RADAR OBSERVATIONS OF THE LYRID METEOR SHOWER IN 1980-1984

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ABSTRACT. Radar observations of the Lyrid meteor shower carried out by the meteor radar at Ondřejov in 1980-1984 are analysed and discussed from the viewpoint of activity. The mean activity curves derived for two different sets of overdense echoes indicate no separation of particles according to their masses, the activity maximum is found to be at solar longitude 31.7° (epoch 1950) and the duration of the shower between the quarter-maximum points is about two days.

РАДИОЛОКАЦИОННЫЕ НАБЛЮДЕНИЯ МЕТЕОРНОГО ПОТОКА ЛИРИД В 1980-1984 ГГ. Анализируются с точки зрения активности радиолокационные наблюдения метеорного потока Лирид, которые проводились в Онджееве в 1980-1984 гг. Исходя из полученных кривых активности для двух разных груп длительных радиоэхо, не наблюдается сепарация метеорных частиц для массы, максимум активности наблюдается при долготе Солнца 31,7° (1950,0) и длительность потока между пунктами с 1/4 численности максимума является около двух дней.

RADAROVÉ POZOROVANIA METEORICKÉHO ROJA LYRÍD V ROKOCH 1980-1984. V práci sú analyzované a diskutované z hľadiska aktivity radarové pozorovania meteorického roja Lyríd získané meteorickým radarom v Ondřejove v rokoch 1980-1984. Vychádzajúc z kriviek aktivity pre dve skupiny dlhotrvajúcich meteorických ozvien, nepozoruje sa separácia častíc roja podľa hmotností, maximum aktivity sa vyskytlo pri dĺžke Slnka 31.7° (ekvinokcium 1950,0) a trvanie roja medzi bodmi so štvrtinovou frekvenciou oproti maximálnej je približne dva dni.

1. OBSERVATIONS

Radar observations of the Lyrid meteor shower have been a part of the regular annual observational schedule by the meteor radar at the Ondřejov Observatory since 1980. The present study is intended to present some of the observational results concerning the activity of the shower, obtained during the first five years since the programme was started.

The Ondřejov meteor radar operates at a frequency of 37.5 MHz, with a peak power of 25 kW, repetition frequency of 500 Hz and a pulse length of 10 μs. The antenna, common for transmitting and receiving, is stable in elevation (maximum gain at the elevation of 45°) and steerable in azimuth. The beam width between the half-power points in the vertical plane is about 52° and in the plane normal to it, about 36°. The limiting sensitivity of the radar was found to be $+7.5^{m}$ (Znojil et al., 1981). A detailed description of the radar and basic processing of the data can be found in the paper by Plavcová and Šimek (1960).

The analysed 1980-1984 observations were carried out on 6-7 consecutive nights starting April 17 or 18. The radar operated for 9 hrs (21-06 UT) in 1980-1982 and 12 hrs (21-09 UT) in 1983-1984 every day, with the antenna beamed to an azimuth differing by 180° from that of the Lyrid radiant. From the standard range-time record, the echoes of the durations of 0.2 s and greater were reduced with an accuracy of $\pm$ 0.05 s. The echoes of durations $\geqslant 0.2$ s are referred to as all echoes. The Lyrid radiant ($\alpha = 272^{\circ}$, $\delta = +34^{\circ}$; Cook, 1973) culminates at Ondřejov at 04:10 LT and attains the highest elevation of 74°. With the antenna being stable in elevation and guided in azimuth according to the procedure stated above, the conditions most suitable for recording the echoes from the Lyrid meteors are at approximately 24 and 08 LT.

2. ACTIVITY OF THE SHOWER

The April Lyrids are a meteor shower whose activity is of a shorter duration,the main part extending over about two days only. With the meteor radar used, it is not possible to identify shower meteors individually by measuring the velocities and orbits. Thus, these can only be obtained by treating the observations statistically.

The shower meteors are normally found by substracting the sporadic background rates from the total echo counts. The sporadic background rates should be defined as the mean rates of the days immediately preceding and following the shower activity. However, the period after the Lyrid activity is already contaminated by the Eta Aquarid meteors and consequently, the resulting "background rates" increase rapidly (Millman and McIntosh, 1964). On the other hand, in some years, the analysed observations were terminated when the Lyrid shower was still active. Therefore, the first nights of observation were considered sporadic, and the background echoes were separated for each duration set individually.

Since the echo count down to the shortest echo-duration boundary of the equipment is not complete due to various atmospheric and instrumental influences, the limiting duration of the echoes, to be included in the analysis, was set at 0.2 s. Records with observations longer than half an hour but shorter than one hour were prorated to equivalent hourly rates. The variation of the echo activity of the Lyrids in 1980-1984 is depicted in Fig.1, where the mean hourly echo rates for three different sets according to duration (all echoes, ⩾1 and ⩾8 seconds) are plotted against the solar longitude referred to the equinox 1950.0.

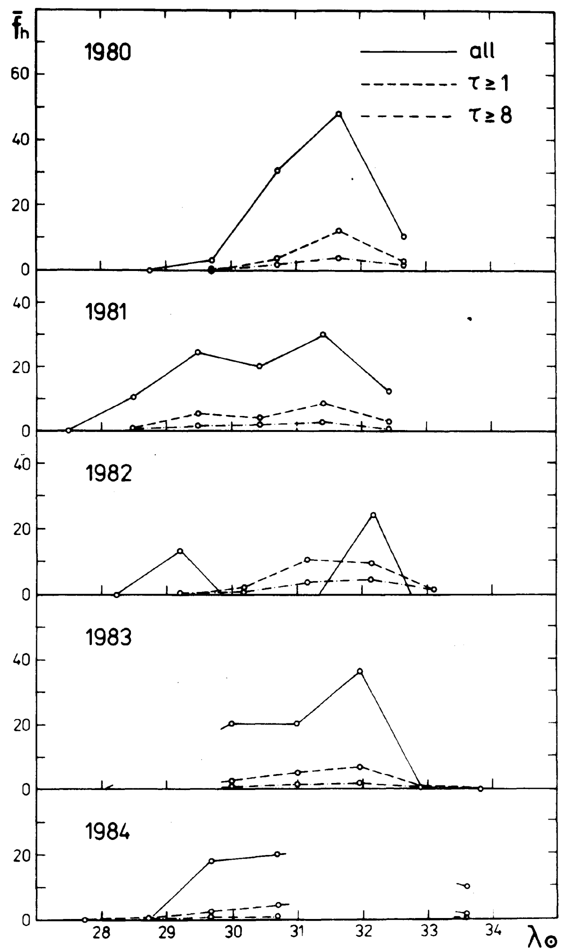

Fig. 1 Variations of the mean hourly echo rates of the Lyrid meteor shower, observed at Ondřejov in 1980-1984, vs. solar longitude (epoch 1950) for three sets of echo durations.

The plotted rates represent the daily means of the observations. Although, the activity curves are not complete due to a mulfunction of the radar, namely,in 1983 and 1984, the comparison of the displays in consecutive years is interesting with regard to the activity as well as the structure of the shower. While the total number of meteors recorded in 1980, 1981 and probably in 1983 is roughly the same, the peak rate in 1980 is about 1.5 times higher, and the duration of the shower at one-quarter of the maximum level also differs significantly. While in 1980, the Earth traversed the shower in about 2.5 days, in 1981 it took about 4.5 days. It can be seen that the activity may change considerably in consecutive years. Similarly, the splitting of the maximum in 1981 and 1982 suggests that structurally the Lyrids form a more complex meteor shower. The largest differences among the returns of the shower are caused chiefly by short-duration echoes (<1s). Exceptional in this respect is the 1982 return with a very low number of short-duration echoes, and the shower can only be separated from the sporadic background for overdense echoes.

The most stable part of the shower is formed by larger particles (echoes of duration $\geqslant$1s), while the major deviations from a common and uniform activity curve are due to the variable flux of the smaller particles. Therefore, to get a reasonable mean activity curve of the shower over a longer period, only the observations of overdense echoes can be combined. Thus, the mean activity curves for two groups of echo durations ($\geqslant$1s and $\geqslant$8s), were obtained by combining the observations over all five years. The result is shown in Fig. 2, where the mean hourly echo rates are plotted vs. the solar longitude for the 1950.0 equinox and the data are approximated by curves. In the diagram, the sporadic background level is represented by a thin line. The observations give a maximum of the overdense Lyrids at solar longitude 31.7°, and there is no evident shift in solar longitude between the peaks of both echo duration sets.

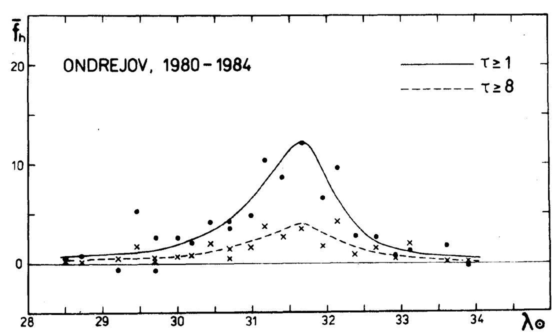

Fig. 2 Mean activity curves of the Lyrid meteors for two sets of overdense echoes, obtained by combining the 1980-1984 data. The thin straight line represents the sporadic background level.

3. DISCUSSION

The radar observations of the Lyrid meteor shower made at the Ondřejov Observatory in 1980-1984 have shown that the shower is a regular meteor shower of lower activity, which the Earth crosses in about 5-6 days. The results indicate that while the incident flux of overdense echoes is comparatively stable, the flux of echoes of smaller particles ($\tau < 1$s), at a given solar longitude, may change considerably on consecutive returns of the shower. The derived activity maximum of the overdense echoes at solar longitude 31.7° is consistent with photographic and visual observations (Cook, 1973; Porubčan and Štohl, 1983), as well as the duration of the shower between the quarter-maximum points, 2 days, as inferred from Fig. 2.

As noted above, a very exceptional return of the Lyrids was observed in 1982. Not only was the overall activity very low and the shower could only be resolved for echoes of durations $\geqslant 1$s, but there appeared a sudden outburst in the activity, predominantly of fainter meteors, on April 22 with a peak at 06:50 UT, observed visually (Adams, 1982) and also by radar (Porubčan and Cevolani, 1985). The increase lasted for about 90 minutes and confirmed the unusual structure of the Lyrids.

The activity of the Lyrid meteor shower was studied by Porubčan and Hajduková (1986) using the radar observations made at the Springhill Meteor Observatory in the five years from 1963 to 1967. The mean activity, its variation and duration of the shower, derived from both radars, are almost completely consistent. It can, therefore be concluded that, on the average, the activity of the April Lyrids is constant over a longer period, with a stable core of the shover defined predominantly by larger particles producing overdense echoes and a variable flux of underdense echo particles.

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