Astron. Astrophys. 343, L94–L96 (1999)

ASTRONOMY AND ASTROPHYSICS

Letter to the Editor

The Giacobinid meteor stream observed by radar in 1998

M. Šimek and P. Pecina

Astronomical Institute of the Academy of Sciences of the Czech Republic, CZ-251 65 Ondřejov, Czech Republic (simek; ppecina@asu.cas.cz)

Received 11 December 1998 / Accepted 14 February 1999

Abstract. The return of the 1998 Giacobinid meteor shower associated with the comet 21P/Giacobini-Zinner was observed by meteor radar at Ondřejov, Czech Republic. The duration of the intense part of the shower was approximately 3 hours. Though the limiting magnitude of the radar is +8 M_r, only overdense echoes down to +4.2 M_r were analyzed. A maximum number of 82 such shower meteors was recorded in the ten minute interval 13h 00m–13h 10m UT corresponding to solar longitude $L_{\odot} = 194\overset{\circ}{.}8200 \pm 0\overset{\circ}{.}0034$ (J2000.0). The mass-distribution index $s = 1.38 \pm 0.04$ indicates a lack of faint meteors in the most dense part of the stream.

Key words: comets: individual: 21P/Giacobini-Zinner – meteors, meteoroids

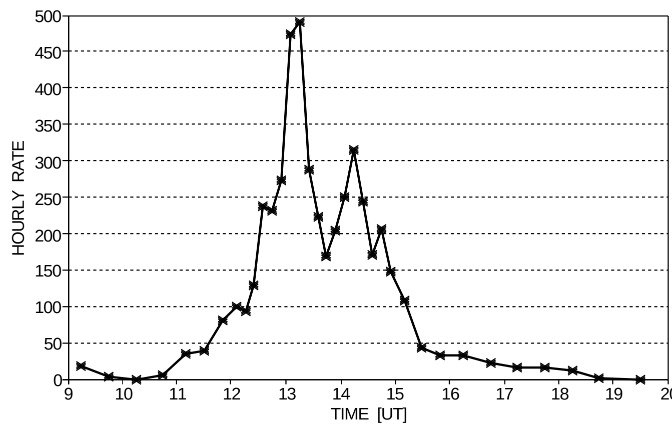

Fig. 1. Shower hourly rates of echoes with $T \geq 0.4$ s observed on 8 Oct. Data were not corrected for the response function of the radar.

1. Introduction

The Giacobinid meteor stream associated with comet 21 P/Giacobini-Zinner belonging to the Jupiter family of comets was characterized by high meteor activity in 1933, 1946, and 1985. In these years the conditions for high activity of the shower for observations from the Earth, recognized by Yeomans & Brandt (1985) were fulfilled. Their conditions read: “1) The Earth closely follows the comet to the comet’s descending node; 2) the Earth passes close to the comet’s orbit; 3) the Earth passes inside the comet’s orbit at the comet’s descending node”. Another comprehensive discussion analyzing the conditions for the occurrence of particular meteor storms was presented by Kresák (1993). He expected an unusual display of the 1998 Giacobinids on October 8.70. For this date the Earth reached the nodal crossing point of 49.5 days before the comet being at 0.0383 AU inside the comet’s orbit. The position of the Earth before the comet was contrary to the situation in 1985 (see Rao 1998) but it could indicate a moderate shower at least. So, the stage was prepared for observations in the northern hemisphere, waiting for the main event; a possible unusual meteor display.

2. Observation

The meteor radar at Ondřejov observatory (Plavcová & Šimek 1960) operated between 9–23 UT on 1998 October 7, 8, and 9. The transmitter works at a frequency of 37.5 MHz (wavelength of 8 m) with a repetition frequency of 500 Hz. The antenna system, steerable in azimuth, has a half-power width of about $52°$ in the vertical and $36°$ in the orthogonal plane with the maximum gain placed at $45°$ elevation with a secondary lobe at about $15°$ elevation. The antenna was steered with its azimuth differing by $180°$ from the azimuth the shower’s radiant.

3. Activity profile

Meteor activity started to be more pronounced at 11h UT, October 8 when the expected radiant at $\alpha = 262°$ and $\delta = 54°$ appeared at a zenithal distance of $z_{\rm R} = 36°$. Remarkable peak rates of observed meteor number were recorded shortly after 13h UT, October 8 when $z_{\rm R} = 19°$, and the end of shower activity was around 16h with $z_{\rm R} = 9°$. To determine the actual observed shower activity, the average hourly rates recorded on October 7 and 9 during each particular hour considered as sporadic activity on October 8, were subtracted from the rates on October 8. The observed activity of the shower across the stream in terms of hourly rates is presented in Fig. 1. A maximum hourly echo rate of 492 for durations $T \geq 0.4$ s (corresponding to radio magnitude +4.2 M_r) was recorded in ten minute interval centered at 13h 15m UT when $z_{\rm R} = 17°$. The Giacobinid radiant culminated at $z_{\rm R} = 4°$ between 14h 48m and 15h 23m

Send offprint requests to: P. Pecina

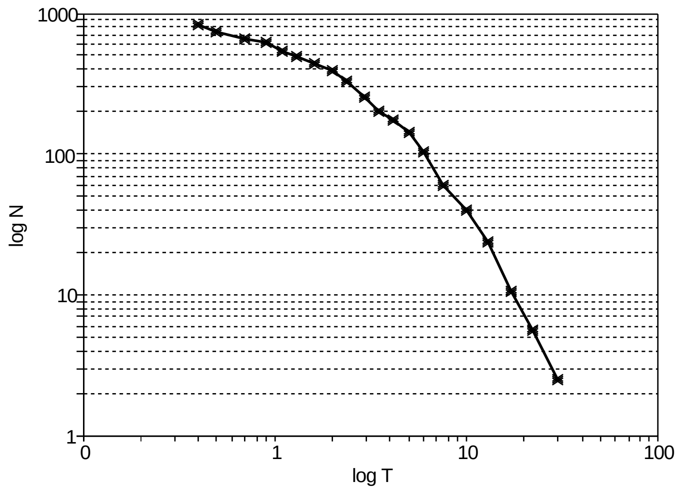

Fig. 2. The echo duration distribution of all Giacobinids having duration $T \geq 0.4$ s observed in the interval 11h–17h UT.

Table 1. Distribution of the mass index, s, along the Earth's path through the stream.

time [UT]	mass index, s
9h 00m - 11h 20m	1.75 ± 0.03
11h 20m - 12h 20m	1.66 ± 0.03
12h 20m - 12h 40m	1.70 ± 0.16
12h 40m - 13h 00m	1.75 ± 0.08
13h 00m - 13h 20m	1.56 ± 0.04
13h 20m - 13h 40m	1.44 ± 0.04
13h 40m - 14h 00m	1.38 ± 0.04
14h 00m - 14h 20m	1.44 ± 0.03
14h 20m - 14h 40m	1.67 ± 0.03
14h 40m - 15h 00m	1.74 ± 0.08
15h 00m - 15h 20m	1.61 ± 0.08
15h 20m - 15h 40m	1.77 ± 0.03
15h 40m - 19h 45m	1.78 ± 0.03

UT. There appears an apparent gap at 13h 45m followed by a recorded secondary apparent maximum at 14h 15m. To explain these two local sub–extremes we must take into account an important feature of the receiver affecting recorded meteor rates. Because of eliminating any terrestrial echoes as well as those from the aircraft operating near Prague airport some 40 km away from the observatory, the receiver is blocked on its output in the range interval 0–50 km. Such blocking repeats because of the repetition frequency of 500 Hz at multiples of 300 km, i.e. at 300, 600, and 900 km ranges. These gaps may drastically reduce recorded shower rates for high elevations of a shower radiant particularly when $z_{\mathrm{R}} < 19°$ and, therefore, more shower echoes should appear at the ranges where the receiver effectiveness is reduced.

4. Mass distribution and flux across the stream

We analyze here those Giacobinid meteor echoes having duration $T \geq 0.4$ s which can be recognized as a lower limit for overdense trails. For determining the mass-distribution coefficient, s, we use the standard formula for the distribution of overdense echoes in the form (e. g. Kaiser 1955)

$$\log N = -\frac{3}{4}(s-1)\log T + \mathrm{const}, \tag{1}$$

where N represents cumulative number of echoes having duration greater or equal T. We employ the linear part of the curve $\log N$ vs $\log T$ which is placed in the region where diffusion alone is the dominant process controlling the volume density of free electrons in meteor ionized trail. For this purpose, the interval of echo durations $0.4 \leq T < 30.0$ s was divided into 20 intervals. Recorded echoes presented in Fig. 1 were used for the calculation of the mass index, s. Linear parts of $\log N$ vs $\log T$ curve were placed in all cases in the interval $0.4 \leq T \leq 2.0$. The results are summarized in Table 1. The echo duration distribution of all Giacobinids having duration $T \geq 0.4$ s observed in the interval 11h–17h UT is presented in Fig. 2.

Lower s-values in comparison to those found during past observations are evident. Mass indices, s, resulting from visual and telescopic observations in 1933 and 1946 summarized by Jenniskens (1995) are between 1.99 and 2.3 which indicates a high number of faint particles in the stream. Similarly, Šimek (1987, 1994) derived $s = 1.94 \pm 0.04$ for overdense echoes recorded by Ondřejov radar in 1985. Results for the Ottawa high-power radar observations in 1985 gave $s = 2.06 \pm 0.02$ for the underdense echoes down to +9.5 radio-magnitude, and $s = 2.11 \pm 0.05$ for overdense echoes. Koseki (1990) suggests $s = 2.28 \pm 0.05$ as a mean value from series of Japanese visual observations in 1985. The resulting s for the 1998 return correspond with higher contribution of larger fresh particles concentrated at central parts of the stream which were exposed in their orbits for a time not sufficient for their massive disintegration.

The activity of a meteor shower can also be characterized by the cumulative flux i. e. the number of particles having masses in excess of some limiting value (here we adopt $m_0 = 10^{-5}$ kg) and crossing the unit area perpendicular to radiant direction per time unit. We employed the method developed by Pecina (1982) with the antenna gain published by Přidal (1995). This approach takes into consideration the response function of the radar for meteors having specified echo duration with respect to the mutual position of the shower radiant and the antenna pattern. The mass indices s necessary for the flux computation were taken from Table 1. The resulting flux is shown in Fig. 3.

5. Conclusions

The results of the Giacobinid meteor shower observed by meteor radar in 1998 at Ondřejov observatory shows the culmination of activity on October 8, 13h 35m UT when the flux $4.59 \times 10^{-11} \mathrm{m}^{-2}\mathrm{s}^{-1}$ of particles related to their minimum mass $m_0 = 10^{-5}$ kg was found. We may try to compare this result with our incomplete observation of this shower in 1985 (Šimek 1986) when the record started about 25 minutes after the maximum determined by Lindblad (1987) at 9h 35m UT. The flux on October 8, 1985 at 10h 00m UT was calculated from

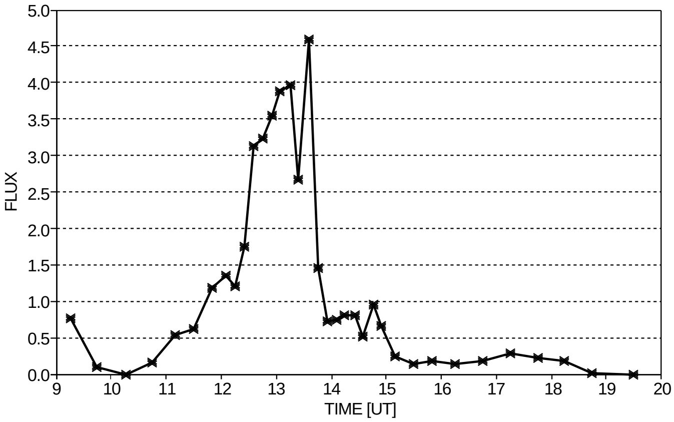

Fig. 3. The flux across the stream related to $m_0 = 10^{-5}$ kg, expressed in units of $10^{-11}\mathrm{m}^{-2}\mathrm{s}^{-1}$.

our original data as $16.61 \times 10^{-11}\mathrm{m}^{-2}\mathrm{s}^{-1}$. Adapting this value to Lindblad's profile we found that maximum flux could reach $20.6 \times 10^{-11}\mathrm{m}^{-2}\mathrm{s}^{-1}$ which is about 5 times the maximum value in 1998. Lower fluxes in 1998 are mainly due to the lower mass-distribution index $s = 1.38$ in 1998 than $s = 1.94$ for 1985 event. This indicates a lack of faint particles in the stream which can be ascribed to recent ejection of not yet disintegrated new particles. Lower s value at the central part of the shower activity in 1998 corresponds with a higher contribution of larger particles in the stream. The shower maximum occurred 7h 25m before the descending node of parent comet, 3h 50m sooner than in 1985.

Acknowledgements. This work has been supported by the key project K1-003-601 and the grant No 205/96/1197 of the Grant Agency of Czech Republic. The authors appreciate the help of Dr. W. J. Baggaley who corrected the English wording of the text.

References

Jenniskens P., 1995, A&A 295, 206
Kaiser T. R., 1955, in Meteors, ed. T. R. Kaiser, 119, Pergamon press, London
Koseki M., 1990, Icarus 88, 122
Kresák L., 1993, A&A 279, 646
Lindblad B. A., 1987, A&A 187, 928
Pecina P., 1982, Bull. Astron. Inst. Czechosl. 33, 1
Plavcová Z., Šimek M., 1960, Bull. Astron. Inst. Czechosl. 25, 180
Přidal P., 1995, Meteor Reports of the Slovak Astron. Soc. 16, 1
Rao J., 1998, WGN 26, 192
Šimek M., 1986, Bull. Astron. Inst. Czechosl. 37, 246
Šimek M., 1987, Bull. Astron. Inst. Czechosl. 38, 80
Šimek M., 1994, A&A 284, 276
Yeomans D. K., Brandt J. C., 1985, The Comet Giacobini-Zinner Handbook, JPL, Pasadena