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The behavior of the Perseid stream in 1996

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Abstract. The visual observations of 1996 Perseids are reported. Based on over 700 hours of observing time an activity profile from July 15 to August 24 is given. The discovery of a small dip in the activity profile near solar longitude $\lambda_\odot \approx 129°$ (2000.0) is also presented. The maximal Zenithal Hourly Rates (ZHRs) equal to 162 ± 26 were noted on August 12.026 ($\lambda_\odot$ = 139.64°). The possibility of the presence of a double peak with maximal values of ZHR at $\lambda_\odot$ = 139.64° and $\lambda_\odot$ = 139.66° is also discussed. The minimum of a population index r were observed around the night of the maximum.

Key words: meteoroids, meteors – interplanetary medium

1. Introduction

In the year 1988 meteor observers noted the appearance of a new peak in addition to the traditional peak in the Perseids' activity profile. This feature preceded the previous maximum by about half a day and its Zenithal Hourly Rates (ZHRs) were comparable with the activity of the older peak. During the next few years these ZHRs were higher and the highest ones were observed in period 1991-1993. In these years fortunate and experienced meteor observer could note over 300 Perseids per hour during the night of the maximum (Rendtel 1993). Predictions made by Williams and Wu (1994) suggested that in the years 1994-1995 the maximal ZHRs could be around 200–300. They were right. On 1994 August 12 at 11^h UT the North American observers estimated the Perseids activity around 250 ± 45 (Rendtel 1994). Twelve hours later European watchers noted ZHR= 130 ± 44 (Olech and Woźniak 1996a). Analysis given by Rendtel (1994) indicated that the first and the higher peak in 1995 should occur on August 12 around 17^h UT. This time was advantageous for Asian observers. In Europe it was only possible to observe a pit between both maxima with ZHR around 80–90 (Olech and Woźniak 1996b). Only the Ukrainian visual observers noted ZHR= 160 ± 80 near 18^h UT on August 12 ($\lambda_\odot$ = 139.64°) (Rendtel 1995). This result was quickly confirmed by Japanese radio observations (Suzuki 1995).

Predictions for 1996 Perseids' maximum fortunately favored the European observers. The moment of the higher maximum should have occur on August 12 around 0^h UT. Additionally the phases of the Moon were almost ideal with New Moon on August 14.

2. Observations

In 1995 a group of 38 Polish meteor observers associated in the Comets and Meteors Workshop (CMW) obtained 448^h30^m of observing time and counted 2503 meteors from the Perseids stream (Olech and Woźniak 1996b). Taking into account the fact that in 1995 the weather conditions in Poland were excellent, we did not expect a higher number of counts in 1996. Surprisingly and fortunately the reality was different. From 1996 July 15 to 1996 August 25 a group of 50 CMW observers obtained 719^h14^m of observing time with 6706 meteors from the Perseids stream and 3505 sporadics. The complete list of our observers together with their total time that they observed is given in Appendix A.

This represents a large number of observations but not all of them can be used for ZHR calculations. Using our standard methods (Olech and Woźniak 1996b) we required that the value of the stellar limiting magnitude in a field of view had to be at least 4.80 mag, the correction factor F resulting from clouds cover had to be smaller than 2.0 and the effective time of observations had to be at least 30 minutes. The exception from the last rule was the night from Aug. 11 to 12 where longer runs were divided into periods of 10–30 minutes each. Finally we obtained 686 good ZHR estimates.

3. Results

3.1. Magnitude distribution and population index r

Although the number of 1995 Perseids in our database was not small, the Full Moon in the vicinity of the maximum made impossible to measure the behavior of a population index r. In 1996 situation was different. The New Moon occured on Aug. 14 i.e. close to the night of maximum and as many as 6290 magnitude estimates for Perseids and 3436 for sporadic meteors were made. The magnitude distributions (without a correction for the altitude of the meteor event) for 1996 Perseids and sporadics are given in Table 1.

Table 1. Magnitude distribution for 1996 Perseids and sporadics.

	≤-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	Tot.
Per.	9	1	1	1	6	13	32	78.5	159.5	322	693.5	953.5	1226.5	1369.5	956	421	47	6290
Spor.						3	6	18	31.5	81	181	364.5	627	888.5	732	443	60.5	3436

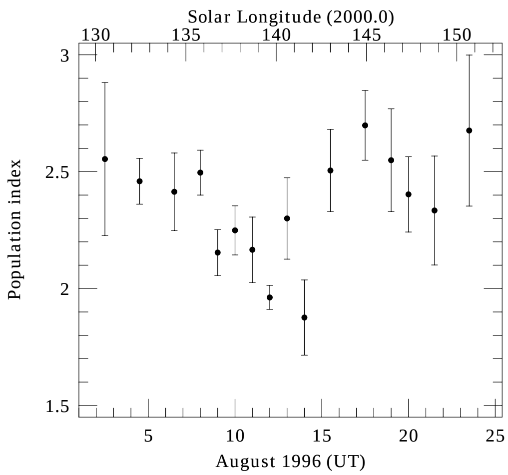

Fig. 1. The run of the population index r with time for 1996 Perseids.

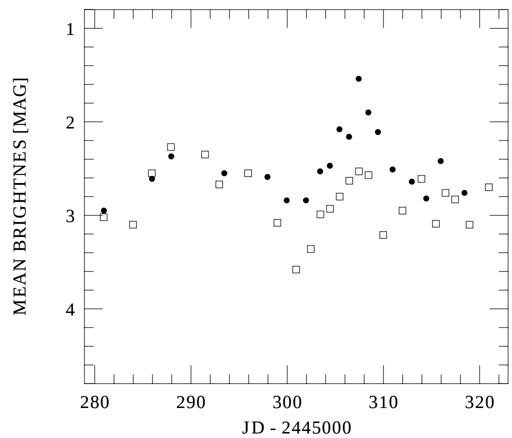

Fig. 2. The run of the mean brightness of Perseids meteors with Julian Day during the period of activity (filled circles). The same function for sporadic meteors is also shown for comparison (open squares).

For the purpose of investigate the changes of the population index r during the stream activity we used methods and probabilities of perception given by Koschack and Rendtel (1990). Our results are presented in Fig. 1. At the beginning of August i.e. from Aug. 1 to 7 and at the end of Perseids' activity i.e. from Aug. 15 to 25 r varied from 2.4 to 2.7, which is a typical value for Perseids. The clear minimum of the population index was observed near the maximum of the activity of the stream i.e. during nights Aug. 8–14, when the value of r amounted to 2.2. The two lowest values were detected during nights from Aug. 11 to 12 and from Aug. 13 to 14 and amounted to 1.96 ± 0.05 and 1.88 ± 0.16, respectively. The second value is even smaller than the value of r during the maximum of activity but its error is large and in reality r might be higher.

Such a small value of the population index during the peak of activity is certainly connected with a large number of bright (massive) meteors. This claim is also visible in Fig. 2 where the mean brightness of meteors from the Perseids stream is plotted versus time for each night. The open squares show the magnitudes for sporadic meteors and the filled circles correspond to the mean magnitudes of the Perseids. The highest point on this graph with value equal to 1.54 mag corresponds to the night of the maximum, confirming that during this night an enhanced number of bright meteors was observed.

The average brightness for all 1996 Perseids was 1.99 mag which is the typical value for this stream and did not change from last years measurements (Olech and Woźniak 1996a, 1996b). For comparison the average value of the brightness of the sporadic meteors was only 2.78 mag. About 23.6% of meteors from Perseid stream had a persistent train and 0.8% ended with a flash. This result is similar to that noted during the previous year.

3.2. The activity profile

Using the obtained values of the population index r we plotted the whole period activity profile for 1996 Perseids. For nights from Jul. 15/16 to Aug. 7/8 and from Aug. 14/15 to 24/25 we adopted r = 2.6, for nights from Aug. 8/9 to 10/11 and from Aug. 12/13 to 13/14 we adopted r = 2.2 and for the night of maximum i.e. Aug. 11/12 r = 2.0. The zenith exponent γ was set to 1.0.

The activity of 1996 Perseids is exhibited in Fig. 3. The maximum value of ZHR was equal to 90.5 ± 5.2 and was noted at the night Aug. 11/12. This point represents the mean value of all proper ZHR estimates made during this night. Because the number of these estimates amounted to 121, we decided to divide it into shorter bins and plot the activity profile only for the night of the maximum. The result of this operation is presented in Fig. 4. It is clearly visible that from Aug. 11.85 UT to Aug. 12.00 UT, ZHRs were low and oscillated around 60. After midnight the activity started to increase and quickly reached the maximal value of 162 ± 26 which occured on Aug. 12.026 UT which corresponds to the solar longitude (epoch 2000.0) $\lambda_\odot$ = 139.64°. After that ZHR dropped to 134 ± 20 at $\lambda_\odot$ = 139.65° and then slightly increased to 135 ± 18 at $\lambda_\odot$ = 139.66°.

The results obtained by International Meteor Organization (IMO) (Rendtel and Arlt, 1996) are marginally different. They noted the maximum activity with ZHR= 121 ± 17 at $\lambda_\odot$ = 139.66° $\pm$ 0.03°. The peak was not as sharp as in previous years and activity around ZHR$\approx$ 120 was observed from $\lambda_\odot$ = 139.63° to $\lambda_\odot$ = 139.70°, i.e. it lasted almost one hour and forty

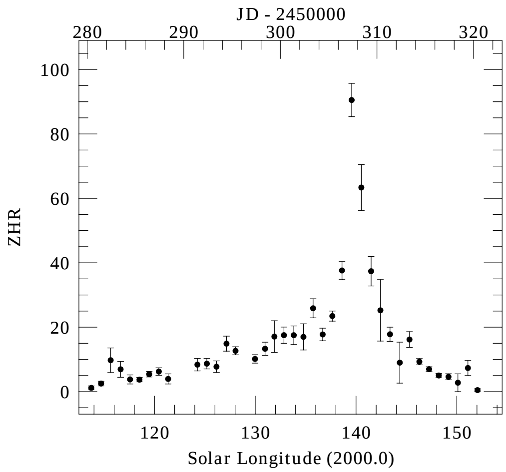

Fig. 3. The activity profile of the 1996 Perseids from July 15 to August 25.

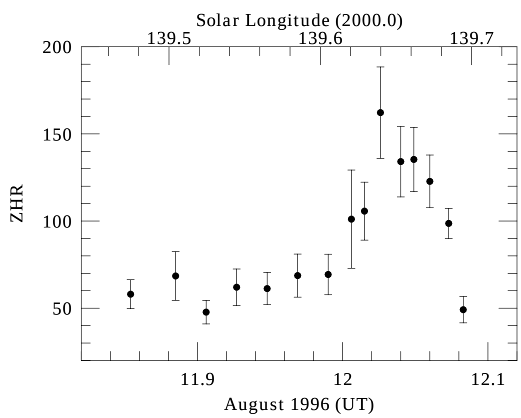

Fig. 4. The activity profile of the maximum of 1996 Perseids.

minutes. They did not note the high activity at $\lambda_\odot$ = 139.64° when our ZHRs exceeded 160. Our maximal point is however the mean value of 11 ZHR estimates and it is hard to imagine that it is erroneous. Compiling both results we can notice that the first peak of 1996 Perseids' activity might exhibit double structure with maxima at $\lambda_\odot$ = 139.64° and $\lambda_\odot$ = 139.66°.

The older maximum with ZHR= 85 $\pm$ 10 occured at $\lambda_\odot$ = 140.08° $\pm$ 0.04°, according Rendtel and Arlt (1996).

Based on the methods described by Koschack and Rendtel (1990), we computed the spatial densities of the meteor events. For the instant of the maximum i.e. $\lambda_\odot$ = 139.64° with ZHR= 162 $\pm$ 26 and r = 1.96 $\pm$ 0.05 we obtained the spatial density of meteors of magnitude at least 6.5 $\rho(m \leq 6.5)$ = 208 $\pm$ 36 particles/10^9km^3 which corresponds to the spatial density of meteor bodies with mass higher than 10^{-3} g $\rho(M \geq 10^{-3}\ g)$ = 26 $\pm$ 5 particles/10^9km^3.

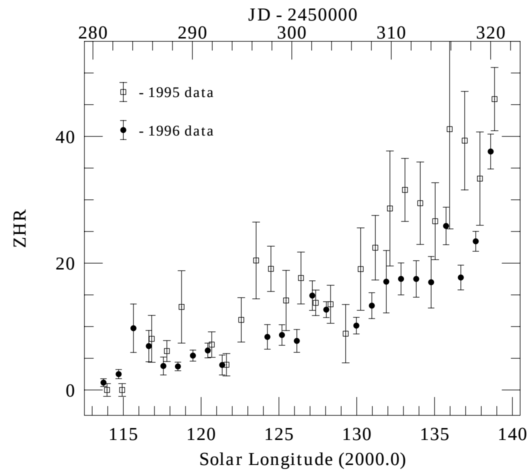

Fig. 5. Comparison of the 1995 and 1996 activity profiles.

3.3. Comparison of 1995 and 1996 activity profiles

The activity profile of 1995 Perseids presented by Olech and Woźniak (1996b) showed a clear dip around $\lambda_\odot \approx 129°$. Before this instant i.e. from $\lambda_\odot$ = 123° to $\lambda_\odot$ = 129° ZHRs gradually decreased but after this instant rapidly increased. Analyzing the 1995 data Olech and Woźniak (1996b) did not mention this feature because of low accuracy of ZHR measurements. The number of 1996 observations was significantly larger and the accuracy of ZHR estimates was better. In spite of a Full Moon around $\lambda_\odot$ = 127° in 1996, the dip in activity profile at $\lambda_\odot$ = 129° is also visible. It is clearly shown in Fig. 5 where part prior to the maximum of both the 1995 and 1996 activity profiles is presented. Open squares correspond to the 1995 data and the filled circles to the 1996 data. The systematic shift between data sets is a result of adopting different values of the zenith exponent γ for each year. In 1995 γ was equal to 1.4 and in 1996 we adopted γ = 1.0.

4. Conclusions

We presented the analysis of Perseids observational data collected by CMW observers during July and August 1996. The graph showing the evolution of the population index r from Aug. 1 to 24 exhibited a clear minimum during the night from Aug. 11 to 12 with $r = 1.96 \pm 0.05$. Low values of r equal to 2.2 were also noted in the vicinity of the maximum. In the remaining part of the activity period the population index was typical and oscillated around 2.6. Such a low value of r during the maximum suggest the presence of large number of massive bodies in the central part of the ribbon of meteoroids. This conclusion is confirmed by the analysis of changes of mean brightness of the Perseids. The minimum value of 1.54 mag was also noted during the night of the maximum. The average brightness for all 1996 Perseids was equal to 1.99 mag.

Due to the large number of 1996 data we obtained precise activity profile for the whole period of activity of the Perseids stream. The detailed analysis of activity near the maximum gave the maximal ZHRs equal to 162 ± 26 at solar longitude $\lambda_\odot$ = 139.64°. After this moment until $\lambda_\odot$ = 139.66° ZHRs were at the level of 135. Comparing our data with results obtained by Rendtel and Arlt (1996) we suggested the presence of the double peak of Perseids activity in 1996 with maxima at $\lambda_\odot$ = 139.64° and $\lambda_\odot$ = 139.66°. More detailed analysis containing larger number of observations is however needed to confirm this conclusion.

The spatial densities of meteor bodies computed from our observations gave values similar the estimates from previous years (see Rendtel and Arlt 1996).

Comparison of 1995 and 1996 activity profiles showed the clear dip near $\lambda_\odot$ = 129°. The discovery of this feature is very interesting and suggests that the old component of Perseids activity is not distributed as uniformly as had been previously thought

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Appendix A

The complete list of CMW observers together with the total time that they observed.

Tomasz Fajfer (99^h16^m), Maciej Reszelski (89^h16^m), Arkadiusz Olech (43^h00^m), Janusz Kosinski (39^h30^m), Krzysztof Wtorek (39^h00^m), Konrad Szaruga (35^h24^m), Marcin Nowak (33^h00^m), Krzysztof Kamiński (27^h14^m), Łukasz Pospieszny (22^h22^m), Robert Szczerba (22^h15^m), Maciej Kwinta (21^h10^m), Krzysztof Gdula (18^h00^m), Łukasz Sanocki (14^h09^m), Michał Jurek (14^h00^m), Jerzy Zagrodnik (12^h10^m), Janusz Płeszka (11^h50^m), Tomasz Dziubiński (11^h40^n), Tomasz Żywczak (11^h00^m), Krzysztof Socha (9^h51^m), Marcin Stolarz (8^h35^m), Marcin Sienko (7^h45^m), Łukasz Kuczkowski (7^h40^m), Katarzyna Gniazdowska (7^h30^m), Adam Grzeszuk (7^h00^m), Józef Wianowski (7^h00^m), Andrzej Skoczewski (6^h44^m), Tomasz Ramza (6^h30^m), Tadeusz Sobczak (6^h25^m), Marcin Konopka (6^h00^m), Łukasz Raurowicz (5^h50^m), Marcin Gajos (5^h18^m), Michał Marek (5^h00^m), Wacław Moskal (4^h50^m), Lesław Materniak (4^h45^m), Tomasz Krzyżanowski (4^h31^m), Wiesław Słotwiński (4^h16^m), Grzegorz Kiełtyka (4^h00^m), Robert Pawłowski (4^h00^m), Kamila Ruta (3^h53^m), Paweł Musialski (3^h40^m), Wojciech Jonderko (3^h24^m), Maciej Kania (3^h15^m), Ryszard Urbaniak (3^h10^m), Michał Antonik (3^h06^m), Ireneusz Sławiński (3^h00^m), Mariusz Wtorek (3^h00^m), Rafał Kopacki (2^h00^m), Marcin Filipek (1^h00^m), Urszula Majewska (1^h00^m), Marek Wojdat (1^h00^m).

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