All-sky video orbits of Lyrids 2009

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Abstract

We report observational results of the Lyrid meteor shower observed by the double station all-sky video system in the night of April 21/22, 2009 at the Astronomical and Geophysical Observatory of the Comenius University in Modra and Arboretum, Tesárske Mlyňany, Slovakia. This observation was the first test of the double stations and orbit determination method within the frame of the new Slovak Video Meteor Network (SVMN). We present the whole set of 17 observed orbits of Lyrids as well as the five most precise orbits in detail form. The comparison with the known datasets, precise photographic IAU MDC and SonotaCo video orbits, demonstrate quite good consistency and similar quality.

**Key words:** interplanetary medium - meteors: meteoroids - meteor showers: individual (Lyrids) - all-sky observation - orbits

1. Introduction

The fish-eye video meteor system at Astronomical and Geophysical Observatory (AGO) in Modra, Slovakia, has started regular observations on April 1, 2007. The system was originally developed at our institute and consists of a fish-eye Canon 2.4/15 mm objective, 2" Mullard image intensifier, Meopta 1.9/16 mm lens. The observation presented here were done by the Watec 120N camera. The analog video signal is digitized in the real time and analyzed by the UFOCapture software (author SonotaCo, http://sonotaco.com/e_index.html), which is able to detect any moving objects including meteors. The resolution of the system is $720 \times 540$ pixels (15 arcmin/px), corresponding to a field of view of $170^\circ \times 140^\circ$. The limiting stellar magnitude is $+5.5^m$ and meteors up to the magnitude $+3.5^m$ are detected. The astrometric precision of reference stars is in average $\sim 5$ arcmin by using few hundreds reference stars. The system operates autonomously (Tóth et al. 2008).

The second station, at the time of the observation equipped with the same opto-electronical system and a Watec 902 H2 analog camera, is located at the Arboretum of the Slovak Academy of Sciences, Tesárske Mlyňany, 80 km in the East direction from Modra. The second station is semiautomatic and is controlled through the internet (remote network access). Both video stations, Modra and Arboretum, constitute the base of the new developing Slovak Video Meteor Network.

2. Observations and data analysis

The observation of Lyrid meteor shower, at the night of April 21/22, 2009 from 19:15 to 2:20 UT, was the first observational test of double stations operation and following orbit calculation. We obtained reliable observational data covering a substantial part of the maximum of Lyrid’s activity. The data were analyzed by the UFO Analyzer and the UFO Orbit software (http://sonotaco.com/e_index.html). We detected 78 and 52 meteors from the first and the second station, respectively. 32 meteors were simultaneously observed at both stations, 17 of them were identified as Lyrids.

The orbits of Lyrids from Modra – Arboretum are consistent with those previously derived by several authors (see Jenniskens 2006, p. 702) and are presented in figure 1 (black line). The orbital element distributions are depicted by using a B-spline technique. The observed 17 Lyrids are compared with 17 IAU MDC photographic orbits (Lindblad et al. 2003) and 75 Lyrids from the SonotaCo Japanese database of video orbits (http://sonotaco.jp/doc/SNM/) obtained in 2007 - 2009. The orbits from SonotaCo database represent the most precise subset of Lyrids in the database selected by the high quality criteria (Vereš & Tóth 2010).

Nevertheless, there are some hyperbolic orbits in all three datasets. The IAU Meteor Database contains 35%, SonotaCo 8% and our data 35% Lyrids on hyperbolic orbits. However, the hyperbolicity of meteors might not be real. According to Hajdúková (2008), the most probable reason is the uncertainty in velocity determination, shifting a part of the data through the parabolic limit. Therefore, only elliptic orbits in the distribution of semimajor axis in figure 1 are presented.

Analogically to Porubčan et al. (2007), we have divided the observed Lyrids into three groups, short periodic (< 200 years), long periodic (> 200 years) and hyperbolic orbits. The mean orbital elements are presented in table 1. Their standard deviations are rather small except for semimajor axis, which is very sensitive for a precise de-
Fig. 1. The distribution of the orbital elements (eq. 2000.0) of Lyrid meteors (q, e, i, ω, a) as well as the geocentric velocity of precise IAU MDC photographic orbits (Lindblad et al. 2003), SonotaCo Japanese database (http://sonotaco.jp/doc/SNM/) for 2007-2009 and observations from Modra – Arboretum (AGO), 2009. The semimajor axis graph contains mean motion resonances with Saturn.
termination of the geocentric velocity. The long periodic part of the stream is very close to the orbit of the parent comet Thatcher within the standard deviation intervals. Our data are consistent and of similar quality as other data sets of Lyrids (figure 1, or Koten et al. 2003). Table 2 presents five most precise Lyrid orbits in detail. The radiant positions of individual Lyrids from Modra and from SonotaCo database are presented as well as with the radiant from IAU MDC (Porubčan et al. 2007). The observed number of 17 Lyrids was not sufficient for a daily motion determination of the Lyrid meteor shower, that is why we used 75 most precise Lyrids from SonotaCo database with individual radiant information. The equation (1) describes this motion in right ascension and declination:

\[
RA = 272.6^\circ \pm 1.2^\circ, DC = 33.2^\circ \pm 0.8^\circ
\]

where 1.25° ± 0.26°, and -0.22° ± 0.18° is the daily motion in RA and Dec, respectively. In comparison with the work of Porubčan et al. (2007), the motion in RA is a bit higher from SonotaCo data.

2.2. Beginning and terminal heights of Lyrids

The specific physical characteristics of the meteors, the atmosphere interaction, the beginning and the terminal heights as a function of the absolute brightness of Lyrids (figure 3), are studied. This relation has not been inspected yet. On the picture, there are depicted SonotaCo data and Modra and Arboretum data matching quite well. When we have investigated the heights of Lyrids in our data set, they behave similarly to SonotaCo data set. For the improvement of our results from the statistical reasons, we decided to show the beginning and terminal heights as a function of the absolute brightness from both data sets, which follows the equations:

\[
\text{Author, Year).}
\]

Table 1. Mean values and standard deviations of the orbital elements, geocentric radiants (eq. 2000.0) and velocities for the short (<200 years), long (>200 years) periodic and hyperbolic subset of observed Lyrid meteors on the base of Modra - Arboretum, April 21/22, 2009. The same parameters of the parent comet C/1861 G1 (Thatcher) are displayed for the comparison (Marsden 1989).

| Type       | a (AU) | q (AU) | e  | i (°) | ω (°) | Ω (°) | α (°) | δ (°) | \(V_g\) (km/s) | \(M_{abs}\) |
|------------|--------|--------|----|-------|-------|-------|-------|-------|----------------|------------|
| short-periodic | 14.46  | 0.912  | 0.19 | 78.7  | 216.0 | 31.9  | 271.3 | 33.2  | 46.07          | 8          |
|            | ±4.71  | ±0.026 | ±0.044 | ±0.9 | ±4.7  | ±0.1  | ±1.9  | ±1.5  | ±0.76          | 8          |
| long-periodic | 52.90  | 0.919  | 0.982 | 79.0  | 214.1 | 31.9  | 271.3 | 33.7  | 46.77          | 3          |
|            | ±13.50 | ±0.006 | ±0.004 | ±1.1  | ±1.1  | ±0.1  | ±1.0  | ±0.3  | ±0.48          | 3          |
| hyperbolic | 0.930  | 0.105  | 33.7  | 32.7  | 33.5  | 47.9  | 6     |       | 47.08          | 6          |
|            | ±0.018 | ±0.062 | ±3.1  | ±3.7  | ±0.1  | ±2.4  | ±1.6  | ±1.75 |               | 6          |

Table 2. Mean values of the orbital elements, geocentric radiants (eq. 2000.0) and velocities and the absolute magnitudes of the five most precise orbits of observed Lyrids on the base Modra - Arboretum, April 21/22, 2009.

| Date-Time   | a (AU) | q (AU) | e  | i (°) | ω (°) | Ω (°) | α (°) | δ (°) | \(V_g\) (km/s) | \(M_{abs}\) |
|-------------|--------|--------|----|-------|-------|-------|-------|-------|----------------|------------|
| 20090422 211532 | 7.44   | 0.922  | 0.876 | 79.4  | 214.6 | 31.80488 | 272.8 | 33.1  | 45.96          | +0.0       |
| 20090422 205955 | 9.98   | 0.922  | 0.908 | 78.5  | 214.3 | 31.91625 | 272.1 | 33.7  | 45.84          | -1.5       |
| 20090422 010531 | 49.83  | 0.914  | 0.982 | 77.7  | 215.2 | 31.92006 | 270.2 | 34.1  | 46.21          | -2.9       |
| 20090422 013515 | 67.66  | 0.918  | 0.986 | 79.5  | 214.3 | 31.94020 | 271.5 | 33.4  | 47.02          | -2.5       |
| 20090422 015213 | 20.40  | 0.930  | 0.954 | 78.0  | 212.2 | 31.95169 | 272.1 | 34.6  | 46.05          | -3.1       |
The beginning and the terminal heights of 75 SonotaCo Lyrids (white triangles) and 17 Lyrids from Modra and Arboretum (black triangles) as a function of the absolute brightness.

\[
\begin{align*}
H_B &= 105.2(\pm 0.6) - 0.5(\pm 0.3) M_A \\
H_E &= 92.2(\pm 0.8) + 2.8(\pm 0.4) M_A,
\end{align*}
\]

where \(H_B\) stands for the beginning height, \(H_E\) for the terminal height and \(M_A\) for the absolute brightness. Beginning heights almost do not depend on the absolute brightness, however, terminal heights decrease with the increasing brightness. Koten et al. (2004) showed, that beginning heights of Perseids, Leonids, Orionids and Taurids increase as a function of the photometric mass. On the contrary, beginning heights of Geminids almost do not change with the photometric mass. According to Koten et al. (2004), all Geminids start to ablate in about 100 km, meaning, that their meteoroids are more rigid and ablate near the melting point of the silicates. It is accepted that Lyrids are of cometary origin but their beginning heights behave in the similar way to Geminids.

3. Discussion

It seems that previous division of Lyrids for short and long periodic orbits would need some revision. According to the SonotaCo data, the semimajor axis distribution shows possible resonant effects. The first and second peak (figure 1, lower right) are close to 1:1 (9.6 AU) and 1:2 (15.1 AU) mean motion resonances with Saturn. Also the first two gaps at 13.3 AU and 22.5 AU are close to 3:5 and 2:7 mean resonances with Saturn. The heliocentric distances of ascending nodes lie mainly in the range of 6 - 10 AU, therefore the influence of both giant planets, Jupiter and Saturn, is significant. The position of mean motion resonances with Saturn do no match perfectly to peaks and gaps of Lyrid’s semimajor axis distribution, but are relatively close. However, more high quality observational data and following precise dynamical inspection would be needed for a conclusive statement.

4. Conclusions

The first Modra – Arboretum double station all-sky video meteor observation test within the frame of the new Slovak Video Meteor Network (SVMN) shows reliable results and should provide a good quality orbits for the future detail studies. The obtained data are comparable with other known databases (IAU MDC, SonotaCo).

Further improvement of the data quality will be achieved in the close future by the digital video camera with the higher resolution. Currently, we are testing the digital CCD camera DMK 41BU02 instead of the analog one. The resolution of the all-sky video system is then 1280x960 pixels with the frame rate 15 per second.

The Lyrid meteor stream structure seems to be more complex as it was considered in previous works. Currently, the number of precise orbits of Lyrids is not so high for more detail theoretical studies. The beginning heights of Lyrids do not depend strongly on the absolute brightness. This behavior is similar to Geminids.

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