Lyrids – analyses of worldwide video data

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In the paper, an analysis of 1616 mostly video orbits of Lyrids is presented. We confirmed an existence of a short and long-period part of the stream. However, the dispersion in semimajor axis and eccentricity is quite large. So based on a distribution in semimajor axis, the short-period part of Lyrids is divided into nine group. Moreover, the distribution suggests a fainter structure of the short-period part which might be caused by resonant effects with giant planets.

1 Introduction

The Lyrids are a regular meteor shower active in April 16-26 with a maximum around April 21-22. Shower's zenital hourly rates are mostly low, of 5 to 20 meteors. The Lyrids are connected to the comet C/1861 G1 Thatcher. In spite of that the Lyrids are known about 2500 years, the structure and evolution of the stream is not well understand.

Together with a development of observational video technique, new catalogues of meteor orbits are created. In contrast to photographic ones, video catalogues contain of about one order more meteor orbits. Considerably higher number of video Lyrids allows us to perform a more detail analysis.

2 TV data of Lyrids

Based on available sources and personal communication, 1616 orbits of Lyrids from seven catalogues have been collected (Table 1). The data come from the following catalogues: CAMS, Cameras for Allsky Meteor Surveillance (Jenniskens et al., 2011), CMN, Croatian Meteor Network (Korlević et al., 2013), CVMO, Catalogue of video meteor orbits (Koten et al., 2003), DMS, Dutch Meteor Society (Betlem et al., 1998), EDMOND, European viDeo MeteOr Network Database (Kornoš et al., 2013), 17 photographic orbits from IAU MDC Catalogue (Lindblad et al., 2003) and SonotaCo Network (SonotaCo, 2009).

A homogenization of data in each orbital element (q, a, e, I, w, W), radiant position (Ra, Dec) and geocentric velocity (V_g) was made by using a 3-sigma criterion. Resulted data set contains 1412 orbits, in which 305 (21.6 %) are hyperbolic ($e > 1$) orbits, 154 long-periodic ($P > 200$ yrs) and 953 short-periodic ($P < 200$ yrs) orbits.

The number of hyperbolic orbits is about two times greater than the number of long-periodic orbits. On the other hand, about two third of all collected data are short-periodic orbits.

The hyperbolicity of orbits is very probably caused by an uncertainty of velocity determination (Hajduková, 2008, 2013).

Table 1 – Video Lyrids from different catalogues (see in text). N – number of orbits.

Source	N
CAMS	251
CMN	113
CVMO	8
DMS	3
EDMOND	954
IAU MDC	17
SonotaCo	270
Total	1616

3 Structure of Lyrids

In the first step, the orbits of Lyrids were divided into two groups, a short-period ($a < 32$ AU) and a long-period ($a > 32$ AU) one. The short-period part contains 942 orbits and the long-period part 165 orbits. The hyperbolic part was excluded from the next analysis.

Applying an iterative method of Porubčan and Gavajdová (1994) and using the limiting value of D criterion of Southworth and Hawkins (1963), $D_{SH} < 0.08$, we derived new mean orbits of short and long-periodic part of Lyrids. The mean orbits of both parts and also of the comet Thatcher are in Table 2.

We found that 142 orbits (86 %) of long-periodic part fulfilled the D criterion. Followed mean orbit is almost the same as the orbit of the parent comet C/1861 G1 Thatcher.

In the short-period part, only 585 orbits (62 %) satisfy the D criterion and also the dispersion in orbital parameters, mainly in semimajor axis and eccentricity, is large. So we decided to perform a new inspection. Based on a distribution in semimajor axis (Figure 1), all 942 short-periodic orbits can be divided into nine

Table 2 – Mean orbital parameters, radiant positions, geocentric velocities and beginning and terminal heights (in km) of short ($a < 32$ AU) and long-periodic ($a > 32$ AU) part of video Lyrids. For coparison, the orbit of parent comet Thatcher is also presented.

	q (AU)	e	a (AU)	i	ω	Ω	Ra	Dec	V_g	H_B	H_T
$a < 32$ AU	0.918	0.919	11.4	79.0	215.1	32.1	272.0	33.3	46.1	105	90
$\pm$	0.007	0.034		1.3	1.5	0.8	1.2	0.7	0.7	4	6
$a > 32$ AU	0.921	0.983	55.0	80.0	213.7	32.3	272.2	33.3	47.2	107	88
$\pm$	0.008	0.008		1.4	1.6	0.8	1.3	0.8	0.6	5	6
Thatcher	0.921	0.984	55.8	79.8	213.5	31.9	272.0	33.5	47.1		

groups separated by local minima in $a = 3.9/\ 5.4/\ 8.9/\ 10.8/\ 13.5/\ 16.6/\ 21.3/\ 27.0/$ and 32.0 AU:

1. $2.3 < a < 3.9$ AU (68 orbits)
2. $3.9 < a < 5.4$ AU (88)
3. $5.4 < a < 8.9$ AU (241)
4. $8.9 < a < 10.8$ AU (113)
5. $10.8 < a < 12.6$ AU (87)
6. $12.6 < a < 16.6$ AU (124)
7. $16.6 < a < 20.2$ AU (90)
8. $20.2 < a < 23.6$ AU (52)
9. $23.6 < a < 32.0$ AU (79)

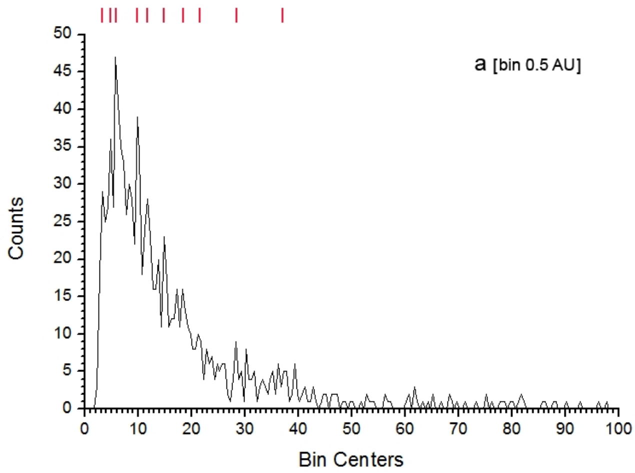

Figure 1 – Distribution in semimajor axis of Lyrids. The data are binned in 0.5 AU.

For each group, a mean orbit was derived. Afterwards, by using the iterative process with $D_{SH} < 0.08$, the definitive mean orbits have been computed (Table 3). The orbits of Lyrids in particular groups are depicted in Figure 2.

The distribution in semimajor axis shows possible resonant effects. All mean motion resonances with giant planets close to each group in Lyrids are shown in Table 4. Some of them might be resposible for fainter structure in the short-period part of Lyrids. However, a detail dynamical analysis would be needed.

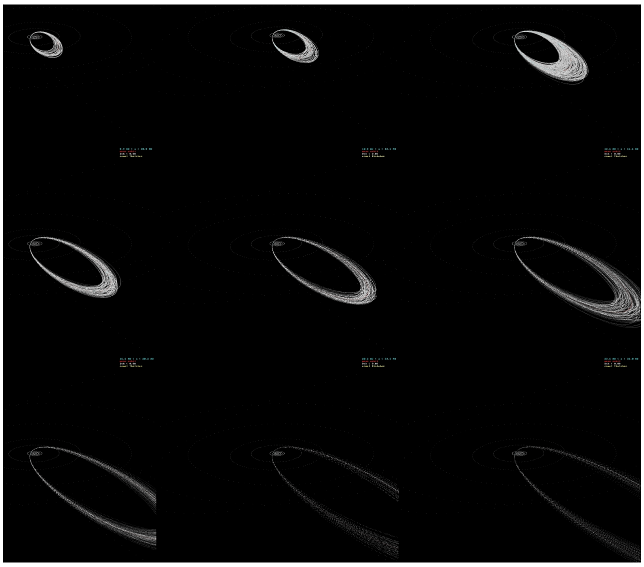

Figure 2 – Groups 1–9 of Lyrids in the short-periodic part.

Table 4 – Mean motion resonances with giant planets within the short and long-period parts of Lyrids and near the orbit of comet Thatcher. a – mean semimajor axis, J – Jupiter, S – Saturn, U – Uranus, N – Neptune.

Group (1–9)	a (AU)	J	S	U	N
$2.3 < a < 3.9$	3.3	2/1	5/1		
$3.9 < a < 5.4$	4.5	6/5	3/1		
$5.4 < a < 8.9$	6.8	2/3	4/3		
$8.9 < a < 10.8$	9.8	2/5	1/1		
$10.8 < a < 12.6$	11.7			2/1	4/1
$12.6 < a < 16.6$	14.4			3/2	3/1
$16.6 < a < 20.2$	18.2			1/1	2/1
$20.2 < a < 23.6$	21.8				
$23.6 < a < 32.0$	27.5		1/5		
$a > 32.0$	55.0			1/5	2/5
Thatcher	55.8			1/5	2/5

4 Conclusion

Data of Lyrids obtained by a sensitive video technique provide enough information for more detail study of origin and evolution of this old but still not well known stream. In the work, we have confirmed the division of Lyrids to a short and long-period part, but prevailing number of short-periodic orbits is surprising. Moreover, the analysis suggests a more fine structure of the stream (mentioned also in Tóth et al., 2011) possibly caused by resonances with giant planets.

Table 3 – Mean orbital parameters, radiant positions, geocentric velocities and beginning and terminal heights (in km) of nine short-period groups of video Lyrids.

	q (AU)	e	a (AU)	i	ω	Ω	Ra	Dec	V_g	H_B	H_T
$2.3 < a < 3.9$ AU	0.914	0.726	3.3	77.7	218.4	32.1	273.3	32.7	43.8	104	92
$\pm$	0.010	0.030		1.5	2.2	0.8	1.4	0.8	0.7	3	5
$3.9 < a < 5.4$ AU	0.920	0.797	4.5	77.9	216.0	32.2	273.0	33.4	44.5	105	91
$\pm$	0.009	0.019		1.5	2.0	0.9	1.4	0.7	0.7	6	6
$5.4 < a < 8.9$ AU	0.916	0.866	6.8	78.6	216.0	32.0	272.1	33.1	45.5	104	91
$\pm$	0.009	0.019		1.3	1.9	0.8	1.2	0.8	0.6	4	6
$8.9 < a < 10.8$ AU	0.917	0.907	9.8	78.7	215.4	32.1	271.8	33.4	45.9	105	89
$\pm$	0.008	0.005		1.4	1.6	0.9	1.3	0.8	0.6	5	5
$10.8 < a < 12.6$ AU	0.920	0.921	11.7	79.2	214.6	32.3	272.4	33.3	46.3	106	91
$\pm$	0.008	0.003		1.0	1.6	0.7	1.1	0.7	0.4	4	7
$12.6 < a < 16.6$ AU	0.918	0.936	14.4	79.1	214.8	32.1	271.9	33.4	46.4	106	90
$\pm$	0.008	0.005		1.3	1.7	0.8	1.2	0.7	0.6	4	6
$16.6 < a < 20.2$ AU	0.918	0.949	18.2	79.2	214.7	32.1	271.8	33.4	46.5	106	89
$\pm$	0.006	0.003		1.3	1.3	1.0	1.3	0.7	0.6	4	6
$20.2 < a < 23.6$ AU	0.918	0.958	21.8	79.0	214.6	32.0	271.5	33.5	46.5	106	91
$\pm$	0.009	0.002		1.6	1.7	0.8	1.4	0.9	0.7	4	5
$23.6 < a < 32.0$ AU	0.920	0.967	27.5	79.5	214.2	32.2	272.0	33.4	46.8	106	89
$\pm$	0.007	0.003		1.3	1.5	0.7	1.2	0.7	0.5	5	6

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