VISUAL OBSERVATIONS OF PERSEIDS 1994

ARKADIUSZ OLECH and PRZEMYSLAW WOŹNIAK
Warsaw University Observatory, Al. Ujazdowskie 4, Warszawa, 00-478 Poland

(Received 3 March 1995)

Abstract. Visual observations of 1994 Perseid meteor stream made by Polish astronomy amateurs are disscused. New peak of activity appeared on August 1994, 12.458 UT with Zenithal Hourly Rate (ZHR) $\approx$ 230 and was not observed in Poland. Observations of second maximum at the moment 94.08.13,00 UT are reported. The new maximum observations collected by International Meteor Organization are also disscused. Spatial density of meteor bodies with mass $> 2.7 \cdot 10^{-4}$ g is estimated.

Key words: Meteors, Perseids

1. Introduction

The Perseid shower is one of the most active and best known meteor stream of the sky. At the end of July and almost all August this shower has been producing regular displays for over 1200 years (Oliver 1925). Its connection with Comet P/Swift-Tuttle (1992t) has also been known for many years (Schiaparelli, 1867). The last apparition of this comet which took place in 1992 and material carried out in 1862 have produced the appearance of a new narrow peak of activity which was first observed in 1988 (Roggemans 1989). This peak comes about half a day before the old flattened one.

Comparing the conditions of the strong Leonids storm of November 12, 1833 when the observed hourly rates exceeded 10^4 to the conditions at the night from 11th to 12th August 1993 when the Earth crossed the Comet P/Swift-Tuttle orbit, there was an expectation that the hourly rates could be much higher. Unfortunately the reality was different. The maximum ZHRs observed at the Canary Islands and the Atlantic Ocean amounted to 300–350 (Rendtel, 1993). However, the higher activity in 1994 has been suggested by Williams and Wu (1994).

2. Observations

In this paper we report the results of visual observations of Perseids 1994 made in period 15th July–20th August 1994 by 32 Polish observers associated in Comets and Meteors Workshop (CMW). We obtained 186.2 hours of observing time with 1981 meteors from Perseid stream, which were observed. Since almost all the observations were made in Poland, we could not observe the first peak of maximum which occurred about midday of local time. However, there are some observations

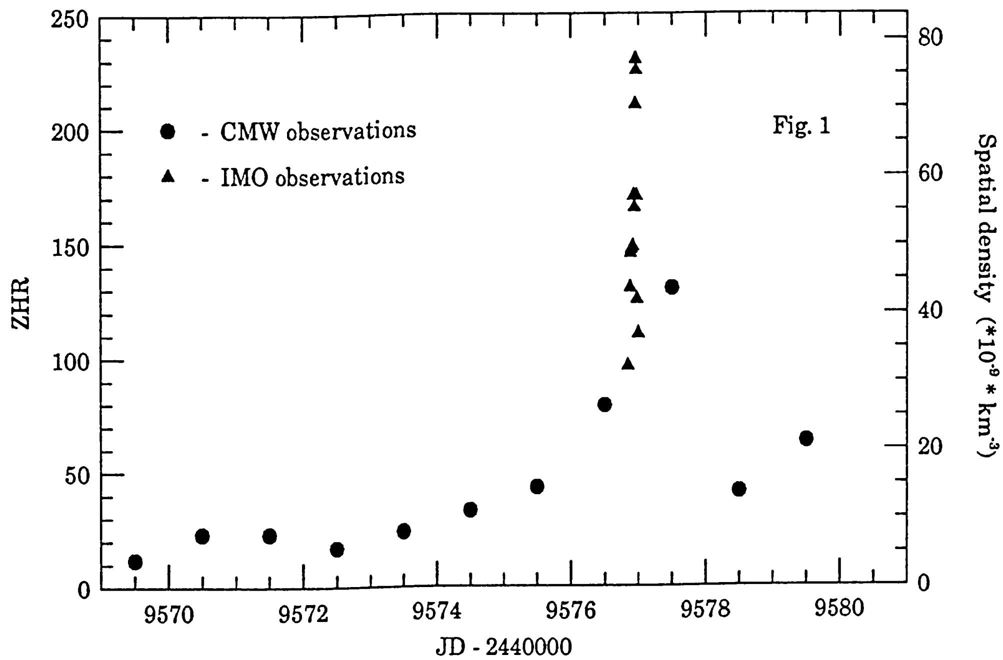

Figure 1. The old (Polish counts) and the new (IMO data) maxima of Perseids. The vertical axes show ZHR (left) and spatial density of meteor bodies (right).

in our database made in California by Polish observers on August 1994, 12.4 UT but their number is too small to derive any valuable conclusions. Thus we discuss this period of activity only thanks to International Meteor Organization (IMO) observers (Arlt 1994). The graph of Perseids 1994 activity from August 4th to 16th is shown in Figure 1. Vertical axis on the left is Zenithal Hourly Rate (ZHR) calculated from (Slanciková 1975, Zvolánková 1983):

$$\mathrm{ZHR} = \frac{N \cdot r^{6.5-M}}{\sin(h + 6^\circ)}$$

where N is the number of meteors observed per one hour, M is the limiting stellar magnitude in the observed field, h is an altitude of the radiant point of Perseids, and r is the apparent luminosity ratio between the number of meteors with magnitude m and $m - 1$ (for Perseids r = 2.5). Data presented in Figure 1 were selected according to the following rules. We required that the observed field obscured by clouds was less than 30%, the limiting magnitude of visible stars $M > 4.0$ mag, all but one observations were longer than 30 minutes, the altitude of the radiant point was always higher than 20°.

In our calculations of the altitude of the radiant point we adopted $\varphi = +52°13.1$ and $\lambda = +01^h24^m07^s$ (Warsaw). This assumption does not lead to significant errors. We also took into consideration the motion of the radiant point of Perseids in equatorial coordinates.

Table I
Magnitude distribution for Perseids 1994

-4^m	-3^m	-2^m	-1^m	0^m	1^m	2^m	3^m	4^m	5^m
3	6.5	14	31	86.5	175.5	222	220.5	136.5	25.5

From the IMO data the new peak is clearly visible at the time 12,458 UT August 1994 with ZHR = 230 ± 25. The second maximum observed in Poland reached ZHR = 130 ± 44 about midnight from 12th to 13th August 1994.

3. Magnitude and Color Distribution

The apparent brightness was estimated for 921 meteors. Apparent magnitude distribution (without a correction for the altitude of the meteor) is given in Table I. The apparent luminosity ratio r for the meteors brighter than 2 mag becomes 2.3 ± 0.3. Average apparent brightness of meteors was 1.9 mag.

The color was estimated for 894 meteors. 749 of them were white, 90 were yellow, 16 were white-blue and 11 were red. Other colors were white-yellow, blue, green and orange. About 12% of meteors had a trail.

4. Spatial Density of Meteor Bodies in the Stream

It is appealing to transform visual meteor counts into the density of meteor bodies and thus learn something about the structure of the stream.

The physical theory of ordinary meteors, i.e., of meteors observable by the naked eye is fairly well developed. We will estimate spatial density of Perseids on the basis of the theory presented in Levin (1955).

Observers associated in CMW and IMO estimate average magnitude of a meteor event. For the brightness of the meteor semi-empirical formula: $I \propto M^x v^y$ does hold, where M – mass of the meteor body "far" from the Earth, v – geocentric velocity of the stream. When $I = \bar{I}$ (mean brightness) then x = 0.7, y = 2.5. Although the magnitude corresponding to the mean brightness is not the average magnitude (estimated by observers) we adopted the latter as the best value for the former. The errors introduced by this procedure are acceptable for this kind of theory (considering visual observations).

Flux density of meteor bodies with masses greater than M across an area perpendicular to the flux is:

$$\nu(M) = avD(M)$$

where $D(M)$ is the spatial density of meteor bodies with masses greater than M, a is the factor that accounts for Earth's attraction ($a = 1 + gR/v^2$), g is the gravitational acceleration in atmospheric layer in which meteors are observed, and R is the geometric distance equal to 6740 km.

The hourly number referred to the radiant in zenith gives in a special system of units the flux density of meteors brighter than $6.^m5$. A field of 60° in diameter centered in the zenith, embraces at the altitude of 80 km an area of about 5000 km^2. Thus:

$$\nu(M(6.5)) = \frac{\text{ZHR}}{1.8 \cdot 10^7}$$

Mass of a meteor body with v = 40 km/s causing an event of 6.5 mag is $\sim 2.7 \cdot 10^{-4}\ g$. Reducing all streams to the standard velocity 40 km/s we obtain spatial density corresponding to this mass:

$$D(2.7 \cdot 10^{-4} g) = \left(\frac{40}{v}\right)^{y\chi} \frac{\text{ZHR}}{1.8 \cdot 10^7 \cdot a \cdot v}$$

$[v]$ = km/s, χ = 1 for Perseids. We derive from this formula that:

1. $D \propto$ ZHR, which means that ZHR profile gives the idea of what density profile along Earth's path is.
2. $D(2.7 \cdot 10^{-4} g) \simeq 7.7 \cdot 10^{-8}$ km^{-3} for Perseids (v = 60 km/s) in the higher maximum reaches ZHR $\simeq$ 230. This is roughly twice as dense as the second maximum.

Figure 1 shows Polish counts together with IMO data for the higher maximum. The vertical axis on the right of the graph is the spatial density of meteoroids. The new maximum is very sharp and high, which indicates that distribution of meteor bodies in the new part of Perseids is highly nonuniform.

Figure 2 shows density profile of Perseids along Earth's orbit from IMO observations of the new peak. The vertical axes are the same as in Figure 1. The horizontal axis is scaled in kilometers. Zero point corresponds to the moment JD=2449576.8 UT. We approximated the Earth's orbit with the straight line.

5. Conclusions

Basing on the Perseids 1994 CMW and IMO observations we have disscused the activity of this stream from August 4th to 16th. From IMO data we obtain maximal ZHRs equal to 230 ± 25 in the first maximum, which occured at the moment 94.08.12,458 UT. There is clearly visible from CMW data, that the second maximum was detected at midnight from August 12th to 13th with ZHR = 130 ± 44.

The apparent luminosity ratio r was 2.3 ± 0.3. This value agrees with last years values.

Average apparent brightness of meteors was 1.9 mag. From CMW observations in 1992 and 1993 we obtained respectively 1.9 mag. and 1.8 mag. Magnitude

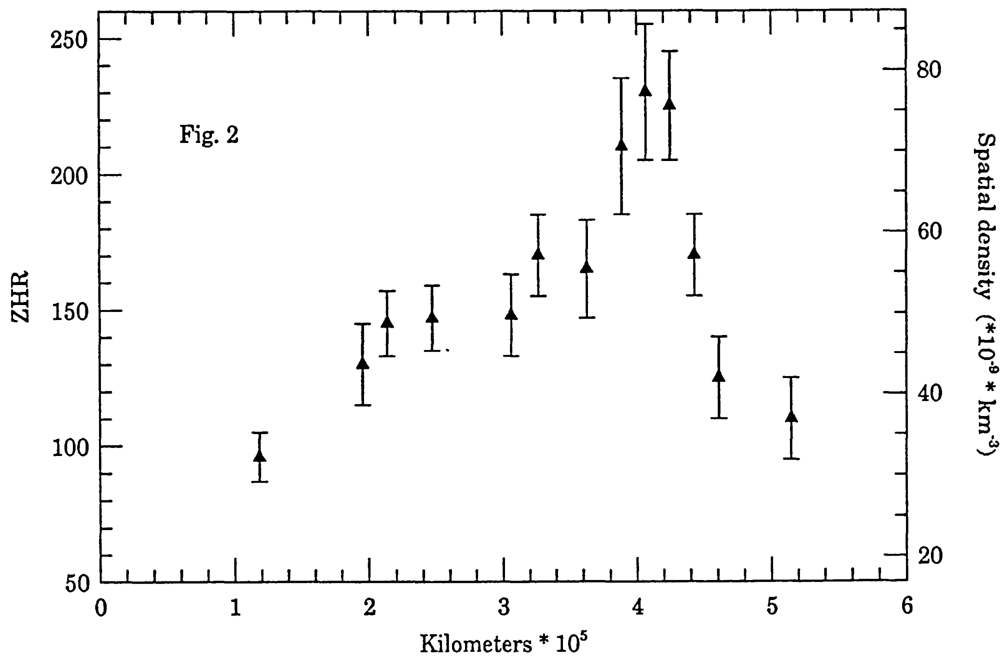

Figure 2. Density profile of the new peak of Perseids along Earth's orbit (from IMO data). Zero point corresponds to the moment JD = 2449576.8 UT.

estimates made before 1987 gave average magnitude of Perseids fainter than 2.5–3.0 mag. These changes are caused by the new sharp maximum observed from 1988 (Roggemans, 1989), which is rich in bright meteors and fireballs.

We have also computed spatial density of meteor bodies in the Perseids swarm. We have obtained $7.7 \cdot 10^{-8}$ particles $\cdot$ km^{-3} for the first and higher maximum, and $4.6 \cdot 10^{-8}$ particles $\cdot$ km^{-3} for the second maximum. The new peak is very high and sharp indicating nonuniform distribution of meteor bodies produced by Comet P/Swift-Tuttle last apparitions.

Acknowledgments

We are grateful to Prof. Jerzy Madej and Dr Janusz Kaluzny for helpful discussions, reading and commenting on the manuscript.

References

Arlt, R.: 1994, Private communication.
Levin, B. J.: 1955, *J. Atmosph. Terr. Phys.* (Special Suppl.) **II**, 131.
Oliver, C. P.: 1925, *Meteors*, Williams and Wilkins Publ. Co. London.
Rendtel, J.: 1993, *WGN* **21**, 235.

Roggemans, P.: 1989, *WGN* **17**, 125.
Slanciková, J.: 1975, *Bull. Astron. Inst. Czechosl.* **26**, 321.
Schiaparelli, G. V.: 1867, *Astron. Machr.* **68**, 331.
Williams, I. P. and Wu, Z.: 1993, *MNRAS* **264**, 980.
Williams, I. P. and Wu, Z.: 1994, *MNRAS* **269**, 524.
Zvolánková, J.: 1983, *Bull. Astron. Inst. Czechosl.* **34**, 122.