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Analysis of the Lyrids' meteor stream structure for long timeslots

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Abstract

Lyrids' structural parameters (luminosity function parameter r of meteors distribution magnitudes, the S parameter distribution of meteoroids in the mass flow, zenithal hour number (ZHR)) are determined by visual observations made in the 1900–2007 interval. The minimal value of S is equal to 1.54 ± 0.02 and corresponds to the Sun longitude $32.19° \pm 0.04°$. Lyrids' activity profiles as ZHR depending on the Sun longitude (L) were constructed for studying the flow activity. ZHR averaging for the individual values was held according the observation in 1900–1963, 1900–2000, 2001–2007 and 1900–2007. The peak position for all groups is the same within the error and equal to $32.326° \pm 0.107$. Two periods of Lyrids activity were revealed: a period which is close to 60 years; and s period of about 10–12 years.

Keywords: Meteoroids; Meteoroid streams; Small bodies of the solar system; The orbits evolution

1. Introduction

At the present time solutions for the questions connected with the structural parameters of meteor showers evolution are important and essential (Sokolova et al., 2013, 2014). The Thatcher 1861 I comet, with an orbital period of 415 years, is the parental comet of Lyrids. Lyrids are observed from 16 to 25 April, and have a low annual activity. However, in some years, the flow activity increases, and it is not associated with the comet's approach to the Sun. Four bursts of the flow activity have been reported and described in the literature in 1803, 1922, 1946 and 1982. Authors' works such as (Arter and Williams, 1995, 1997, 2002), and also articles such as (Emelyanenko, 2001) and (Rendtel and Arlt, 2007) which were dedicated to the study of Lyrids' stream activity. In these papers the 12-year cycle of the stream activity and its possible causes, primarily related to Jupiter's influence on the meteoroids' motion in the stream, are discussed. Another interesting point is that Lyrid' meteor stream was registered in the year 687 B.C. and has a quite low activity. However in some years the activity of Lyrid' meteor stream greatly exceeds its mean value. These spikes take place with a period of 12 years. The activity spikes of Lyrid' meteor stream cannot be explained within the approximation of parent comet close to the Earth, since its period is about 400 years. The observed periodicity can be explained by certain circular rotation of the Lyrid' meteor stream structure.

Thus, as a rule, the main research method is the simulation of possible scenarios of Lyrids' meteoroid swarm formation and its further evolution. The study of the shower structure by visual observations, obtained over a long time interval, allows us to clarify the period of the periodic activity of the Lyrids.

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2. The determination of the meteors luminosity function and the mass distribution parameters

Lyrids' structural parameters (luminosity function parameter of r meteors distribution magnitudes, the S parameter distribution of meteoroids in the mass flow, zenithal hour number ZHR) are determined by visual observations of Lyrids, made in 1987–2007, under the aegis of the International Meteor Organization (IMO), as well as earlier observations, which were published in various sources.

S parameter of the meteors mass distribution is defined in the following form:

$$S = 1 + 2.5 \lg r, \quad (1)$$

where the value of function of r luminosity in visual observations is found by the distribution of meteors' magnitudes obtained by an observer for each night of observation.

The method of r and S parameters definition by visual observations is described in detail in Belkovich et al. (2001) and Belkovich and Ishmukhametova (2006).

According to the most statistically secured observations made in 1987–2007, and published on the International Meteor Society (IMS) website for each year of the observations, S individual values calculated by formula (1) were averaged over intervals of the Sun's longitude, taking into account the balance.

At the first stage, S values were averaged separately for each year and in the observation groups in 1987–1999 and in 2000–2007 (Fig. 1). The comparison of S values in each group showed that the results agree with each other within the errors. Thus, the average S curve as a function of the Sun's longitude was derived by averaging all the 1987–2007 observations (Fig. 1: firm line).

Fig. 1 shows averaged values of the parameter S Lyrids, by visual observation in 1987–1999, 2000–2007 and 1987–2007. In contrast to the start period and the end of the air flow, the interval of the Sun's longitude 31°-33° is well provided by observations, so S parameter is held by the

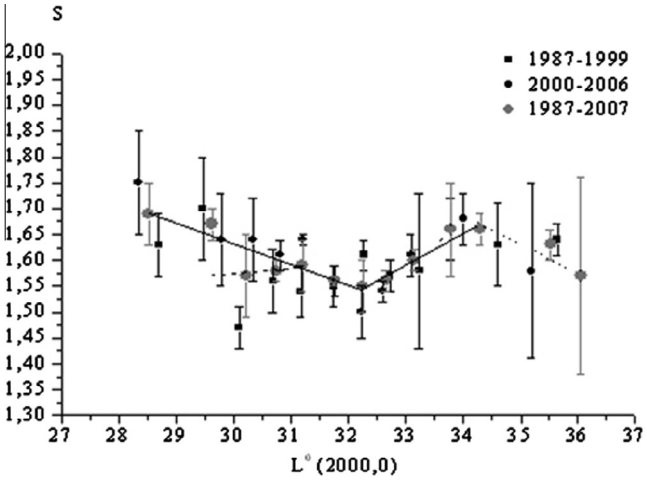

Fig. 1. Averaged values of the parameter S Lyrids.

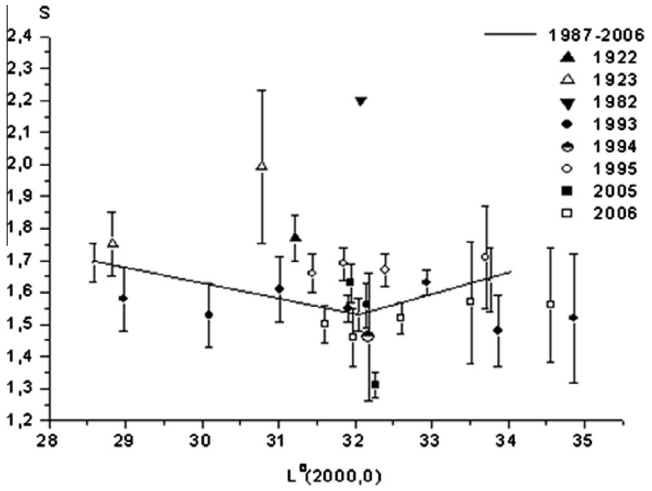

Fig. 2. S parameter from the observations of Lyrids in different years (Firm line – according to visual observations 1987–2007).

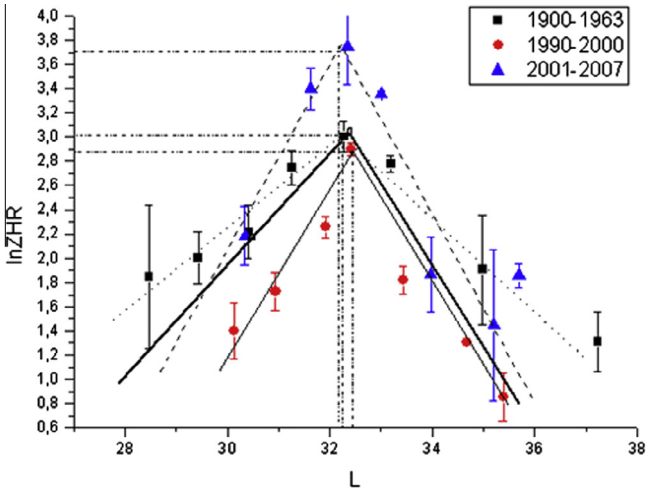

Fig. 3. ln (ZHR) averaged values for the Lyrids' flow by visual observations 1901–1972 (...), 1990–2009 (-) and 2001–2007 (—), solid thick line 1901–2007.

dotted line for these areas (Fig. 1). The minimum value of S is equal to 1.54 ± 0.02 and corresponds to the Sun's longitude $32.19° \pm 0.04°$.

Descending and ascending branches performed by the least-squares method are described by the equations:

$$S = S_{min} + 0.04|L - L_{min}|,$$
$$S = S_{min} + 0.05|L - L_{min}|. \quad (2)$$

The values of the S parameter, which were obtained by other authors on the visual and radar observations of the Lyrids, are in the range of 1.54–1.93, which agree with derived values.

Based on the 12-year period of the Lyrids' activity, we can analyze the value of S parameter in 1922, 1994 and 2006, compared to the average curve, which was obtained according the observations of 1987–2007 (Fig. 2). Fig. 2 also shows S values for adjacent 1923, 1993, 1995 and