Asteroids, Comets, Meteors 1991, pp. 469-472
Lunar and Planetary Institute, Houston, 1992

BURST OF THE 1969 LEONIDS AND 1982 LYRIDS

V. Porubčan and J. Štohl
Astronomical Institute of the Slovak Academy of Sciences,
Czech and Slovak Federal Republik

Abstract

Radar observations of the last bursts of the Leonids in 1969 and Lyrids in 1982, carried out at the Springhill Meteor Observatory, Canada, both of very short duration, with the rates exceeding a quarter-maximum rate within 50-55 minutes, are used for a study of the mass distribution of meteoroids. In both cases the mass distribution exponents of the meteoroids in the dense clouds largely differ from the values obtained for the older populations of the streams. The highest mass exponent $s \sim 2.2-2.4$ is found around the peak of the activity, confirming high contribution of smaller meteoroids, and thus also a recent origin of the dense clouds. Consequences of this findings are discussed.

Activity and mass distribution

The showers were observed at the Springhill Meteor Observatory, the 1969 Leonids by the high power radar and the 1982 Lyrids by the patrol radar. (For details about the equipments cf. Millman and McIntosh, 1964, and Neale, 1966a,b).

The 1969 Leonid shower observations cover a five-hour interval of November 17, 07:37-12:40 UT. The peak occured on November 17, at 09:02 UT (solar longitude 234.577, epoch 1950.0), with 460 echoes in one minute. The duration of the storm was 15 minutes between half-maximum points, and 55 minutes between quarter-maximum points. The 1982 Lyrid peak occured on April 22, at 06:49 UT (solar longitude 31.380, epoch 1950.0), with 33 echoes in one minute. The duration of the storm was 22 and 50 minutes between half-maximum and quarter-maximum points, respectively.

In Fig. 1 we present two activity curves of the 1969 Leonids storm. The dotted one was derived by Millman (1970) from visual observations carried out at the Springhill Meteor Observatory. The corresponding radar activity curve (the full line) was derived from our data using the same smoothing procedure as was applied to the visual data by Millman. A striking feature of the activity curves is their similarity not only in the positions and width of their main maxima, but also in the secondary maxima, in both cases occuring at about 08:00 UT. The activity curve of the 1982 Lyrids burst can be found in Porubčan and Hajduková (1988).

The mass distribution of meteoroids of the form $dN \sim m^{-s}dm$ and the differential mass exponent s can be derived from the echo

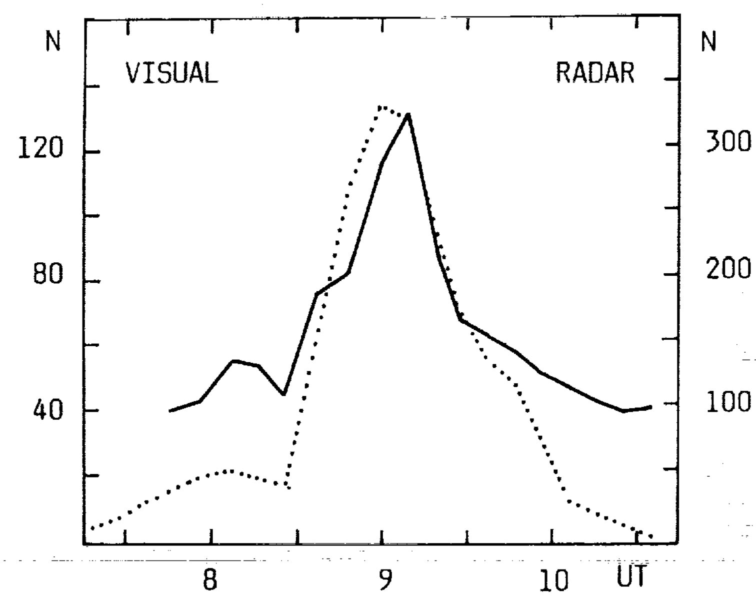

Fig. 1. Activity of the Leonids 1969 observed visually (dotted line) and by radar (full line). The values represent 10-minute counts of meteors by 6 visual observers and of echoes with duration ⩾ 0.4 sec.

durations. The minimum echo duration considered in our analysis was 0.4 sec. Mass exponent s obtained for the 1969 Leonids is listed in Table 1, together with the results for the Lyrids 1982 derived earlier by Porubčan and Hajduková (1988). From Table 1 we can see that for the mass exponent s the radar observations give relatively high values. Let us remind that for the 1969 visual Leonids the value s = 2.2 was derived by Millman (1970). Statistical reliability of this value, however, is low owing to the relatively small number of meteors available for the analysis. The same value s = 2.2 was also derived from the patrol radar observations of the Springhill Meteor Observatory for the 1966 Leonid storm by McIntosh and Millman (1970) and for the peak of the 1982 Lyrids bursts by Porubčan and Hajduková (1988). More reliable high power radar values presented in Table 1 are still higher, especially for the peak period of the 1969 Leonids (s = 2.43).

Table 1. Mass exponent s of the 1969 Leonids and 1982 Lyrids

1969 Leonids: UT	n	s	1982 Lyrids: UT	n	s
8:30-9:30	840	2.31	6:00-6:35	63	1.75
8:55-9:10	353	2.36	6:35-7:00	201	2.21
9:00-9:05	152	2.43	7:00-8:00	126	1.55

Discussion of the origin

High values of the mass exponent s ~ 2.2-2.4 for meteoroids of the 1966 and 1969 Leonids and 1982 Lyrids bursts confirm a very high incidence of small particles in the corresponding dense clouds of the two streams. It follows that the small particles have not yet been removed from these places by cumulative dispersional effects which begin to influence structure of a stream immediately after the ejection of meteor particles from the parent bodies. Thus dense clouds consisting of small particles in the streams must be of recent origin.

In the case of the Leonid storms there seems to be no serious problem in accepting this consequence. As was concluded by Yeomans (1981) from his analysis of the Leonid showers over the 902-1969 interval, most of the stream particles are fresh ejecta from its parent comet P/Tempel-Tuttle (1966 I, period 33 years). For the 1969 storm of the Leonids McIntosh (1973) has found that the corresponding cloud of small particles, lagging the comet 1600 days, was ejected from the comet before 5-6 orbital evolutions, i.e. less than 200 years ago. There still remains a problem of the dispersion of the particles orbits which would demand appearance of the bursts in several years about the encounter time (Williams, 1990), but the conclusion about recent origin of the particles by ejection from their parent comet seems to be firmly established.

Origin of the 1982 Lyrids burst, however, must be different and demands another scenario. The corresponding cloud of small particles is lagging the parent comet P/Thatcher (1861 I, period 415 years) over 120 years and does not therefore allow an explanation of its origin in recent ejection directly from the comet. On the other hand, the dense cloud predominantly consisting of small particles does demand a recent origin. Moreover, the cloud of small particles is imbeded into an older Lyrid population containing larger particles, which follows from the low mass exponent $s = 1.6$ of the standard Lyrid population (Porubčan and Šimek, 1988), as compared with $s = 2.2$ observed at the peak of the 1982 burst.

One possibility how to explain the 1982 Lyrids burst is that the small particles had their origin in a secondary, relatively large body loosed from the parent comet Thatcher at an earlier time, perhaps together with smaller particles that dispersed more quickly along the orbit due to their higher ejection velocities. The chunk could disintegrate later on, producing a dense cloud of non-ejected particles of various sizes, moving in similar orbits for relatively longer period, since not influenced by the dispension of velocities occuring at an ejection process. Evidence for such an origin on a larger scale can be seen in disintegrations of cometary nuclei followed by strong meteor storms, as was the case with the comet P/Biela and the Andromedids. On much smaller scale, an evidence can be seen in non-random groupings of meteoroids observed in young, dense meteor streams (Porubčan, 1979), resulting in a continuing process of disintegration of large meteoroids into smaller ones. As for the time-scale of loosing the chunk from the comet Thatcher we can make a simplified estimation. Neglecting other effects and considering ejection velocity of e.g. $1 m.s^{-1}$ at the perihelion in the direction of comet motion we obtain that the chunk left the comet 36 revolutions ago, which is about 1.5×10^4 years.

Acknowledgemets

The authors are indebted to the Herzberg Institute of Astrophysics in Ottawa and to B. A. McIntosh for the kind permission to use the original Canadian radar records from the Springhill Meteor Observatory. The research was supported by the Slovak Academy of Sciences Grant 493/1991.

References

McIntosh B.A. (1973) Origin and evolution of recent Leonid meteor showers. In Evolutionary and Physical Properties of Meteoroids (C.L. Hemenway, P.M. Millman, and A.F. Cook, eds.), pp. 193-198, NASA SP-319. NASA Washington, D.C.

McIntosh B.A. and Millman P.M. (1970) The Leonids by radar - 1957 to 1968. Meteoritics, 5, 1-18.

Millman P.M. (1970) Meteor news. Roy. Astron. Soc. Canada, 64, 55-57.

Millman P.M. and McIntosh B.A. (1964) Meteor radar statistics I. Canad. J. Phys., 42, 1730-1742.

Neale M.J. (1966a) Radar equipment for continuous meteor observations. Canad. J. Phys., 44, 1021-1028.

Neale M.J. (1966b) A megawatt pulse transmitter for meteor research. Canad. J. Phys., 44, 1573-1582.

Porubčan V. (1979) Clustering of particles in meteor streams. Contr. Astron. Obs. Skalnaté Pleso, 8, 89-96.

Porubčan V. and Hajduková M. (1988) Mass distribution exponent of the Lyrid meteor shower enhanced activity in 1982. Acta Astron. Geophys. Univ. Comenianae, 13-14, 77-82.

Porubčan V. and Šimek M. (1988) Distribution of Lyrid meteoroids in a large range of echo duration. Bull. Astron. Inst. Czechosl. 39, 165-168.

Williams I.P. (1990) The formation of meteor streams. In Asteroids, Comets, Meteors III (C.-I. Lagerkvist, H. Rickman, B.A. Lindblad, and M. Lindgren, eds.) pp. 585-594 Uppsala Universitet, Uppsala.

Yeomans D.K. (1981) Comet Tempel-Tuttle and the Leonid meteors. Icarus, 47, 492-499.