shower enhanced activity returns expected in 1998-1999 invoke a regular monitoring of the shower activity by all means available in order to gather as much information on the activity and orbit of the stream as possible. The parent comet of the stream 55P/Tempel-Tuttle is passing within 0.36 AU of the Earth on January 17, 1998 and is at perihelion on February 28, 1998 (Yeomans et al. 1996) so there raises a possibility of strong meteor displays in the following two years. The first photographic orbit of the stream was presented by Wright (1951) and one of the current ones by Lindblad et al. (1993). Here we present results of a study of the shower activity and mass distribution of meteoroids obtained by a new forward-scatter system in 1995 and 1996.

2. Activity in 1995-1996

2.1. Equipment

Since September 1996 there has been operating a new forward-scatter system for meteor observation transmitting signal simultaneously along two mutually almost rectangular baselines with the transmitter at Budrio (44.6° N, 11.5° E) near Bologna, Italy and receivers at Modra (48.4° N, 17.3° E), Slovakia and Lecce (40.3° N, 18.2° E) in Southern Italy. The system was built up for systematic monitoring shower and sporadic meteor activity enabling a comparison of meteor flux data of a shower radiant at different baseline positions. It is operating regularly each month for about two weeks, 24 hrs per day. It is expected that the system might also assist in detecting short-term meteor activity enhancements and identifying spurious bursts of non-meteor origin.

The equipment utilizes a continuous wave transmitting frequency at 42.7 MHz, with a fixed modulating tone at 1 kHz and a 0.25 kW mean power transmitted in the direction of both receiving stations. The transmitting and receiving antennas are horizontally and vertically polarized with an elevation angle of 15°. The baseline distances between the transmitter and receivers are: Bologna - Lecce 700 km (azimuth 307°) and Bologna - Modra 590 km (azimuth 224°).

2.2. Observations

Meteor activity in November 1996 was monitored at both receiving stations in the period Nov. 12-26. The observed data (all echoes, shower and sporadic) for three echo duration groups (all, $\geq$2 s and $\geq$8 s) recorded at Modra station are shown in Fig. 1. It is evident that the Leonids can be clearly recognized only for echoes of longer duration. Similar trend is observed also in the data from Lecce.

Shower activity was obtained by subtracting sporadic background counts from all echoes in corresponding hours. For Modra, as sporadic were taken the mean hourly counts on Nov. 19 and 20 and for Lecce the counts on Nov. 11/12. The shower echo counts for echo duration groups $\geq$8 s for Modra and Lecce are plotted in Fig. 2. The Lecce data on Nov. 13-14 are missing due to some technical problem with the receiver on these days. Fig. 2 exhibits that the shower acitivity is apparent already from Nov. 13. The gaps observed between 12-21 UT are due to the Leonid radiant being for both the stations below horizon. In the shower counts at least two peaks cited also in other radio observations in Europe (McBeath 1996), are observed. To discriminate the peaks more distinctly, 30 - minute shower echo counts of echo duration $\geq$8 s separately for Modra and Lecce are shown in Fig. 3. The data exhibit a rather flat maximum lasting for about 10-11 hrs on Nov. 17 (solar longitude interval $235.0° - 235.4°$, eq. 2000.0), with three peaks for Modra ($235.08°, 235.23°$ and $235.30°$) and two for Lecce ($235.06°$ and $235.27°$). The Modra peak 2 and 3 may be just only a result of a not correct subtraction of the sporadic background, and therefore, more likely

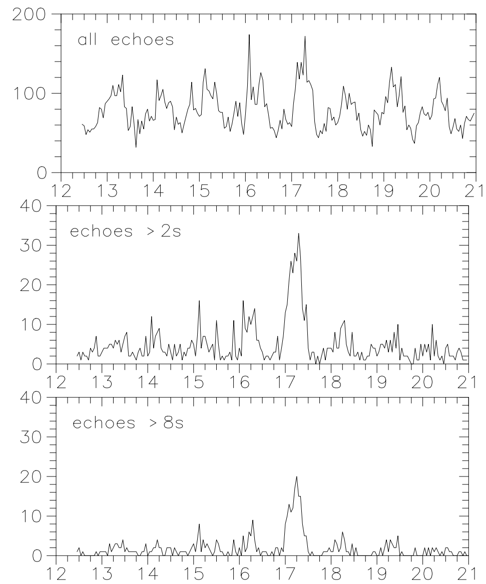

Figure 1. Modra station: Record of echoes in three echo duration groups (all, ≥2 s and ≥8 s) on November 1996 (days)

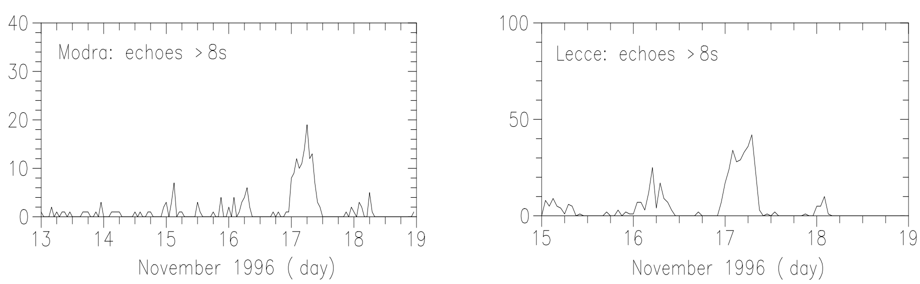

Figure 2. Shower echoes of duration ≥8 s

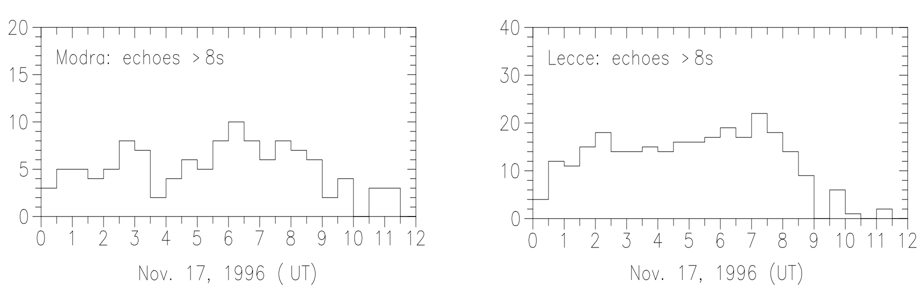

Figure 3. Shower echoes of duration ≥8 s in 30-minute intervals

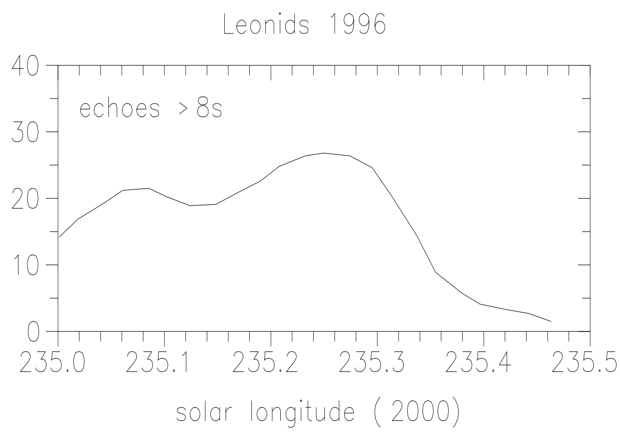

Figure 4. Activity curve of the Leonids 1996

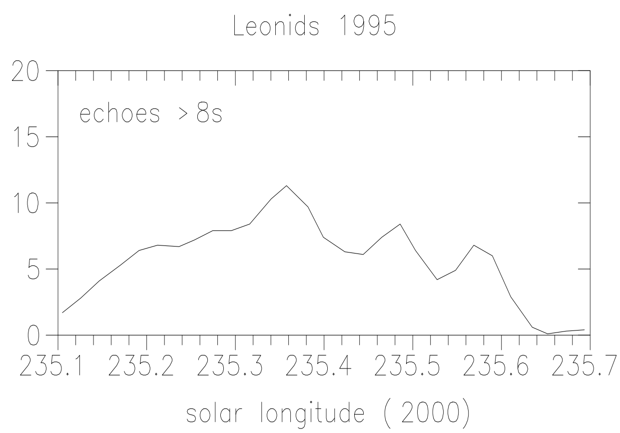

Figure 5. Activity curve of the Leonids 1995

there are only two peaks obtained by compounding the Modra and Lecce data at approx. 235.07° and 235.27° (Fig. 4).

Though a correct derivation of a meteor shower activity curve and corresponding maxima should involve a correction of the observed rates for the observability function of a particular equipment including various effects, what is a rather complex problem with the FS observations, the positions of the 1996 Leonid peak observed at Modra and Lecce are rather consistent with the compound visual data from 1996 presented by Arlt and Brown (1997) proposing also two Leonid peaks at 235.15° and 235.37° (eq. 2000.0). However, our data (Fig. 4) indicate a peak closer to the node of the comet at 235.26° (Yeomans et al. 1996).

The 1995 Leonid observations were carried out only on the baseline Bologna

- Lecce, with the transmitter working at a higher power of 1kW and exhibit a multiple shower maximum, too. The distribution of shower echoes in 30-minute intervals (corrected for the sporadic background) shows three peaks for the solar longitude 235.36°, 235.49° and 235.57° (Fig. 5). The second peak is identical with the maximum obtained from the 1995 visual observations for the solar longitude of 235.5° (Brown 1996) and all the peaks are fully consistent with the Ondřejov backscatter radar (49.9° N, 24.8° E) data exhibiting peaks at 235.3°, 235.5° and 235.6° (Brown et al. 1997).

The activity of the Leonids 1995 and 1996 cannot be directly compared due to change of the tramsmitting power from 1 kW (1995) to 0.25 kW (1996).

3. Mass distribution

The 1995 and 1996 FS data from Lecce and Modra provided a possibility to derive the mass distribution exponent from the observed echo durations of the shower and sporadic meteor echoes. The mass distribution exponent s was derived from the distribution of the cumulative numbers of echo duration considering diffusion for dominant process of an echo decay. The 1996 data were combined together (Modra and Lecce) and s derived from the period of the observed shower maximum (Nov.16, 21 UT - Nov.17, 12 UT, solar longitude $234.84° - 235.47°$) for shower echoes of duration ≥ 0.3 s is 1.51. The value is confirming a very high proportion of long duration echoes in the Leonids 1996. The mass exponent of the sporadic background reaches its standard value of s = 2.28. The value of s obtained for shower echoes of ≥ 1 s (closer to visual data) is 1.56, which is corresponding to the population index r = 1.67. Visual data at the maximum provide r = 1.66 (Arlt et al. 1996).

Table 1. Mass distribution exponent of the Leonids 1996 in different solar longitude intervals

Day	UT	Sun (2000.0)	s
Nov. 16	21 - 24	234.84 - 234.97	2.08
Nov. 17	00 - 03	234.97 - 235.10	1.53
Nov. 17	03 - 06	235.10 - 235.22	1.59
Nov. 17	06 - 09	235.22 - 235.35	1.34
Nov. 17	09 - 12	235.35 - 235.47	1.53
sporadic			2.28

Table 1 shows the mass exponent derived for five intervals around the peak Leonid activity (Nov.16, 21 UT - Nov.17, 12 UT, $234.84° - 235.47°$). The lowest values of s of 1.53 and 1.34 for the intervals 00-03 and 06-09 UT, respectively, correspond to the two peaks of the long-duration echoes found in the 1996 Leonids (Fig. 4).

Table 2. Mass distributions exponent of the Leonids 1995 and 1996 (r-population index corresponding to s obtained for echoes $\geq$ 1 s)

	Sporadic	Shower $\geq$ 0.3 s	Shower $\geq$ 1 s	r	r_{vis}
Leo 95	2.24	1.67	1.69	1.89	1.8 *
Leo 96	2.28	1.51	1.56	1.67	1.66 **

*Brown (1996); **Arlt et al. (1996)

The mass exponent derived for the Leonids 1995 (Lecce data) was found equal to 1.67, 1.69 and 2.24 for the shower echoes of duration $\geq$0.3 s, $\geq$1 s and sporadic background, respectively. Visual data from 1995 (Brown 1996) provide the population index r of the shower meteors of about 1.8, which is also in a very good agreement with our result presented in Table 2.

From a comparison of both Leonid returns in 1995 and 1996, the mass exponent clearly indicates a higher percentage of larger particles in the 1996 Leonid return.

Acknowledgements. The authors acknowledge support of the FISBAT, CNR Bologna and the Slovak Academy Grant 5101/98.

References

Arlt, R., Rendtel, J. and Brown, P.: 1996, *WGN* **24**, 203
Brown, P.: 1996, *WGN* **24**, 139
Brown, P., Šimek, M. and Jones. J.: 1997, *Astron. Astrophys.* **322**, 687
McBeath, A.: 1997, *WGN* **25**, 45
Kaiser, T.R, Closs, R.L.: 1952, *Phil. Mag.* **43**, 1
Yeomans, D.K., Kevin, K.Y. and Weissman, P.R.: 1996, *Icarus* **124**, 407
Lindblad, B.A., Porubčan, V. and Štohl, J.: 1993, in *Meteoroids and Their Parent Bodies*, ed.: J. Štohl and I.P. Williams, Astron. Inst. SLovak Acad. Sci., Bratislava, 177
Wright, F.W.: 1951, *Harward Techn. Rep.* **7**, 1