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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 on the night of 2009 April 21/22 at the Astronomical and Geophysical Observatory of the Comenius University in Modra and Arboretum, Tesárske Mlyňany, Slovakia. This observation was the first test of 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. A comparison with the known datasets, precise photographic IAU MDC and SonotaCo video orbits, demonstrate quite good consistency and similar quality.

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

1. Introduction

The fish-eye video meteor system at Astronomical and Geophysical Observatory (AGO) in Modra, Slovakia, started regular observations on 2007 April 1. 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 observations presented here were made using the Watec 120N camera. The analog video signal was digitized in real time, and analyzed by UFOCapture software (author SonotaCo[1]), which is able to detect any moving objects, including meteors. The resolution of the system is 720 × 540 pixels (15′/pixel), corresponding to a field of view of 170° × 140°. The limiting stellar magnitude is $+5\overset{\mathrm{m}}{.}5$ and meteors up to a magnitude of $+3\overset{\mathrm{m}}{.}5$ are detected. The astrometric precision of reference stars is on average ∼ 5′ by using a few hundred reference stars. The system operates autonomously (Tóth et al. 2008).

The second station, at the time of an 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 East 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, on the night of 2009 April 21/22 from 19:15 to 2:20 UT, was the first observational test of double-station operation and following orbit calculations. 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.[1] We detected 78 and 52 meteors from the first and second stations, respectively; 32 meteors were simultaneously observed at both stations, and 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 were compared with 17 IAU MDC photographic orbits (Lindblad et al. 2003) and 75 Lyrids from the SonotaCo Japanese database of video orbits[2] obtained in 2007–2009. The orbits from the SonotaCo database represent the most precise subset of Lyrids in the database selected by 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 Hajduková (2008), the most probable reason is the uncertainty in the velocity determination, shifting a part of the data through the parabolic limit. Therefore, only elliptic orbits in the distribution of the semimajor axis in figure 1 are presented.

Analogically to Porubčan et al. (2007), we divided the observed Lyrids into three groups: short periodic (< 200 yr), long preriodic (> 200 yr) and hyperbolic orbits. The mean orbital elements are presented in table 1. Their standard deviations are rather small, except for the semimajor axis, which is very sensitive for a precise determination 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 with and of similar quality to other data sets of Lyrids (figure 1, or Koten et al. 2003). Table 2 presents the five most precise Lyrid orbits in

[1] ⟨http://sonotaco.com/e_index.html⟩.

[2] ⟨http://sonotaco.jp/doc/SNM/⟩.

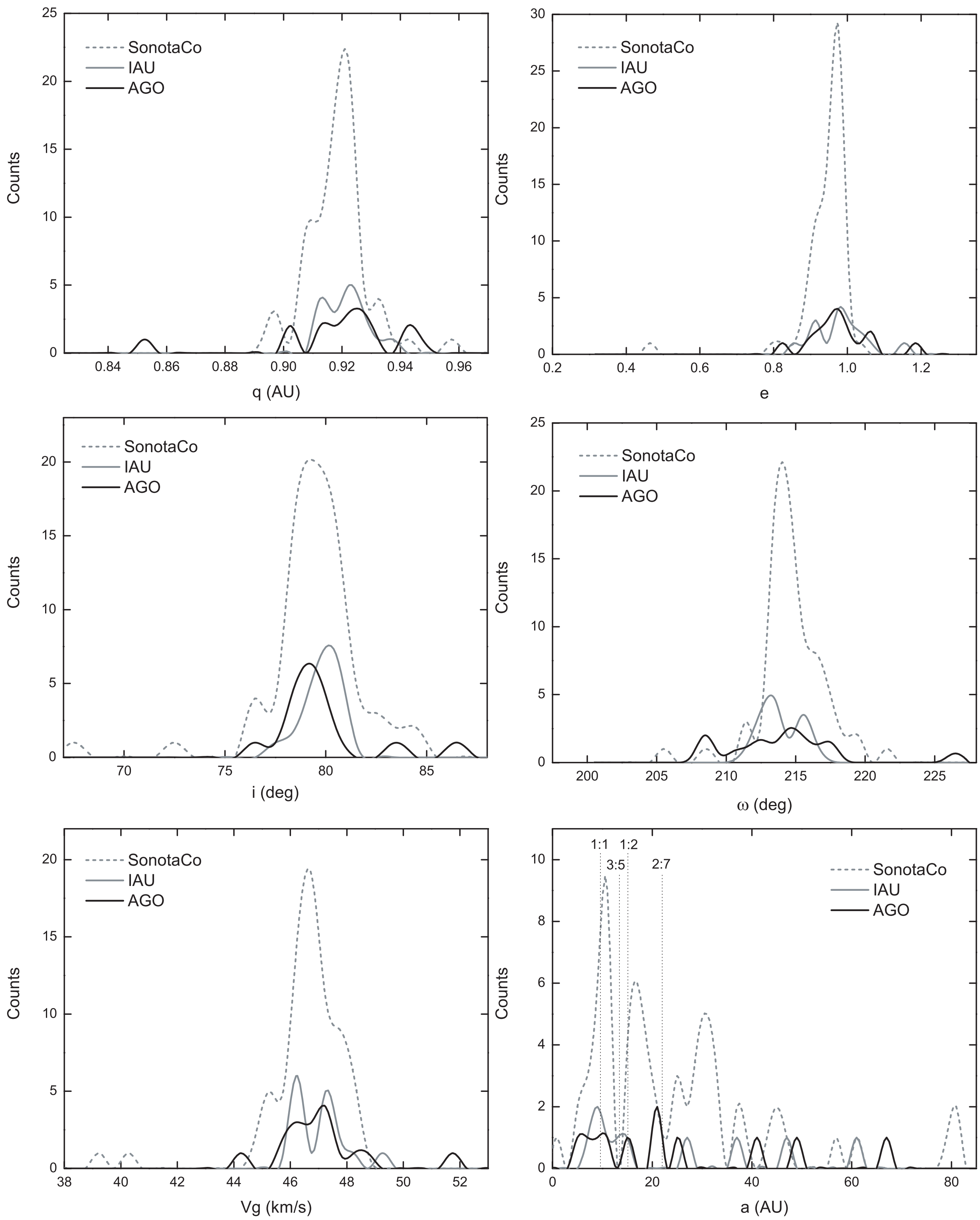

Fig. 1. Distribution of the orbital elements (eq. 2000.0) of Lyrid meteors (q, e, i, ω, a) as well as the geocentric velocity of precise IAU MDC photographic orbits (Lindblad et al. 2003), SonotaCo Japanese database[2] for 2007–2009 and observations from Modra–Arboretum (AGO), 2009. The semi-major axis graph contains the mean motion resonances with Saturn.

Table 1. The mean orbital elements.

	a (AU)	q (AU)	e	i (°)	ω (°)	Ω (°)	α (°)	δ (°)	V_g (km s^{-1})	n
Short-periodic	14.46	0.912	0.919	78.7	216.0	31.9	271.3	33.2	46.07	8
	±7.16	±0.026	±0.044	±0.9	±4.7	±0.1	±1.9	±1.5	±0.76	
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	
Hyperbolic	–	0.930	1.065	81.1	211.2	31.8	272.6	33.5	48.39	6
		±0.018	±0.062	±3.1	±3.7	±0.1	±2.4	±1.6	±1.75	
Comet Thatcher	55.62	0.921	0.984	79.8	213.5	31.9	272.0	33.5	47.08	

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

Table 2. Five most precise Lyrid orbits.

Date-Time	a (AU)	q (AU)	e	i (°)	ω (°)	Ω (°)	α (°)	δ (°)	V_g (km s^{-1})	M_{abs}
20090421 221532	7.44	0.922	0.876	79.4	214.6	31.80488	272.8	33.1	45.96	+0.0
20090422 005955	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 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, 2009 April 21/22.

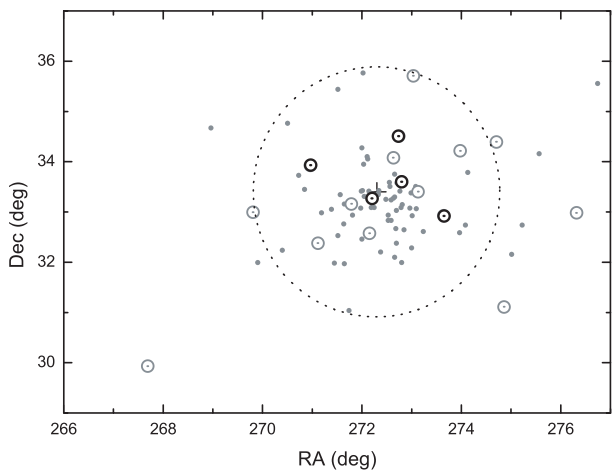

Fig. 2. Radiant distribution in the equatorial system (eq. 2000.0) of individual 17 Lyrid meteors (⊙) observed from Modra–Arboretum, 2009 April 21/22. Gray small dots are radiant positions from SonotaCo data. The expected radiant position and 5-degree circular area are depicted. The data are shown with respect to the solar longitude, 32.°5.

detail. The high-quality criteria were adapted according to Vereš and Tóth (2010).

2.1. *Radiant Positions*

The radiant positions of individual Lyrids from Modra–Arboretum and from SonotaCo database are presented in figure 2. The mean radiant derived from our 17 Lyrids for the mean solar longitude of the time of the observation, 31.°9, is as follows: RA = 271.°8 ± 2.°0, Dec = 33.°4 ± 1.°3.

For comparisons with other authors, we recalculated the obtained mean radiant position to solar longitude 32.°5, the usual time of the Lyrid's maximum activity, using equation (1). Our new radiant position is 272.°6, 33.°2, which is consistent with the SonotaCo radiant RA = 272.°4 ± 1.°2, Dec = 33.°2 ± 0.°8 from 75 Lyrids 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 of the most precise Lyrids from the SonotaCo database with individual radiant information. Equation (1) describes this motion in right ascension and declination:

$$\mathrm{RA} = 272.^\circ4 + 1.25\,(L_\odot - 32.^\circ5),$$
$$\mathrm{Dec} = 33.^\circ2 - 0.22\,(L_\odot - 32.^\circ5), \qquad (1)$$

where 1.°25 ± 0.°26, and −0.°22 ± 0.°18 is the daily motion in RA and Dec, respectively. Compared with the work of Porubčan et al. (2007), the motion in RA is slightly higher than 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), have been studied. This relation has not yet been inspected. On the picture, there are depicted SonotaCo data and Modra and Arboretum data, which match quite well. When we investigated the heights of Lyrids in our data set, they behave similarly to the SonotaCo data set. To improve our results for statistical reasons, we decided to show the beginning and

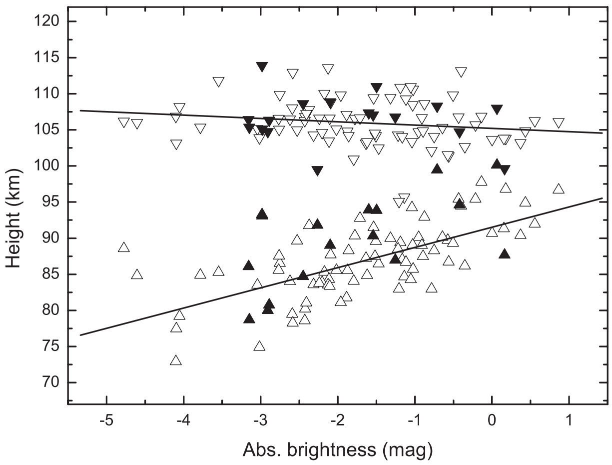

Fig. 3. Beginning and terminal heights of 75 SonotaCo Lyrids (white triangles) and 17 Lyrids from Modra and Arboretum (black triangles) as a function of the absolute brightness.

terminal heights as a function of the absolute brightness from both data sets, which follow:

$$H_\mathrm{B} = 105.2(\pm 0.6) - 0.5(\pm 0.3)\ M_\mathrm{A},$$
$$H_\mathrm{E} = 92.2(\pm 0.8) + 2.8(\pm 0.4)\ M_\mathrm{A}, \quad (2)$$

where H_B stands for the beginning height, H_E for the terminal height and M_A for the absolute brightness. The beginning heights almost do not depend on the absolute brightness; however, the terminal heights decrease with increasing brightness. Koten et al. (2004) showed that the beginning heights of Perseids, Leonids, Orionids and Taurids increase as a function of the photometric mass. On the contrary, the beginning heights of Geminids almost do not change with the photometric mass. According to Koten et al. (2004), all Geminids start to ablate within about 100 km, meaning that their meteoroids are more rigid and ablate near to the melting point of the silicates. It is accepted that Lyrids are of cometary origin, but their beginning heights behave in a 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 peaks (figure 1, lower right) are close to 1:1 (9.6 AU) and 1:2 (15.1 AU), the mean motion resonances with Saturn. Also, the first two gaps at 13.3 AU and 22.5 AU are close to the 3:5 and 2:7 mean resonances with Saturn. The heliocentric distances of the 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 the mean motion resonances with Saturn does no perfectly match to the peaks and gaps of Lyrid's semimajor axis distribution, but are relatively close. However, higher quality observational data and following a 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 good-quality orbits for future detailed studies. The obtained data are comparable with that of other known databases (IAU MDC, SonotaCo).

Further improvement of the data quality will be achieved in the near future by using a digital video camera with higher resolution. Currently, we are testing the digital CCD camera DMK 41BU02 instead of an analog one. The resolution of the all-sky video system is then 1280 × 960 pixels with a frame rate of 15 per second.

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

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