Lyrids

The Lyrid meteor shower in 2006 and 2007

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Visual meteor observations during the 2007 Lyrids are analysed. A peak ZHR of 20.4 ± 1.1 and occurred at $\lambda_\odot = 32\overset{\circ}{.}31 \pm 0\overset{\circ}{.}05$ (corresponding to 2007 April 22, 22^h20^m UT), quite similar to other recent returns. Since there were some expectations for enhanced rates in 2006 due to the 1-revolution dust trail of comet C 1861/G1 (Thatcher), this data was re-analysed. No significant activity increase was found.

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1 Introduction

The Lyrids are related with comet C 1861/G1 (Thatcher). Details of early observations and outbursts is given by Arter & Williams (1995), Rendtel, Arlt & McBeath (1995) and Arter & Williams (1997). The shower recurs annually with a relatively constant activity. The radiant reaches sufficient elevation for useful observations already before local midnight in northern latitudes, and the activity can be monitored for about five hours per night at best. Average ZHRs are of the order of 15 to 20. The typical duration of a peak is about six hours (FWHM) and can thus be observed mainly by observers from a limited geographical longitude range. The annual peaks do not occur at a fixed solar longitudes but vary considerably in time (Table 1).

There are indications that the annual Lyrid activity be modulated by a 12-year outburst cycle (cf. Jenniskens, 1995, and references therein). At such times ZHRs well above 100 can be observed (see Table 1). The most recent documented Lyrid outburst occurred in 1982 (Adams, 1982; Spalding, 1982; Porubčan & Cevolani, 1985). While enhancements in some years seem to be driven by Jovian perturbations (Arter & Williams, 2002), neither the 1994 return (Dubietis & Arlt, 2000) nor the 2006 return (see Section 5 of this paper) of the Lyrids showed enhanced rates.

2 Observational data in 2007

The astronomical conditions were almost perfect in 2007 with the first-quarter Moon on April 24. So the favourable part of the night with high radiant positions remained undisturbed. The input possibility on the IMO webpage with an on-the-fly graph obviously stimulated observers to provide their data soon after the observation.

The sample included in this paper was collected by 64 visual observers from 18 countries worldwide. It contains data of 1757 Lyrids observed in 308.52 hours effective observing time. The following observers contributed to the 2007 Lyrid analysis (five-letter code of the VMDB, effective observing time, and number of Lyrids):

Salvador Aguirre (`AGUSJ`, 1.h00, 8), Rainer Arlt (`ARLRA`, 3.h11, 36), Pierre Bader (`BADPI`, 11.h45, 118), Ricardas Balciunas (`BALRJ`, 3.h00, 32), Ana Bankovic (`BANAN`, 5.h32, 32), Ivana Belic (`BELIJ`, 5.h07, 66), Felix Bettonvil (`BETFE`, 1.h78, 8), Jean-Marie Biets (`BIEJE`, 2.h48, 16), Andreas Buchmann (`BUCAN`, 6.h12, 44), Ionut Costache (`COSIJ`, 2.h68, 80), Tibor Csórgei (`CSOTJ`, 0.h50, 10), Ivana Cvijovic (`CVIIJ`, 3.h60, 84), Nenad Davidovic (`DAVNJ`, 7.h40, 82), Dariusz Dorosz (`DORDA`, 6.h50, 64), Gunther Fleerackers (`FLEGJ`, 2.h33, 22), Stela Frencheva (`FREST`, 4.h09, 54), George W. Gliba (`GLIGE`, 3.h00, 46), Mitja Govedic (`GOVMI`, 8.h95, 178), Robin Gray (`GRARO`, 1.h03, 0), Pavol Habuda (`HABPA`, 2.h33, 36), Wayne T. Hally (`HALWA`, 8.h70, 70), Joost Hartman (`HARJS`, 2.h07, 8), Roberto Haver (`HAVRO`, 4.h18, 84), Visnja Jankov (`JANVI`, 6.h00, 24), Carl Johannink (`JOHCA`, 2.h63, 24), Jay Kansara (`KANJJ`, 3.h43, 18), Roy Keeris (`KEERJ`, 2.h91, 20), André Knöfel (`KNOAN`, 8.h76, 84), Sandra Lakicevic (`LAKSJ`, 10.h40, 142), Alister Ling (`LINAJ`, 1.h72, 12), Paul Martsching (`MARPA`, 8.h00, 24), Pierre

Table 1 – The table summarizes visual outburst data listed in (Arter & Williams, 1995), 1988–2000 data from Table 2 in (Dubietis & Arlt, 2000), 2003 data from (Dubietis & Arlt, 2003) and the recent 2006 and 2007 results calculated in this work. All solar longitudes refer to J2000.

Year	$\lambda_\odot$	ZHR
1803	32.°05	670
1922	31.°994	360–600
1922	32.°006	180
1934	32.°07	56–80
1945	31.°943	100
1946	31.°966	110
1946	31.°970	80
1982	32.°076	253
1988	32.°3	21
1993	32.°35	23
1994	32.°1	17
1995	32.°45	14
1996	32.°4	18
1998	32.°4	18
1999	32.°15	21
2000	32.°05	16
2003	32.°32	19
2006	32.°28	20
2007	32.°31	20

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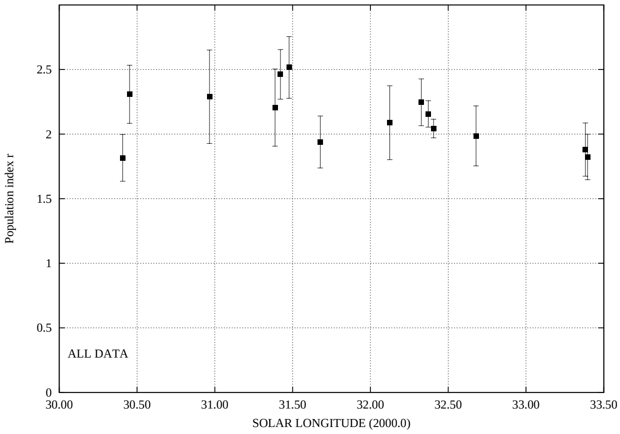

Figure 1 – Profile of the population index r of the 2007 Lyrids, based on all available magnitude data.

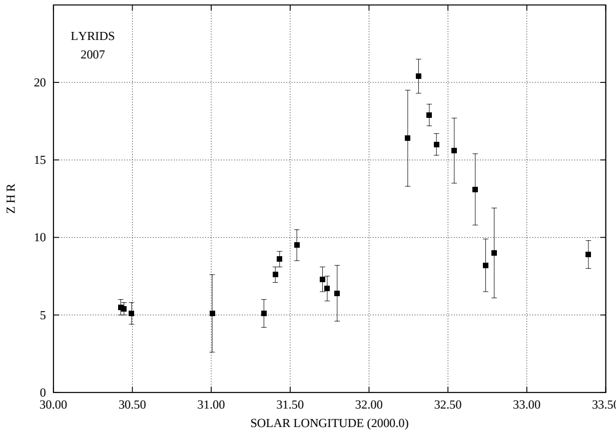

Figure 2 – ZHR-profile of the 2007 Lyrids based on all data with lm ≥ 5.5 and the radiant at least 20 degrees above the horizon and a maximum correction factor of $C = 5.0$

Martin (MARPI, $2^{h}.15$, 40), Stefan Martinka (MARST, $10^{h}.59$, 128), Alastair McBeath (MCBAL, $3^{h}.75$, 60), Bruce McCurdy (MCCBR, $4^{h}.83$, 42), Ana Milovanovic (MILAJ, $4^{h}.00$, 34), Milka Miletic (MILMI, $7^{h}.32$, 86), Koen Miskotte (MISKO, $7^{h}.45$, 110), Sabine Wächter (MORSA, $1^{h}.25$, 6), Sven Näther (NATSV, $7^{h}.25$, 46), Martin Nedved (NEDMA, $4^{h}.28$, 76), Markku Nissinen (NISMA, $1^{h}.32$, 22), Danica Pajovic (PAJDJ, $5^{h}.33$, 102), Dusan Pavlovic (PAVDJ, $8^{h}.50$, 94), Swapnil Pawar (PAWSJ, $2^{h}.95$, 12), Mila Popović (POPMI, $10^{h}.08$, 110), Jatin Rathod (RATJJ, $3^{h}.46$, 10), Jürgen Rendtel (RENJU, $20^{h}.84$, 202), Branislav Savic (SAVBR, $8^{h}.35$, 118), Mila Savic (SAVMJ, $5^{h}.30$, 38), Ulrich Sperberg (SPEUL, $4^{h}.29$, 26), Wesley Stone (STOWE, $2^{h}.00$, 30), Marija Todorovic (TODMJ, $4^{h}.00$, 52), David Vansteenlant (VANDJ, $2^{h}.05$, 32), Michel Vandeputte (VANMC, $12^{h}.25$, 254), Jovan Vasiljevic (VASIJ, $2^{h}.33$, 36), Jovan Vasiljevic (VASJJ, $2^{h}.33$, 10), Jan Verfl (VERJX, $3^{h}.26$, 48), Nemanja Vojvodic (VOJNJ, $5^{h}.92$, 32), Frank Wächter (WACFR, $1^{h}.25$, 8), William Watson (WATWI, $2^{h}.50$, 10), Thomas Weiland (WEITH, $4^{h}.50$, 82), Roland Winkler (WINRO, $2^{h}.14$, 6), Kim S. Youmans (YOUKI, $3^{h}.00$, 34),

3 Population index profile in 2007

On most occasions observers describe the Lyrids as a shower with mainly faint meteors. This is obvious from recent analyses: Dubietis & Arlt (Figure 10 therein) find an average population index of $r = 2.1 \pm 0.08$ for the near-maximum period between 31° and 33° and a value of $r = 1.95 \pm 0.07$ for the immediate peak period close to $\lambda_\odot = 32\overset{\circ}{.}2$. This corresponds to the fact that we find a considerable portion of bright meteors during the peak period. However, fireballs are a rare exception (Beech & Nikolova, 1999).

In 2007 we had 162 magnitude distributions available for the analysis. The method used for the calculation of the population index r was described by Arlt (2003). Due to the smaller sample as compared with the Leonids or other major showers, the individual bins were constructed so as to contain 50 Lyrids each. This caused larger errors, but we were interested in possible short minima of the population index r close to the activity maximum. The result is shown in Figure 1. Alternatively, we checked whether magnitude data obtained under poor conditions yielded systematic deviations in the profile. Therefore the same calculation was done for all intervals with a limiting magnitude of at least +5.8, then involving 118 magnitude distributions. The difference between the two profiles is very small. Obviously, the increase of the number of fainter meteors remains constant in the relevant interval, indicating that the procedure is relatively robust against the conditions. For the ZHR calculation we use the r-profile shown in Figure 1 which includes all magnitude data.

4 ZHR profile in 2007

For the ZHR calculation we use the r-profile derived from all available magnitude data. As mentioned in the Introduction, the coverage of the global data is not complete. Gaps occur due to the distribution of the observers' locations. In particular, data between 10^{h} and 19^{h} UT are missing — that is mainly the 'pacific gap'. Again, we did several calculations of the ZHR profile using different limits for the limiting magnitude to avoid over-corrections. Here we present a ZHR-profile for the entire period which is covered by observations (Figure 2). It is based on the r-profile described in the previous section (Figure 1). The ZHR profile shown in Figure 2 included 321 intervals with lm $\geq +5.5$. The maximum correction factor was set to $C = 5.0$, the radiant elevation $h_{\rm rad} \geq 20°$. Stronger criteria did not change the shape of the profile, but since some data points were omitted, the gaps became larger. We used a zenith exponent $\gamma = 1.0$ for all profiles. The recent analysis of the Orionids 2006 (Rendtel, 2007) indicates that a value of $\gamma > 1.0$ leads to overcorrections. Detailed information on the calculated values is listed in Table 2.

Applying the routine analysis to all intervals with a lm $\geq +5.8$ using the criteria listed above yields a peak ZHR of 26 ± 6.7 at $\lambda_\odot = 32\overset{\circ}{.}26$, that is 2007 April 22, $21^{h}10^{m}$ UT. However, the point defining the peak is based on four intervals containing only 14 Lyrids, obtained when the radiant was between 20 and 30 degrees above the horizon. Additionally, in the same intervals the sporadic rates were about two times of the average of about 8, indicating a systematic deviation.

Therefore we consider the profile shown in Figure 2 as the conclusive ZHR profile of the 2007 Lyrid return. The peak ZHR of ZHR = 20.4 ± 1.1 occurred at $\lambda_\odot = 32\overset{\circ}{.}31 \pm 0\overset{\circ}{.}05$, i.e. on 2007 April 22, $22^{\rm h}20^{\rm m}$ UT. This point is composed of 57 intervals containing 330 Lyrids. As already mentioned, data is missing from the interval between $31\overset{\circ}{.}9$ and $32\overset{\circ}{.}2$, about $12^{\rm h}$ to $19^{\rm h}$ UT on April 22.

Surprisingly, we find a small maximum of the Lyrids already in the night before with a ZHR of 9.5 ± 1.0 (Figure 2). The maximum value itself at $\lambda_\odot = 31\overset{\circ}{.}54$ (2007 April 22, $03^{\rm h}20^{\rm m}$ UT) is based on 15 intervals containing 82 Lyrid meteors, and the neighbouring ZHRs support that this is not just a short statistical fluctuation. Looking into the values of the population index r, we see that this period is characterized by higher values of $r \approx 2.5$ than in the immediate peak period. Hence this portion of the stream was mainly composed of smaller meteoroids. We can exclude observational effects, because of the size of the sample, no intervals with exceptional conditions, the radiant elevation well above the chosen limits and no intersection between regions with different astronomical conditions.

5 Comparison with 2006

While the IMO's VMDB contains a nearly continuous data set of the 2007 return with only the 'Pacific gap', there are some larger gaps in the near-peak period in the 2006 data set. The 2006 return is of particular interest because it was expected that the Earth encounters the 1-revolution dust trail of comet C 1861/G1 (Thatcher) on 2006 April 22, $09^{\rm h}25^{\rm m}$ UT, i.e. $\lambda_\odot = 32\overset{\circ}{.}03$ (Lyytinen 2006). Therefore we re-analysed the 2006 data set. Unfortunately, the amount of magnitude data is not sufficient to calculate a reliable profile of the population index r for 2006. Seen the 2007 data as well as other population index data of previous returns, we assumed a constant value of $r = 2.2$ for the entire period. The respective 2006 profile is shown in Figure 3. For comparison, we show the ZHR graph of the 2007 return at the same scale and the same interval as for the 2006 return in Figure 4. Unfortunately, the expected peak period is not covered by visual data, hence we cannot draw a conclusion about any further peak.

Continuous data, which can be provided by radar and forward scatter radio observations, does not give conclusive hints at high Lyrid rates in 2006. Data of the CMOR radar in Canada (Brown, personal communication) do not show an increase of the Lyrid activity around the maximum in 2006.

6 Discussion

In 2007 the available visual data document a Lyrid return which resembled very much the average over the last decade. A small ZHR maximum $0\overset{\circ}{.}77$ before the main peak is found. The meteoroid size distribution does not vary significantly in the entire period between $30\overset{\circ}{.}4$ and $33\overset{\circ}{.}5$ as seen form the r-profile (Figure 1).

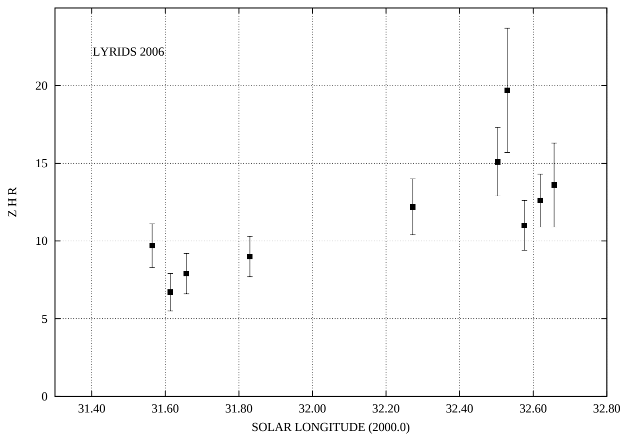

Figure 3 – ZHR-profile of the 2006 Lyrids around the maximum and the expected encounter time with the 1-revolution dust trail of comet C 1861/G1 (Thatcher) at $\lambda_\odot = 32\overset{\circ}{.}03$. Here a constant value of $r = 2.2$ was assumed.

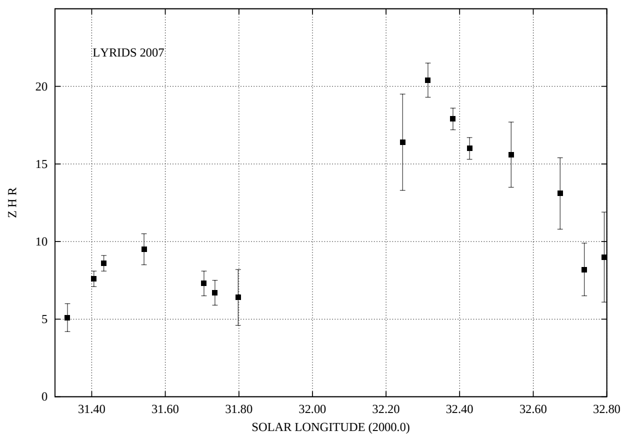

Figure 4 – Detail of the 2007 ZHR profile for the same period as shown in Figure 3 for the 2006 Lyrid return.

From the data provided by the Radio Meteor Observation Bulletin (RMOB), we calculated a tentative activity profile from the forward scatter radio data of 2007, calibrating the rate with the data of four adjacent nights around the maximum. The radio data do not show a systematic Lyrid rate increase in the period of $32\overset{\circ}{.}2$–$32\overset{\circ}{.}6$.

The 2006 visual data series has large gaps due to the uneven distribution of the observers and unfavourable weather conditions at several observing locations. Therefore, the peak ZHR cannot be calculated with the same accuracy as in 2007. Radar data showed that there was no Lyrid activity at outburst level caused by the young filament.

The data listed in Table 1 show that there was no event supporting the suspected 12-year periodicity in Lyrid outbursts. The last outburst occurred in 1982, while 1994 and 2006 yielded 'average' returns with no unusual activity. If we only consider the outbursts with rates above 200 (Table 1), this would rather support a periodicity of about 60 years, or five Jupiter revolutions. Whether the parent comet could have provided meteoroids in one region which remains in a 1:5 commensurability with Jupiter must remain speculative based on the available Lyrid data. It is interesting, however, that the next predicted Lyrid outbursts are in 2040 and 2041 (Lyytinen & Jenniskens 2003) — 58 and 59 years after the last outburst in 1982.

7 Conclusions

The 2007 Lyrid return provided us with considerable magnitude and rate data. The population index profile is rather smooth with no significant structure in the vicinity of the peak. A ZHR maximum of ZHR $= 20.4 \pm 1.1$ was found at $\lambda_\odot = 32\overset{\circ}{.}31 \pm 0\overset{\circ}{.}05$, corresponding to 2007 April 22, $22^{\mathrm{h}}20^{\mathrm{m}}$ UT. The maximum ZHR is similar to the average over the last decade and the position is almost identical with the 1996 and 2003 Lyrids. The re-analysed 2006 data yield a maximum of ZHR $= 19.7 \pm 4.0$ at $\lambda_\odot = 32\overset{\circ}{.}53 \pm 0\overset{\circ}{.}1$, corresponding to 2006 April 22, $21^{\mathrm{h}}40^{\mathrm{m}}$ UT. This is of comparable strength with the maximum rates found over the last decade. Visual data in 2006 do not cover the expected encounter time of the 1-revolution dust trail of C 1861/G1 (Thatcher). Other data indicate that no high-level activity occurred in 2006.

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Table 2 – ZHR and population index for the 2007 Lyrids. Obs. gives the number of observers contributing to the average. LYR and SPO is the number of Lyrids and sporadic meteors recorded in the interval, respectively. LM is the average limiting magnitude of all included intervals and the values of r are interpolated from the detailed profile shown in Figure 1.

Date, April 2007	Observers	$\lambda_\odot$(2000.0)	LYR	ZHR	Error	SPO	LM	r	Error
15.575	2	25°114	7	2.5	0.9	26	6.30	3.08	2.37
16.521	7	26°044	19	2.6	0.6	64	6.26	2.92	1.90
17.229	7	26°741	17	2.9	0.7	48	6.23	2.70	1.59
18.719	6	28°194	17	3.2	0.8	44	6.27	2.89	1.95
19.150	7	28°618	15	2.9	0.7	40	6.19	2.86	1.88
19.571	4	29°036	3	1.7	0.9	17	6.06	2.09	1.03
21.000	38	30°426	106	5.5	0.5	231	6.07	2.02	0.20
21.025	54	30°447	152	5.4	0.4	342	6.13	2.11	0.21
21.075	17	30°495	46	5.1	0.7	114	6.22	2.31	0.24
21.592	2	31°006	2	5.1	2.5	8	6.03	2.26	0.31
21.929	14	31°334	34	5.1	0.9	65	6.38	2.22	0.31
22.001	62	31°406	235	7.6	0.5	354	6.17	2.36	0.25
22.030	58	31°433	251	8.6	0.5	356	6.15	2.41	0.24
22.142	15	31°542	82	9.5	1	92	6.30	2.31	0.22
22.312	18	31°705	92	7.3	0.8	82	6.18	1.97	0.21
22.342	15	31°735	77	6.7	0.8	64	6.19	1.96	0.21
22.406	2	31°798	12	6.4	1.8	6	6.39	1.98	0.22
22.865	10	32°245	28	16.4	3.1	17	5.84	2.18	0.22
22.933	57	32°314	330	20.4	1.1	220	5.91	2.20	0.16
23.012	111	32°382	737	17.9	0.7	497	6.04	2.11	0.11
23.052	71	32°427	470	16.0	0.7	328	6.11	2.05	0.09
23.167	11	32°540	54	15.6	2.1	38	6.05	2.02	0.14
23.304	7	32°673	32	13.1	2.3	13	6.01	1.98	0.22
23.371	4	32°739	22	8.2	1.7	24	6.44	1.98	0.23
23.425	1	32°793	9	9.0	2.9	15	6.80	1.97	0.23
23.042	20	33°390	97	8.9	0.9	172	5.81	1.85	0.20