Lyrid meteor shower observed by a forward scatter meteor radar

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Abstract. Radio observations of the 1995 Lyrid meteor shower by a forward scatter system on the baseline Bologna-Lecce (Italy) are analysed and discussed. The 1995 Lyrids have shown a distinct maximum only for overdense echoes (echo duration > 1 s) with the peak rate on April 23, 03 UT (solar longitude 31.88°, eq. 1950). The flux of underdense echoes (duration < 1 s) appears to be very variable; the smallest particles (< 0.07 s) follow the trend of the overdense stream activity with an exceptional peak at solar longitude 29° (April 20) and can be ascribed to some kind of fragmentation.

Key words: Lyrid meteor shower – forward scatter radar

1. Introduction

Lyrid meteor shower is observed in the second half of April with a maximum at the solar longitude about 31.5° (April 21-23) and the total activity for a week. The shower moves in an unusual orbit being almost perpendicular onto the ecliptic (i = 79°) and is generically related to comet Thatcher (1861 I, the period of revolution about 415 years).

The longest series of systematic radio observations of the shower analysed so far, extending over almost 30 years, was presented by Porubčan et al. in 1989. The observations mentioned above were obtained by the back scatter radars at Springhill and Ondřejov and the Lyrids appeared to be a meteor shower with a rather stable flux of overdense echoes (duration > 1 s) and a very changeable flux of underdense echoes (duration < 1 s) in both the position of maximum and peak activity. Since a new forward scatter radar system on the baseline Bologna-Lecce (Italy) was introduced for meteor observations, the Lyrid shower observation become a part of a routine observational program of the radar. A detailed analysis of the 1994 Lyrids observed on this baseline has shown a new feature concerning the structure of the shower unknown from the back scatter radar results, namely, an occurrence of very short duration shower echoes (< 0.07 s) at the shower maximum (Porubčan et al. 1995).

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In the present paper we analyse the 1995 Lyrids observed by the forward scatter radar on Bologna-Lecce baseline in order to verify the above result.

2. Forward scatter radar Bologna-Lecce

The CNR forward scatter meteor radar has the transmitting station at Budrio (latitude = 44.6°N) near Bologna and receiving station is at Lecce (latitude = 40.3°N) in the Southern Italy at a distance of 700 km. The system utilizes a CW transmitting frequency of 42,7 MHz, a 1 kW mean power and fixed tone of 1 kHz. The transmitting and receiving Yagi antennas are installed at an elevation angle of about 15° in the Bologna-Lecce direction (azimuth from the north 127°), and consist of 5 horizontally polarized elements. The equipment is described in details elsewhere (Cevolani et al. 1995).

A drawback of the system is that during the recording of an echo the equipment is blocked for another echo appearing at the same time, which may cause certain lowering of the observed echo numbers at higher echo rates as well as some shortening of duration of another echo appearing simultaneously. However, for the rates corresponding to standard Lyrid activity the above effects are not effective.

3. The 1995 Lyrid meteor shower

The 1995 Lyrid shower was monitored continuously from April 19, 22:00 UT and observation continued until May 12 (end of the Eta Aquarid shower activity). Due to a technical problem there was a 9 hour interruption in the observations on April 24, between 15-24 UT and one hour interval on April 25 (06-07 UT) was seriously influenced by disturbances, and therefore, from the analysis was rejected. The overall counts of echoes of both shower and sporadic, recorded by the equipment on April 19-28, are shown in Fig. 1.

Fig. 2 shows the shower activity obtained for three sets of echo duration (>1 s, >8 s and <0.07 s) vs. solar longitude (equinox 1950.0). We shall refer the shower activity for the sake of comparison to 1950 equinox, as all the previous analyses summarizing the Lyrid shower activity are referred to 1950. The curves in Fig. 2a,b are smoothed by a 5-point smoothing procedure, with one hour sampling interval. The shower activity was obtained by subtracting sporadic background counts from the total echo counts in corresponding hours. An inspection of the total flux has revealed that the days starting from April 27 are already contaminated by the Eta Aquarids and so we limited the analysis to April 19-26. For sporadic were chosen data from April 26.

The underdense echo 1995 Lyrid activity (<1 s) has shown to be much dispersed and contrary to the 1994 return of the shower (Porubčan et al. 1995) no pronounced maximum can be observed. This is consistent with the previous analyses exhibiting that the Lyrid underdense echo flux from year to year

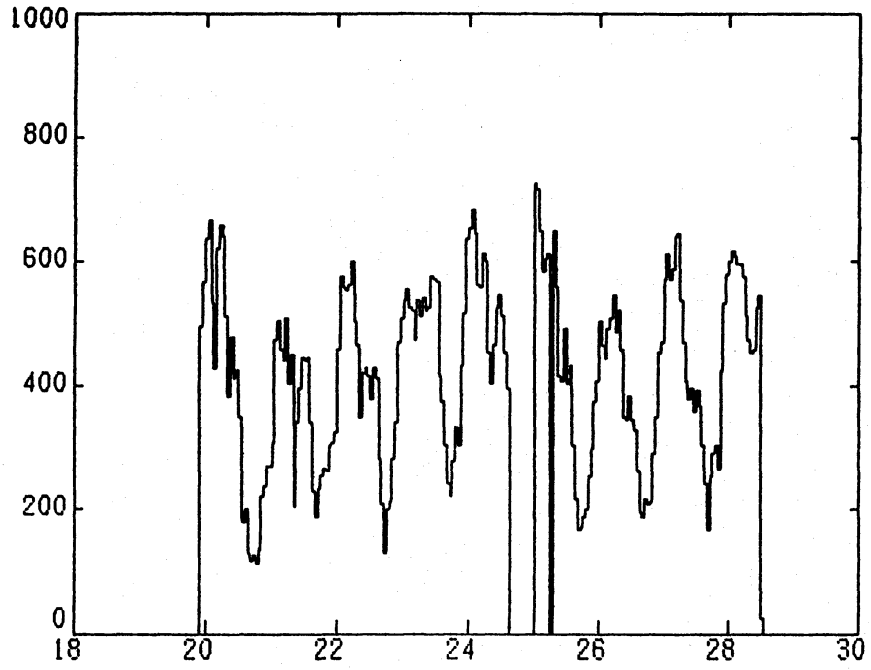

Figure 1. Counts of all echoes registered by the forward scatter radar on the Bologna-Lecce baseline in the period April 19-28, 1995. (*abscissa*: Days of April 1995; *ordinate*: Number of echoes registered per hour.

is much variable. The shower overdense echo maxima (echo duration >1 s and >8 s (Fig. 2a,b) are defined clearly and appeared on April 23.128 UT, solar longitude 31.88° and April 23.253 UT, solar longitude 32.00°, respectively. The maxima correspond to the 10 minute interval with the highest number of shower echoes in the peak hour (Apr. 23, 03:00 – 03:10 UT for echoes >1 s and Apr. 23, 06:00 – 06:10 for echoes >8 s). As the plots in Fig. 2a,b are smoothed, the maxima obtained from general trend of the curves for echoes >1 s and >8 s slightly differ from those obtained above from echo counts in the peak hours and correspond to the solar longitudes of 32.0° and 31.9°, respectively.

In a comparison of the 1994 and 1995 Lyrid activity, while the total flux of overdense echoes was approximately the same, the 1995 activity was rather flat, with a peak rate about half of that in 1994. Except of this, there is an evident shift between the position of the shower maxima. As the 1994 maximum for echoes >1 s appeared at the solar longitude 31.54° (1950.0), the shift is 0.34°, rather large with respect to the mean maximum derived from the back scatter data covering almost 30 years (Porubčan et al. 1989) at 31.5°. Amateur radio observation of the 1995 Lyrids on April 21-24 in Finland by Ilkka Yrjola is also in favour of a later Lyrid activity, with the overall counts of reflexions being

generally higher on April 23, between 0 – 9 UT (Steyaert 1995).

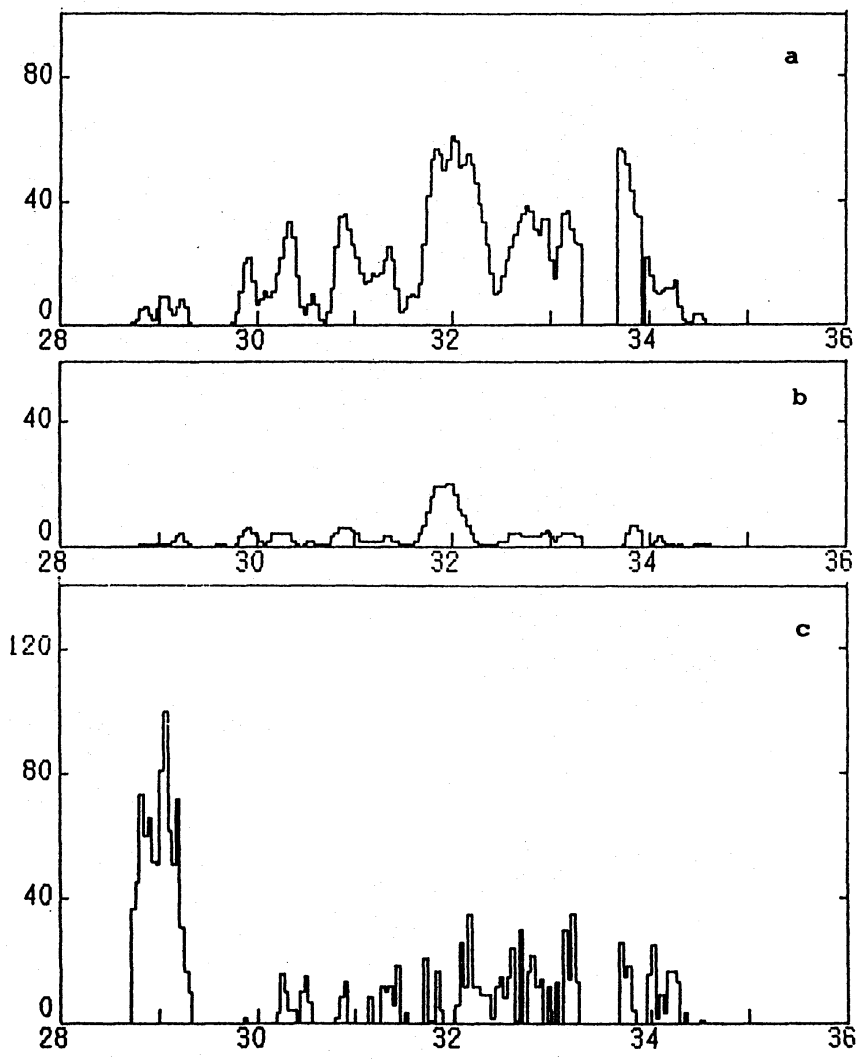

Figure 2. The Lyrid meteor shower observed by the Bologna-Lecce forward scatter radar for three echo duration groups: (a) Overdense echoes of duration > 1 s, (b) overdense echoes of duration > 8 s, (c) underdense echoes of duration < 0.07 s. The plots depict the hourly echo counts (*ordinate*) vs. solar longitude in degrees (*abscissa*) for equinox 1950.0.

4. Discussion

The forward scatter radar observation of the 1994 Lyrids on the Bologna-Lecce baseline has revealed an occurrence of very short duration echoes (< 0.07 s) with a peak just at the shower maximum. Such a short duration echoes could not be

read off reliable from a film record of a back scatter radar while an automated regime of a forward scatter radar has enabled a reduction also echoes of such a short duration. The simplest explanation of the existence of the echoes may be a fragmentation process in the atmosphere. The 1994 Lyrid data still left some space for speculation about possible connection of the tiny particles with the stream itself. The 1995 result, for the sake of comparison also for echoes < 0.07 s, is presented in Fig. 2c. The curve of activity follows the trend of overdense echoes with an exception of a high peak on April 20 (solar longitude 29°). This peak is evident also in a comparison of the larger underdense (< 1 s) and overdense echoes (> 1 s), and as we could not explain its occurrence by instrumental effects, it could demonstrate real inhomogeneity in the spatial structure of the underdense Lyrids reported earlier.

A presence of still smaller particles corresponding to echo duration smaller than 0.07 s in the present Lyrid stream, being over 130 years beyond the parent comet, is questionable. From the general stream evolution (Kresák 1976, Williams 1993, 1995), the smallest particles are leaving the stream very soon after their ejection due to the direct radiation pressure and other non-gravitational effects. Thus their occurrence in a stream would mean recent origin what is very difficult to suggest for the 1995 Lyrids, unless some secondary fragmentation or disintegration of meteoroids to still smaller particles, on their orbit in space, is not a continuous process. However, for a more conclusive explanation of the occurrence of the shortest echoes in a forward scatter radar record, further observations are needed.

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