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ACTIVITY OF THE LYRID METEOR STREAM

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Abstract - The activity of the Lyrid meteor stream is in most years fairly low with a visual rate at maximum (21-22 April) of 5-10 meteors per hour. Short bursts of very high Lyrid activity, with visual hourly rates of 100 or more, have sometimes been reported. These observations generally refer to faint visual meteors. The reported bursts of high activity have occurred in a very narrow interval of solar longitudes (31°.24 to 31°.38 equinox 1950.0), while the recurrent or "normal" maximum for bright meteors occurs at solar longitude 31°.6, or slightly later. A mass separation of the meteors in the shower is thus indicated.

Introduction - The Lyrid meteor stream is associated with Comet Thatcher (1861 I). The shower appears in the period 15-24 April with a maximum on April 21-22. An early discussion in the scientific literature of a possible, annual meteor shower in mid-April is due to Herrick (1838). For further references see Lindblad and Porubçan (1991). The present visual h.r. at maximum is low, about 5-10 meteors per hour. It is, however, known that the Lyrid meteor stream in the past has given rise to intense meteoric displays. Less well known is that short, intense outbursts of Lyrid activity have been observed on several occasions during the 19th and 20th century. The present paper summarizes the historical records and attempts to determine the precise solar longitude at which the Lyrid outbursts have occurred. Unfortunately several records before 1900 could not be used since they do not give the precise time - in some cases there is also an uncertainty as to the date of the display.

Observations - Table 1 summarizes those reports after 1800 for which precise date and time information has been found. Table 1 shows that the Lyrid outbursts have occurred in a narrow range of solar longitudes (31°.24 to 31°.38). In some cases the activity maximum can be specified to within 1 minute corresponding to approximately 0°.001 in solar longitude. Owing to the rapid change in Lyrid rates near the peak, there is in some cases an uncertainty as to the exact meaning of the published hourly rates. Most observers give an hourly rate corresponding to the rate at peak activity. Rates listed in Table 1 are zenithal hourly rates for a single observer, i.e. if group watches were made they were corrected to zenith and to rates for one observer. A few comments on the data of Table 1 are given below.

Contemporary newspaper accounts of the 1803 Lyrid display were collected by Olmsted (1834), Herrick (1839) - and a century later by Fisher (1931). Olmsted's report led Herrick (1838) to suspect the existence of an annual meteoric display in April. Herrick's conclusions were discussed by Benzenberg (1838) and other European astronomers. Subsequently Herrick (1839) confirmed the existence of an April Lyrid shower by direct visual observations, and determined a radiant at $\alpha = 273°$, $\delta = 45°$. The 1803 Lyrid display was evidently a meteoric storm of length several hours and with an hourly rate of 670 or more.

For the 1922 and 1946 apparitions time information is available from two independent sources. There is an apparent discrepency between the time of the 1922 maximum as reported by Russel and Gadomski. We note that Russel's observations were accidental. On April 21, 1922 he happened to observe an intense shower with a radiant near α Lyrae. Russel counted meteors during three time intervals, with a break between 21:40 and 21:55 hrs local time. Since Gadomski lists 21:40 as the time of shower maximum, it is evident that Russel's observations were incomplete. There is thus no contradiction between the two reports.

For the 1946 Skalnate Pleso observations Porubçan and Stohl (1983) list a zenithal hourly rate corrected to a single observer of ≃ 40. Inspection of the original records reveals that this rate refers to 6 observers averaged over a 60 minute time interval. If the most experienced observer (Mrkos) is selected and his h.r. is based on the 20 minute peak interval we deduce an h.r. of 110 in good agreement with results reported from Prague.

The 1982 Lyrid apparition was observed both visually and by radar. It is therefore the best studied display on record. Detailed information on the magnitude and/or mass distribution is available. A predominance of faint meteors in the shower is evident from McLeod's visual observations (Adams 1982). A peak zenithal rate of about 250 meteors per hour, persisting for 15 minutes between half-maximum values, was reported by McLeod. He also reported for the same period an observed mean Lyrid magnitude of 3.62 - to be compared with his "normal" Lyrid mean magnitude of 2.84. A detailed study of the 1982 radar observations has been published by Porubçan and McIntosh (1987). They report a shower duration of 22 minutes between half-maximum points. In a subsequent paper Porubçan and Hajdukova (1988) studied the most active part of the outburst and determined a mass index $s = 2.2$. This value may be compared with the "normal" Lyrid value of $s = 1.6$. Again an excess of small meteoroids in the 1982 Lyrid stream is indicated.

In conclusion we note that most observers state that the 1922-82 Lyrid outbursts were of short duration (total duration 2 hours or less and period of peak activity about 15 minutes) and that they mainly consisted of faint meteors.

Normal Lyrid activity profile - For comparision purposes we derive the visual activity profile of the recurrent or "normal" Lyrid meteor shower. This is difficult to determine because of the very low number of Lyrids observed in most years. For our study we have used three data sets: 1) Visual rates obtained by British and American observers in 1969 (Hindley 1969). 2) Rates obtained by Dutch observers in 1984-88 (Jenniskens and Veltman 1988). 3) Rates obtained in 1982-90 by the Arbeitskreis Meteore, Potsdam (Rendtel 1990). Hourly rate curves for all three groups are plotted in Fig. 1A. All rates have been reduced by the original authors to the zenithal hourly rate of a single observer. We note that the rates are very consistent with peak rates of 14.0, 13.5 and 10.4 observed at solar longitudes 31°.5, 31°.6 and 31°.75 by Hindley, Jenniskens and Veltman, and Rendtel, respectively. Fig. 1B shows an activity profile based on two series of long-term radar observations (Porubçan, Simek and McIntosh 1989). It is evident that radar and visual data are in good agreement and that both types of data place the recurrent or "normal" Lyrid maximum at solar longitude 31°.6 (equinox 1950.0).

Discussion. -It is evident that there exists a filamentary structure in the Lyrid stream consisting mainly of small particles. The Earth transits this filament in about one hour, indicating a flux tube of transverse extension of about 100 000 km. Since the Lyrid outbursts do not occur every year, there exists a longitudinal structure in the filament. The persistence of such structures over long time periods is difficult to explain. Since the Earth encounters this filament about 0.25 days earlier than it encounters the main maximum of the stream a mass separation in the stream is indicated. The filament could be due to small particles which were ejected from the parent comet at a different time than the main Lyrid release. An alternative explanation is to postulate the operation of some unknown mass dependent dispersive mechanism (the Poynting-Robertson effect operates in the orbital plane of the stream and is therefore not applicable).

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Y M D	UT (h m)	Solar L (1950.0)	ZHR	Location	Reference	Comments
1803 04 19	--	31°.35	670	Eastern USA	Herrick, E.C., 1838, Am. Journ. Sci., 34, 398 Benzenberg, J.F., 1838, Astron. Nachr. 355, 325-327	Newspaper reports. 01-03 hrs in the morning (local time). Duration > 2 hrs
1922 04 21	19 40	31°.294	360-600	Southern Poland	Gadomski, J., 1929, Publ. Astron. Obs. Warzawa Univ. 5, 69-70	Gadomski and two co-observers. Max. at JD = 2423166.32
1922 04 21	19 58	31°.306	180	Greece	Olivier, C., 1929, Publ. Leander McCormick Obs., 5, 24-25	Observations by H.N. Russell. Maximum at 21.58 (local time)
1934 04 21	23 15	31°.370	56-80	Sonneberg	Teichgraeber, A., 1934, Die Sterne 14, 137	Observers C. Hoffmeister and A. Teichgraeber
1945 04 21	15 50	31°.243	100	Japan	Olivier, 1946, Meteor Notes, Pop. Astron. 54, 305-307	Observations by K. Komaki 00.00-01.17 (local time), 22 April
1946 04 21	22 40	31°.266	110	Skalnate Pleso	Porubcan,V. and Stohl, J., 1983, Contr. Astron.Obs. Skalnate Pleso, 11, 169-184	Observations by A. Mrkos 23.40 (local time)
1946 04 21	22 46	31°.270	≃80	Prague	Guth, V. 1947, Bull. Astron. Inst. Czechosl. 1, p. 1-4 Lhotsky,O. and Gaertner,L., 1946, Rise Hvezd, 27, 137-138	Observations by a large group ZHR refers to a single observer
1982 04 22	06 48	31°.376	253	North America	Adams, M.T., 1982, Meteor News 581	Observations by N.W. McLeod
1982 04 22	06 49	31°.377	--	Ottawa	Porubçan,V. and McIntosh,B.A., 1987 Bull. Astron. Inst. Czech., 38, 313-7	Springhill high power radar
1982 04 22	06 38	31°.369	--	Budrio	Porubçan, V. and Cevolani, G., 1985, Contr. Astron. Obs. Skalnate Pleso 13, 247-253	Budrio radar

Table 1. Visual and radar observations of exceptional Lyrid activity

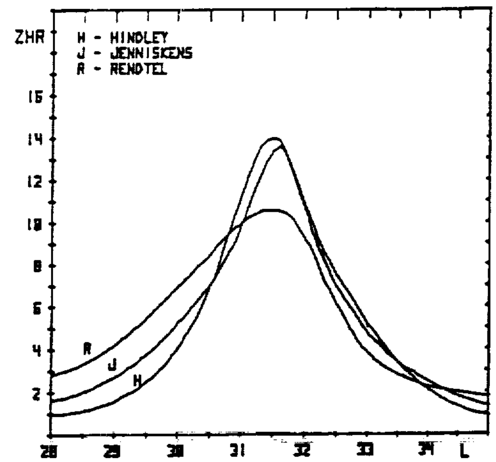

Fig. 1A
Visual zenithal hourly rates of "normal" Lyrid shower versus solar longitude 1950. Observations by three experienced groups.

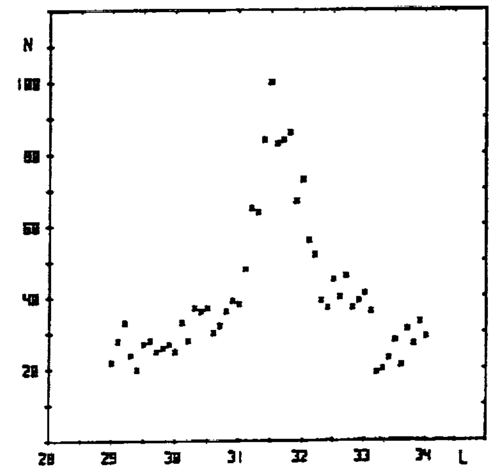

Fig. 1B
Radar activity profile based on 18 years of observations at Ottawa and Ondrejov. Hourly rate of radar echoes normalized to 100.

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