ACTIVITY OF THE LYRID METEOR SHOWER FROM RADIO OBSERVATIONS AT DUSHANBE

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ABSTRACT. Radio observations of the Lyrid meteor shower at Gissar Observatory in 1982-1986 are analysed and discussed. The Lyrid activity, derived on the basis of range distribution analysis, exhibits a compound maximum at solar longitude 31°9 /epoch 1950.0/. Fluxes of Lyrid meteoroids of masses $m \geq 10^{-3}$ g at the peak period are of the order of $(1\div2).10^{-12}$ m^{-2} s^{-1}.

АКТИВНОСТЬ МЕТЕОРНОГО ПОТОКА ЛИРИД ПО РАДИОЛОКАЦИОННЫМ НАБЛЮДЕНИЯМ В ДУШАНБЕ. Исследуются радиолокационные наблюдения метеорного потока Лирид из Гиссарской обсерватории в 1982-1986 гг. Активность потока обнаружена на основе анализа распределения дальностей; объединенный максимум потока имеет место при долготе Солнца 31°9 /эпоха 1950.0/. Плотность падающего потока метеороидов Лирид с массами $м \geq 10^{-3}$ г в период максимума, порядка $/1\div2/.10^{-12}$ $м^{-2}$ $с^{-1}$.

AKTIVITA METEORICKÉHO ROJA LYRÍD Z RADAROVÝCH POZOROVANÍ V DUŠANBE. V práci sa analyzujú a diskutujú radarové pozorovania meteorického roja Lyríd získané na Gissarskom observatóriu pri Dušanbe v rokoch 1982-1986. Aktivita roja je odvodená z rozdelenia vzdialeností ozvien; stredné maximum aktivity zo všetkých návratov roja sa nachádza pri dĺžke Slnka 31°9 /ekvinokcium 1950.0/. Hustota toku meteoroidov Lyríd s hmotnosťami $m \geq 10^{-3}$ g je v okolí maxima rádove $(1\div2).10^{-12}$ $m^{-2}.s^{-1}$.

1. INTRODUCTION

The Lyrid meteor shower belongs to the regular meteor showers with lower activity and a duration of about one week in the second half of April. Although now of moderate activity, the shower has exhibited great meteor showers in the past /Olivier, 1925/. The last enhanced activity return was observed in 1982, both visually /Adams, 1982/ and by radar /Porubčan and Cevolani, 1985; Porubčan and McIntosh, 1987/. From the higher activity returns, it can be inferred that the shower has a more complicated structure and is regularly supplied by its parent comet 1861 I /Thatcher/. Systematic radio observations have revealed that the shower has a variable flux of smaller particles, but a rather stable flux of larger particles, with the maximum appearing at solar longitude $31^{\circ}.7$, epoch 1950.0 /Porubčan, 1986/. For a better understanding of the shower structure, it is necessary to carry out systematic simultaneous observations at different stations. A part of such a program are the Lyrid observations at the Gissar Observatory, the first results of which are discussed in the present paper.

2. EQUIPMENT AND OBSERVATIONS

Systematic radio observations of the Lyrid meteor shower at the Gissar Observatory /$38^{\circ}.6$ N; $68^{\circ}.8$ E/ near Dushanbe, USSR, have been pursued since 1984. Previous observations, also yielded some data on the Lyrids from April 19-23, 1982 during a regular campaign of wind measurements in the meteor zone.

The new Gissar meteor radar began to operate in 1981, recording meteor echoes originally on film. Since then the radar has been modified almost every year, ranging from the automation of the instrument to feed data to a computer to constructing new types of antennas. Consequently, the basic parameters of the radar varied from year to year /Table 1/.

Observations were carried out, as a rule, simultaneously in two mutually rectangular directions /south and west oriented antennas/ until 1985. Therefore, the transmitting power was divided equally between the antennas. In 1986, a special antenna, enabling a better separation of the shower meteors, was put into operation. The antenna was characterized by an attenuated reception of disturbances received at low angles with respect to horizon. With this antenna, the observations were carried out only in one direction, but the antenna was turned to the west and east for 12 hours at the lower and upper transits of the Lyrid radiant, respectively. At these moments, the Lyrid radiant has elevations of $-18^{\circ}.5$ and $84^{\circ}.5$ at Gissar, and the Lyrids cannot be observed. As for the limiting sensitivity of the radar listed in Table 1, this can be decreased considerably by random radio disturbances.

In 1982, meteor echoes were recorded on film, and the data were read off manually. In the following years, an automatic system which stored and then put out the data at the end of each hour was introduced. The output set of data consists of the total number of recorded echoes, their distributions into 14 groups of slant ranges /from 90 to 200 km in 10 km intervals, then at 225, 250 and up to 300 km/ and 14 groups of echo durations within limits equal to $0.01 \times 2^{n-1}$,

Table 1

Parameters	1982	1984	1985	1986
1. Transmitting power in kW (τ = 40 μs, f = 500 imp/s)	22x2=44	22x2=44	13x2=26	25x1
2. Beam width (half power) vertical plane	$\pm 30^{\circ}$	$\pm 30^{\circ}$	$\pm 25^{\circ}$	$\pm 12^{\circ}$
horizontal plane	$\pm(25^{\circ} \div 30^{\circ})$	$\pm(25^{\circ} \div 30^{\circ})$	$\pm 15^{\circ}$	$\pm 15^{\circ}$
3. Elevation of maximum antenna gain	$\sim 45^{\circ}$	$\sim 45^{\circ}$	$\sim 40^{\circ}$	$\sim 48^{\circ}$
4. Antenna gain coefficient ($G_T = G_R$)	~ 12	~ 12	25	48
5. Registration time in each of antenna directions (south and west; in 1986, east and west) in hours	0.5	1	1	1
6. Limiting sensitivity at a signal of U = 8 μV, in stellar magnitudes	6.5	6.5	7.2	8.3
7. Limiting meteoroid mass at $z_R = 45^{\circ}$, U = 8 μV, in grams	6×10^{-4}	6×10^{-4}	3.2×10^{-4}	1.2×10^{-4}
8. Relative number of meteors recorded in one hour (1985 is taken for 1)	0.65	1.3	1	1.4

where n = 1 ÷ 14 /i.e. 0.01; 0.02; 0.04 s, etc., with the last group in the interval of 41-327 seconds/.

Considering specular reflection, the Lyrids can be observed at Gissar by the eastern antenna at 01-05 UT, by the southern antenna at 17-21, 02-06 UT and by the western antenna at 18-22 UT. For persistent trains of overdense echoes, the time of observation is larger by 0.5-1.0 hour /towards the time of transit of the Lyrid radiant at 23.5 UT/.

Lyrid meteors can be distinguished from the sporadic background only with difficulty, especially if a meteor radar with a narrow antenna beam is being used, in which case the separation is based on a comparison of the hourly echo rates derived from shower and sporadic periods. More information about the shower activity can be obtained from the distribution of ranges, taking into account the fact that in both antenna orientations /east and west/, the shower meteors are observed only in a very narrow interval of ranges every hour. This is clearly demonstrated in Fig. 1, where for the westwards oriented antenna, the effective cross-section areas S_{eff}, computed for the mean value of a given hour, are plotted vs. the corresponding ranges. For the eastwards oriented antenna the plots are analogous, but symmetrical with respect to the radiant

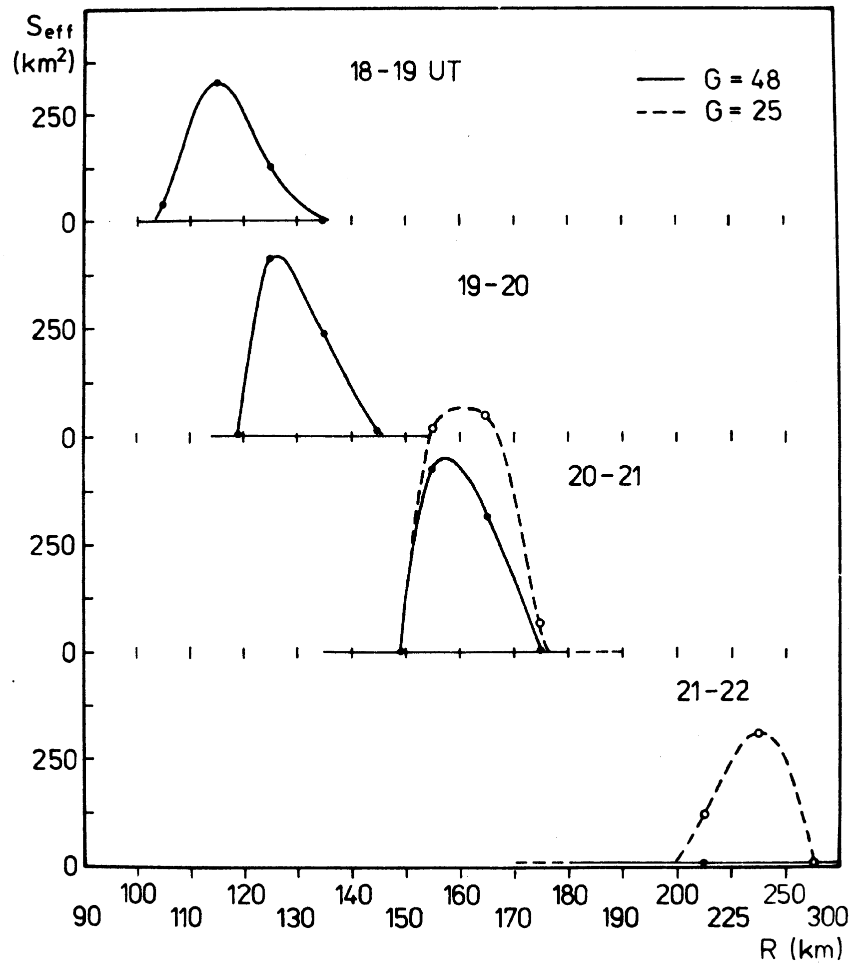

Fig. 1 Dependence of the effective cross-section area of the Gissar meteor radar antenna on the position of the Lyrid radiant /expressed in time, UT/. Curves are computed with a 10 % accuracy of the centres of the corresponding time intervals. The horizontal solid lines represent ranges at which the Lyrid meteors can be observed within the given intervals. At 18-19 and 19-20 UT, the curves of both antennas /G = 48 and G = 25/ are practically the same.

transit. S_{eff} was computed as the area normal to the direction of motion of the shower meteors. As the observed number of shower meteors is proportional to the shower activity and effective area S_{eff}, distribution of ranges of the recorded shower meteors will be analogous.

Figure 1 shows that practically all Lyrid meteors, appearing between 18--19 UT, have to be observed at ranges of 100-135 km, between 19-20 UT, at ranges of 115-155 km, etc. In the interval 18-20 UT the ranges and S_{eff} are practically identical for both antennas with G = 48 and G = 25. In the interval 20-21 UT, an apparent distinction is already observed, and at 21-22 UT and longer ranges, for G = 48 underdense echoes are practically not observed. The range intervals, as well as S_{eff}, should apparently be larger for the antenna with G = 12 than for the antenna with G = 25. This is also valid for all antennas and persistent overdense echoes, where the interval of the recorded ranges of shower meteors and particularly S_{eff} vary. Due to the distortion of persistent trains, the effective overdense echo area S_{ov} may be several times larger than the corresponding geometrical S_{eff}.

3. LYRID ACTIVITY

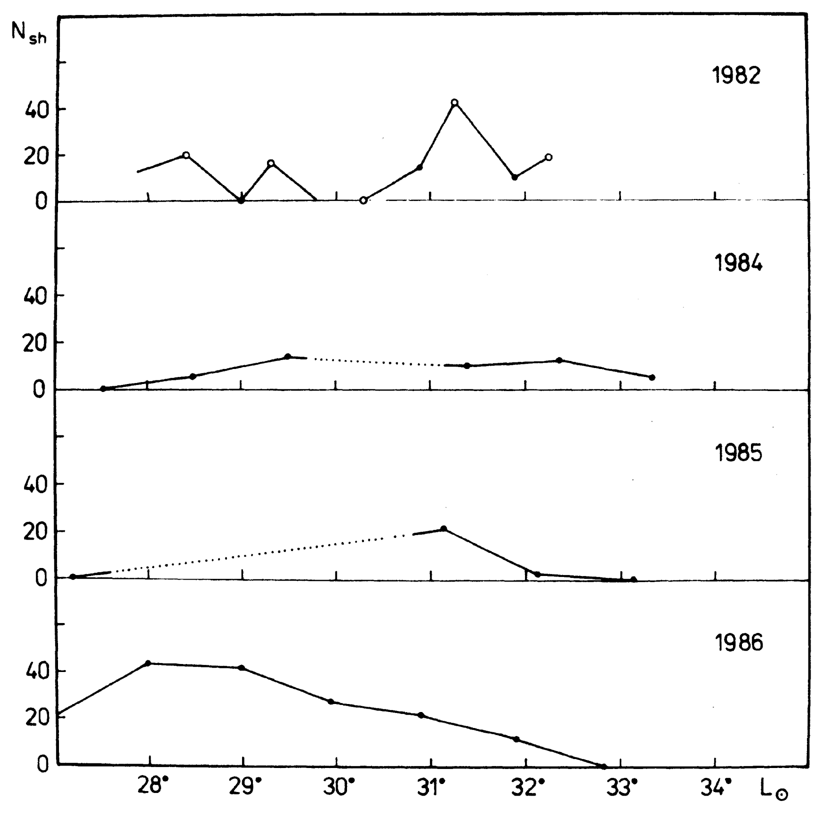

Fig. 2 Variations of the mean hourly rates of the Lyrid meteors observed at Gissar vs. solar longitude /equinox 1950.0/.

Shower activity is normally determined by subtracting the corresponding sporadic background rates from the activity period of the meteor shower. The dates preceding and following the shower are usually taken to be sporadic. As the Lyrids are already contaminated by the Eta Aquarids in the second half of their activity /Millman and McIntosh, 1964/, only the days preceding the Lyrids can be considered as sporadic. Generally, the shower displays lower activity and its statistical separation from the sporadic background on the basis of hourly rates observed in radio observations, is rather difficult. The variations of the mean hourly rates of the Lyrids in the four years, listed in Table 1, obtained in this way are plotted in Fig. 2. The variations were derived from the observed rates covering a period of 4 hours /18-22 UT/ on each day, when the Lyrid meteors entered the westwards-oriented antenna of the Gissar radar. Only in 1982 were the observations also carried out simultaneously with in the southern antenna /circles in Fig. 2/. However, due to various disturbances and interruptions in observations, the data are not complete and the variations are not representable enough to demonstrate the actual pattern of Lyrid activity.

Better results are obtained by applying a method based on range distribution, which does not require complete data records /Porubčan et al., 1986/, to the observations. The method utilizes the fact that the observed range distri-

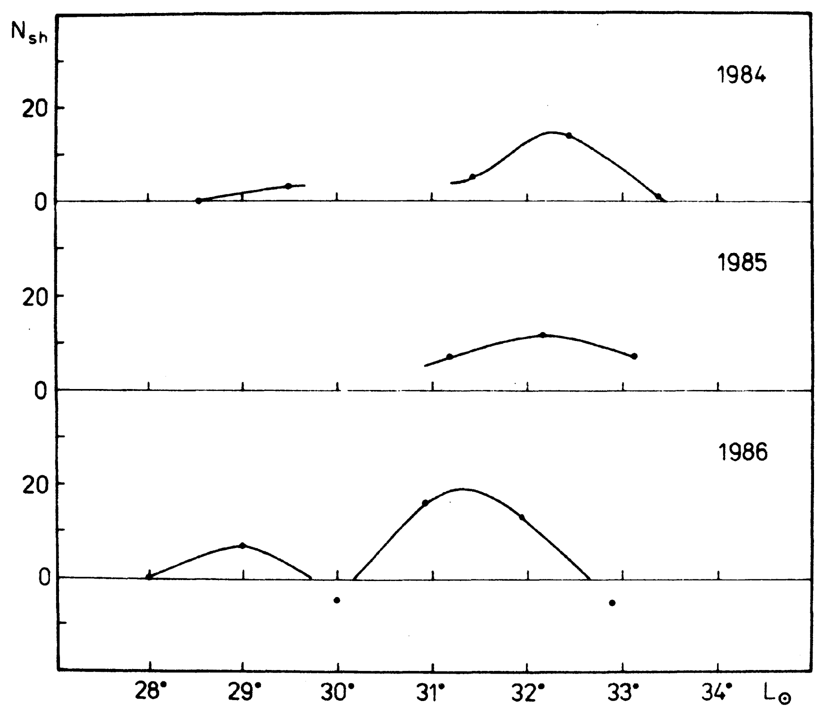

Fig. 3 Variations of the mean hourly rates of the Lyrid meteors obtained on the basis of range distributions vs. solar longitude /equinox 1950.0/.

bution of echoes of a meteor shower strongly depends on the position of the shower radiant with respect to the antenna beam /Fig. 1/. The main problem here is to obtain the ratio of the shower meteors to the sporadic background, omitting the intervals of ranges in which the Lyrid meteors can not be observed.

In Gissar the Lyrid radiant culminates at 23:35 UT. The radar antenna was oriented westwards and eastwards at an elevation of about 45° /Table 1/ and thus optimum conditions for detecting Lyrid meteors occurred about 4 hours be-

Table 2

Date	$L_{1950.0}$	$N_{>145}$	$N_{<145}$	R	R/R_{Sp}	N_{Sh}
April 1984						
19	28°53	15	12	1.20	1	-
20	29.50	24	16	1.50	1.25	2.9
22	31.46	18	11	1.64	1.37	4.2
23	32.43	29.5	11	2.68	2.23	14.2
24	33.40	13.5	10	1.35	1.12	1.4
April 1985						
18	27.30	35	10	3.85	1	-
22	31.21	48.5	10.5	4.62	1.20	7.0
23	32.18	41	8	5.12	1.33	11.6
24	33.16	38.5	8	4.81	1.25	8.7
April 1986						
19	28.02	70	99	0.71	1	-
20	29.00	62.5	77.5	0.81	1.14	7.0
21	29.98	46.5	73	0.64	0.90	-5.0
22	30.96	62	66	0.94	1.32	16.0
23	31.93	56	62.5	0.90	1.27	13.5
24	32.90	33.5	53.5	0.63	0.89	-5.5

fore and after the transit of the radiant. As the post-transit period can already be contaminated by the Eta Aquarid meteors /the Eta Aquarid radiant culminates about 3 hours after the Lyrid radiant/, only the data from the period preceding the culmination of the Lyrid radiant were used for the analysis, i.e. the observations from the westwards oriented antenna. The analysis indicated that the best resolution of the Lyrids can be obtained at the longest ranges, just before radiant transit, at 20-22 UT, when the Lyrids are observed only at ranges exceeding 145 km /Fig. 1/.

The results of the range distribution analysis are summarized in Table 2 and shown in Fig. 3. The 1982 observations could not be analysed in this way as there was no information about the ranges in that year. Columns 1 through 5 of Table 2 list, respectively, the dates of observations, solar longitudes of the centres of the analysed intervals, the mean hourly counts of echoes at ranges greater and smaller than 145 km and their ratios $R = N_{>}/N_{<}$. The first days listed in Table 2 were taken for sporadic /R_{Sp}/, and the ratios R/R_{Sp} clearly demonstrate a higher proportion of the Lyrid meteors in the observations of each year as compared to the sporadic days. The mean hourly echo counts of the Lyrids, N_i, can be derived from the ratios R/R_{Sp} if the number of echoes at ranges larger than 145 km is known from the sporadic period N_{Sp}/$N_{>145}$/:

$$N_i = N_{Sp}\left[R_i/R_{Sp} - 1\right].$$

The values of N_i are listed in the last column of Table 2 and plotted vs. solar longitude in Fig. 3.

4. DISCUSSION

The Lyrid activity in 1984-1986, observed at the Gissar Observatory and resulting from the range distribution analysis, is depicted in Fig. 3. Comparing the results obtained by both methods, it can be concluded that, unless the data are complete and statistically significant, the range distribution analysis is more reliable and provides a much better resolution of the shower from the total echo counts than standard subtraction of the sporadic rates from the shower period. This is clearly illustrated in the 1986 observations. The 1986 variation of the hourly rates presented in Fig. 2 was derived taking the mean rates on April 11 and 17 as the sporadic background. Taking the rates on April 19 /$L_\odot \sim 28^\circ$/ as sporadic should result in no positive contribution of the shower, while in fact by the range distribution analysis the Lyrids are very good resolved.

The Gissar observations have shown that the position of the Lyrid maximum may vary from year to year. However, the mean maximum, compounded of all three returns, lies at a solar longitude of $31\overset{\circ}{.}9$ /epoch 1950.0/, which is in very good agreement with the analyses of larger sets of radio observations which place the mean Lyrid maximum at a solar longitude of $31\overset{\circ}{.}7$ /Porubčan, 1986/.

The results enabled the flux of Lyrid meteoroids to be estimated at the peak activity, which can be approximated by the ratio N_{Sh}/S_{eff}, and which concerns particles with masses $m \geq m_{min}$ /Table 1/. For meteoroids with masses $m \geq 10^{-3}$ g, the resulting fluxes were estimated to 1.7×10^{-12}, 1.1×10^{-12} and $1.3 \times 10^{-12}\ m^{-2}\ s^{-1}$ in 1984, 1985 and 1986, respectively.

REFERENCES

Adams, M.T.: 1982, Meteor News 58, 1.

Millman, P.M., McIntosh, B.A.: 1964, Canad. J. Phys. 42, 1730.

Olivier, C.P.: 1925, Meteors, Baltimore, p. 60.

Porubčan, V.: 1986, in Asteroids, Comets, Meteors, ed. C.I. Lagerkvist, B.A. Lindblad, H.H. Lundstedt and H. Rickman, Uppsala Univ., Uppsala, 527.

Porubčan, V., Cevolani, G.: 1985, Contr. Skalnaté Pleso Obs. 13, 247.

Porubčan, V., Cevolani, G., Formiggini, C.: 1986, Il Nuovo Cimento, Vol. 9C, N. 6, 1062.

Porubčan, V., McIntosh, B.A.: 1987, Bull. Astron. Inst. Czechosl. 38, 313.