The Perseids 1995 in Poland

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Abstract

Visual observations of 1995 Perseid meteor stream made by Polish astronomy amateurs are reported. Using this material we obtained new accurate points in the activity profile during maximum. The Zenithal Hourly Rates (ZHRs) for the whole period of activity are presented. We also discuss the magnitude, the colour and the velocity distributions of Perseids.

Key words: Meteors

1 Introduction

Since 1988, when the new narrow and high peak of Perseids activity was first observed (Roggemans 1989), all meteor observers world wide are especially interested in watching this stream. The reason is high ZHRs noted in 1993 that reached 300 - 350 (Rendtel 1993) making Perseids the most active regular meteor stream of the sky. The 1994 observations gave maximum ZHR=250 $\pm$ 45 (Rendtel 1994). Calculations made by Williams and Wu (1994) suggested that in 1995 we can expect similar activity. Analysis given by Rendtel (1994) also indicated that the 1995 first and high peak should occur on August 12 at $17^h \pm 3$ UT. The old, more flattened and well known maximum should be observed on August 13 about 9^h UT.

The predicted time of the first maximum favoured observers in Eastern Europe and Asia. The second maximum time was very good for North-American observers. Unfortunately the Full Moon occurring on August 10 possibly could reduce maximal ZHRs values by factor even 10.

2 Observations and Data Reduction

The weather in Central Europe, unfortunately enough, does not coddle the sky observers. As a result it is very hard to obtain good observational data covering a long period of time. But such data are necessary for the analysis of the meteor stream

behaviour during its activity. Fortunately the year of 1995 was different. There were many clear nights from the beginning of July to the end of August. Such good conditions allowed us to obtain a large number of Perseids 1995 observations.

In 1994, a group 32 Polish observers associated in Comets and Meteors Workshop (CMW) obtained 186.2 hours of observing time with 1981 meteors from Perseid stream observed (Olech and Woźniak 1996). In this paper we report the results of visual observations of Perseids 1995 made by CMW members. From July 16 to August 22, a group of 38 observers obtained 448.5 hours of observing time with 2503 meteors from Perseid stream, which were observed. The total number of hourly rate estimates is 430.

Although the number of observations is large, not all observations can be used for ZHR calculations. To obtain the most valuable conclusions we selected our data according to the following rules:

• the mean stellar limiting magnitude in the center of the field of view must be higher than 4.5 mag.,

• the effective time of observation must be equal to or longer than 30 minutes,

• the correction factor F resulting from clouds cover must be smaller than 2. We calculated F from equations given by Koschack (1991).

The observations satisfying these conditions accounted for 348.1 hours of observing time with 343 good hourly rate estimates. These data can be used for Zenithal Hourly Rate (ZHR) calculations. We adopted the formula given in Slančiková (1975) and Zvolánková (1983):

$$ZHR = \frac{N \cdot r^{6.5-LM}}{(\sin H)^{\gamma}}$$

where N is the number of meteors observed during one hour of the effective time, LM is the mean stellar limiting magnitude in the observed field, H is the altitude of the radiant point of Perseids, r is the apparent luminosity ratio between the meteors with magnitude $m+1$ and m (r is also called population index), and γ is the stream dependent constant. We took $r = 2.5$ and $\gamma = 1.41$ from Jenniskens (1994).

There is a problem with zero hourly rate detections. Except for the first two nights of activity, when all estimates had no meteors detected, we use such observations to compute mean ZHR only when the stream had nonzero detections during the same night. The second problem is the statistic error of the zero hourly rate detection. We assumed the formal error of 1.0.

The complete list of our observers, their location, the effective observing time, the numbers of total hourly rate estimates, total ZHR estimates and the observed meteors from Perseid stream is given in Table I.

Table 1: List of CMW observers.

Observer	**Place**	**Tot. hours**	**Tot. HR estimates**	**Tot. ZHR estimates**	**Tot. meteors**
Maciej Reszelski	Szamotuły	105^h	105	105	388
Arkadiusz Olech	Pruszcz Gd.	61^h50^m	63	63	577
Marcin Gajos	Opole	32^h	32	25	213
Krzysztof Gdula	Brodnica	20^h	23	9	122
Sylwia Hołowacz	Pasłęk	19^h35^m	14	0	136
Agnieszka Kaczorowska	Pasłęk				
Wojciech Jonderko	Rybnik	19^h30^m	13	4	15
Tomasz Dziubiński	Szamotuły	19^h	19	12	54
Konrad Szaruga	Telatyn	17^h	17	11	53
Łukasz Sanocki	Wola Dębowiecka	15^h	15	14	70
Krzysztof Kamiński	Poznań	14^h10^m	13	3	58
Adam Grzeszuk	Szóstka	12^h25^m	13	11	82
Jerzy Zagrodnik	Krosno	12^h10^m	13	13	88
Krzysztof Socha	Piórków	11^h	11	11	9
Izabela Solica	Pasłęk	9^h20^m	8	0	27
Urszula Bąk	Namysłów	9^h15^m	4	3	149
Joanna Hibowska	Namysłów				
Katarzyna Hibowska	Namysłów				
Paweł Gembara	Warszawa	7^h38^m	7	7	43
Janusz Płeszka	Kraków	6^h45^m	7	7	92
Krzysztof Wtorek	Grudziądz	6^h	6	6	16
Michał Marek	Zawiercie	5^h40^m	6	6	19
Karol Zwilling	Katowice	5^h05^m	5	2	37
Maciej Kwinta	Kraków	5^h	5	4	21
Michał Jurek	Polska Nowa Wieś	4^h22^m	4	3	23
Grzegorz Bonikowski	Warszawa	4^h20^m	3	3	42
Tomasz Ramza	Świebodzin	4^h	4	4	13
Krzysztof Zurek	Kraków	3^h55^m	3	3	25
Urszula Majewska	Chełm	3^h30^m	4	4	28
Piotr Grzywacz	Łódź	3^h	3	3	16
Michał Kopczak	Sanok	2^h30^m	2	2	4
Sebastian Nieznaj	Czechowice-Dziedzice	2^h	1	1	21
Łukasz Pośpieszny	Ostroróg	2^h	2	1	4
Jacek Burda	Kraków	1^h30^m	1	1	8
Elzbieta Brembor	Wielichowo	1^h	1	0	2
Marcin Nowakowski	Starogard Gd.	1^h	1	1	5
Tomasz Piotrowski	Gdańsk	1^h	1	0	0
Józef Wianowski	Lublin	1^h	1	1	3
ALL		448^h30^m	430	343	2503

3 Results

3.1 Activity profile

Figure 1 shows the activity of Perseids stream from July 16 (JD 2449915.5) to August 22 (JD 2449952.5). There was only one night without ZHR estimate (August 16). We also removed one single observation point of July 22 which had the error comparable with the value of ZHR itself.

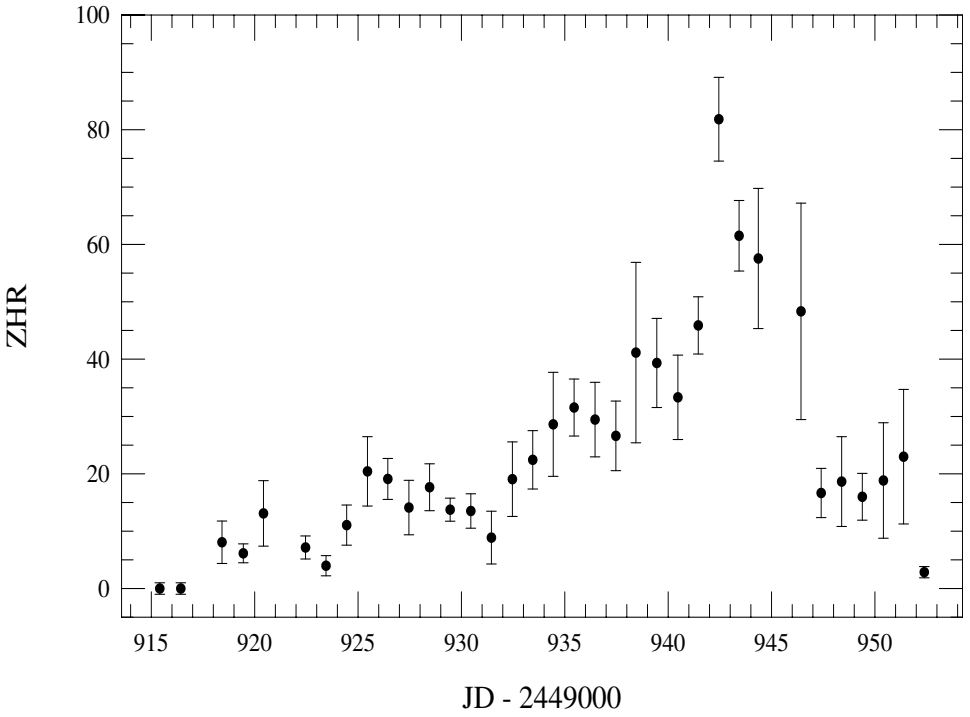

Figure 1: The graph of Perseids 1995 activity from July 16 to August 22.

This graph differs slightly from that of the previous year (Olech and Woźniak 1996) especially in the wings of activity profile. The ZHRs noted at the end of July and at the beginning of August are higher than the counts of the previous year. It suggests more uniform distribution of meteor bodies in the whole ribbon of Perseid meteoroids.

The maximum value presented in Figure 1 is the mean value of 20 good ZHR estimates. We tried to divide these estimates into five bins and added them to the graph given by Rendtel (1995). The resulting diagram is shown in Figure 2. The filled triangles are International Meteor Organization (IMO) observations and the filled circles are CMW points. Only the first two of our points have large errors because of small number of observations being averaged. However these errors are similar to IMO estimates. Our next three points are more precise and show nice monotonic decrease of activity. There is also good conformity of IMO and CMW results.

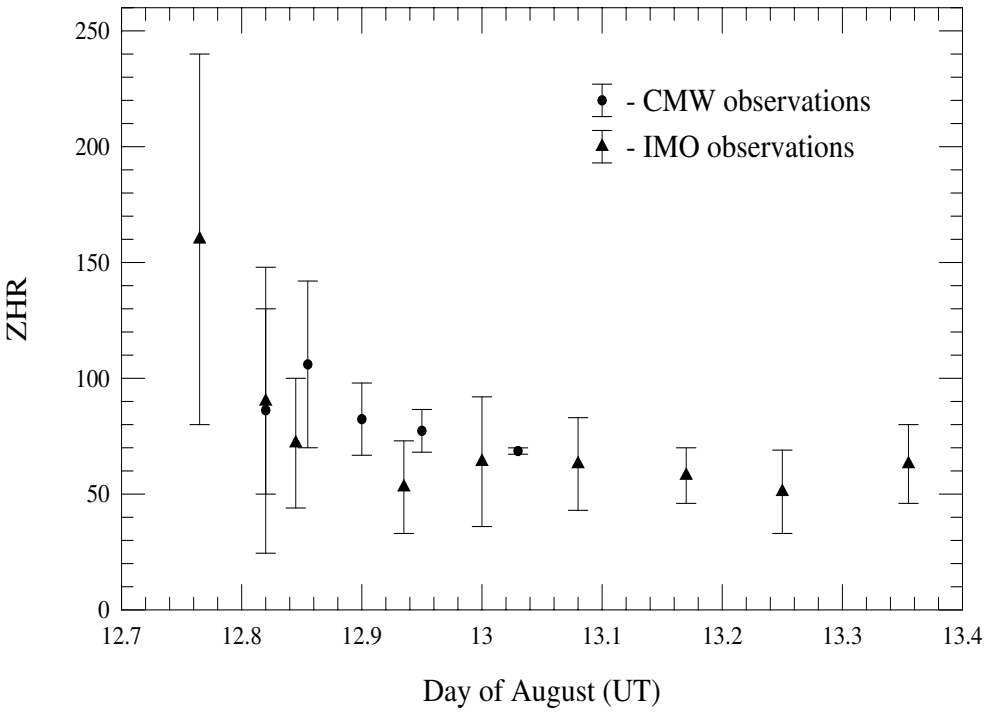

Figure 2: ZHR graph of the Perseids 1995 maximum from IMO (triangles) and CMW (circles) observations.

From the Figure 2, it is clearly visible that the maximum occurred at about 18^h UT on August 12, which corresponds to $\lambda_\odot = 139.^\circ64$. The maximum ZHR of the peak given by Rendtel (1995) was 160 ± 80, but in our opinion the slightly earlier ZHRs could have been even higher. This would be in quite good agreement with the moment of maximum activity derived from radio observations reported by Suzuki (1995). His observations suggested that the maximum hourly rate of echoes reached 300 between August 12.71-12.79 UT, which corresponds to 17^h-19^h UT and solar longitude $\lambda_\odot = 139.^\circ6$ (equinox 2000.0), and that the strongest activity lasted for about 50 minutes (from 17^h50^m UT to 18^h40^m UT).

It is clearly visible that the most favourable places for watching the maximum of Perseids 1995 were Eastern Europe and Asia sites. Unfortunately there are not many meteor observers there.

We are also waiting for more precise estimate of the moment of the second maximum and its ZHR made by North-American observers. The predictions suggested that the second maximum can be expected on August 13 at 9^h UT. The graph presented by Rendtel (1995) (see Figure 2 in this paper) strongly suggests that the actual maximum occurred slightly later in comparison to the above predictions.

3.2 Magnitude distribution and brightness estimates

The apparent brightness was estimated for 2061 events. The magnitude distribution (without a correction for the altitude of the event) is given in Table II. From this distribution we can derive the mean population index r for the whole period of activity of the stream. The value of r for the meteors brighter than 2 mag becomes 2.11 ± 0.44. It is in quite good agreement with the value of r reported by other authors (Jenniskens 1994). We also tried to investigate the changes of r during the stream activity (see Figure 1 in Rendtel 1994 for comparison), but the errors of our measurements were too large for such analysis and no sensible trend was obtained.

Nevertheless we tried to plot the average brightness of meteors from Perseid stream for each night versus time. The result of this operation is shown in Figure 3. It is clearly visible that the brightness increases from the beginning of activity to the maximum and drops after this moment. However, the points in the vicinity of August 10, when the Full Moon caused the drop of the stellar limiting magnitude, can be artificaly overestimated. On the other hand the point corresponding to the maximum of activity is the highest point of the graph. This fact suggests the presence of increased density of bigger particles in the central part of the stream.

Table 2: Magnitude distribution for Perseids 1995

-5^m	-4^m	-3^m	-2^m	-1^m	0^m	1^m	2^m	3^m	4^m	5^m	6^m
5	8	14	40	86	210.5	386	514	469.5	239	85	4

3.3 Velocity and colour distributions

The angular velocity of the meteor event on the sky was estimated using 0-5 scale. There were 1817 such estimates in total. The velocity distribution is given in Table III. The average velocity of all Perseid meteors in this scale becomes 4.3. Knowing that true velocities of meteoroids in atmosphere vary from 11 km/s to 72 km/s this value corresponds to 61 km/s. The result differs from the real Perseids velocity which is equal to 59 km/s (Koschack 1991). The difference between our estimates and the real velocity can be a result of the small number of our counts.

We also computed the mean velocity as a function of Julian day. No systematic trends were visible, and the points were uniformly spread around the average value 4.3.

The colour was estimated for 1885 meteors. 80.2% of them were white, 10.4% were yellow, 2.3% were white-blue, 2.1% were orange, 1.8% were red and 1.6% were blue. Other colours were white-yellow, white-red, green and pink. About 21.3% of meteors had a trail and 0.6% were finished with a flash or fragmentation. These results are similar to the last year results, and only the number of trails seems to be two times greater than during last apparition of Perseids (see Olech and Woźniak 1996).

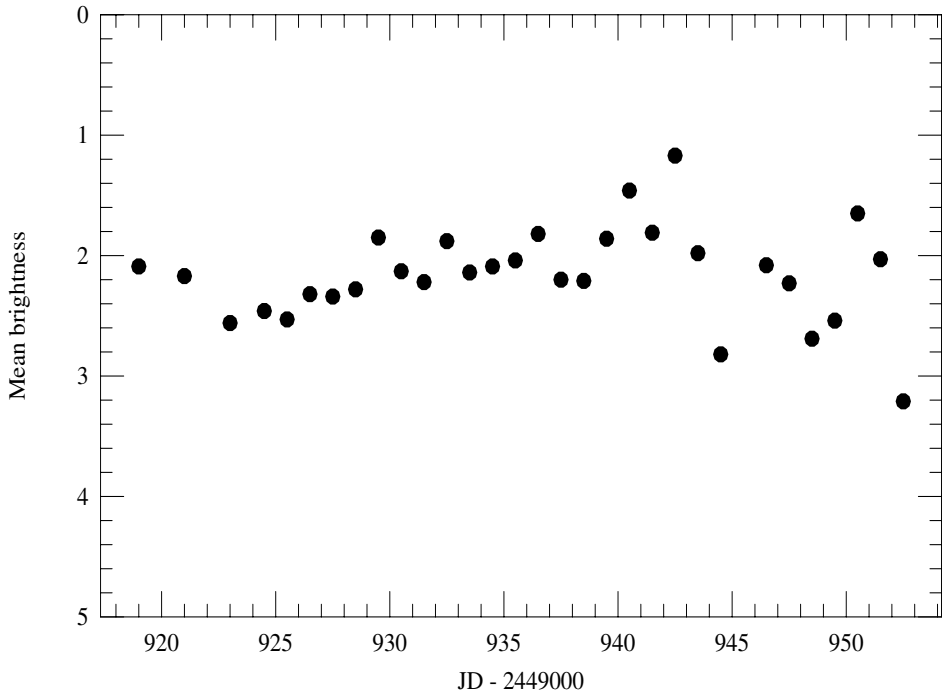

Figure 3: The changes of the mean brightness of Perseid meteors during the period of activity.

Table 3: The velocity distribution for Perseids 1995

0	1	2	3	4	5
6	0	18	269	776	757

4 Conclusions and Summary

Thanks to the good weather conditions during July and August 1995 we obtained large number of Perseids 1995 observations. In spite of the Full Moon which occurred on August 10, we obtain quite numerous set of observations. From these data we could derive some valuable conclusions. We presented the whole period ZHRs graph, which differs from previous years data especially in the wings of the activity profile. The ZHRs in these points of the graph are slightly higher than on the plots from previous years, which suggests the evolution of the swarm towards the more uniform distribution of meteor bodies.

Our ZHR estimates during the night of the maximum are accurate points and confirm precisely the results presented by Rendtel (1995). We agree with Rendtel

(1995) and Suzuki (1995) conclusions concerning the moment of the maximum and its ZHRs. We regret only that the moment of the maximum occurred too early to be well observed in Poland.

We also presented the figure of mean brightness versus Julian day, and we noted the highest mean brightness of meteors during the night of the maximum. It suggests that the large particles are more numerous in the center of the meteoroids ribbon.

We also discussed the velocity and the colour distributions, and we conclude that the results do not differ strongly from the measurements of the previous year (Olech and Woźniak 1996).

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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 $\lambda_\odot \approx 129^\circ$ (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

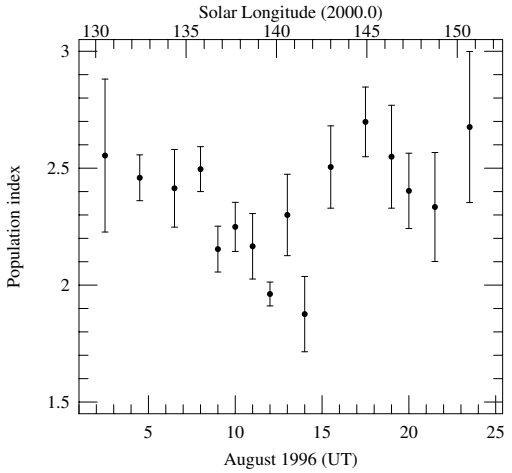

Fig. 1. The run of the population index r with time for 1996 Perseids.

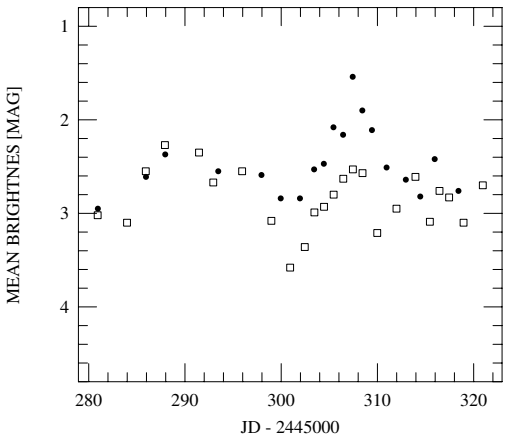

Fig. 2. The run of the mean brightness of Perseids meteors with Julian Day during the period of activity (filled circles). The same function for sporadic meteors is also shown for comparison (open squares).

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

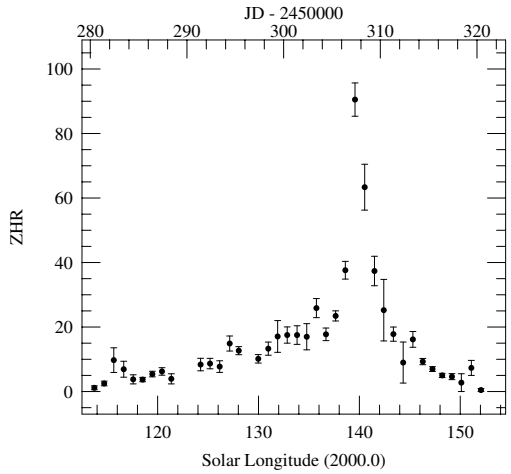

Fig. 3. The activity profile of the 1996 Perseids from July 15 to August 25.

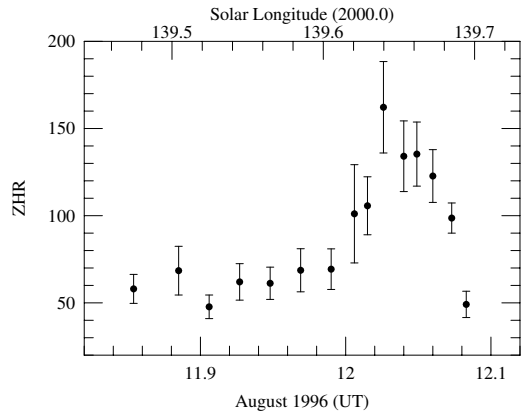

Fig. 4. The activity profile of the maximum of 1996 Perseids.

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.

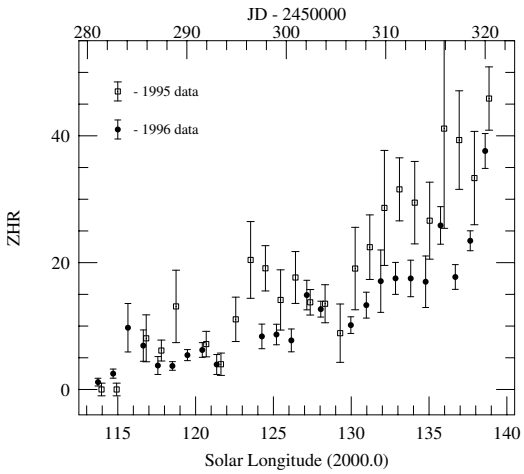

Fig. 5. Comparison of the 1995 and 1996 activity profiles.

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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Alpha Cygnids - a possible July minor meteor shower

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Abstract. We present a comprehensive study of a possible α-Cygnid meteor shower. Based on visual and telescopic observations made by Polish observers we estimate basic parameters of the stream. Activity of α-Cygnids lasts from around June 30 to July 31 with clear maximum near July 18 (solar longitude $\lambda_\odot = 116.5°$). Maximal Zenithal Hourly Rates (ZHRs) are equal to 3.6 ± 1.2. The structure of the radiant analyzed by RADIANT software is most compact for geocentric velocity of the events equal to 41 km s^{-1}, and for the drift of the radiant (in units °/day) equal to $\Delta\alpha = +0.6$ $\Delta\delta = +0.2$. Center of the radiant for the moment of maximum is $\alpha = 302.5°$ $\delta = +46.3°$. We derive population index r equal to 2.55 ± 0.14 from magnitude distribution of 738 possible members of the stream. Comparing the velocity distributions of 754 possible α-Cygnids and 4339 sporadic events by χ^2 and Kolmogorov-Smirnov tests we conclude that both distributions are different with a probability very close to 1.0.

Telescopic observations strictly confirm the results obtained from visual observations. The smallest values of χ^2 parameter were obtained for the geocentric velocity equal to 40 km s^{-1} and for the drift of the radiant (in units °/day) equal to $\Delta\alpha = +0.6$ $\Delta\delta = +0.2$. The center of the radiant for moment of maximum is $\alpha = 304.9°$ $\delta = +46.2°$.

In spite of making many photographic exposures we still have no photographic or video confirmation of the existence of this stream.

Key words: meteoroids, meteors — interplanetary medium

1. Introduction

The first data about meteors from radiant near α Cygni come from W.F. Denning (Denning 1919). In years 1885–1918 he observed 50 meteors radiating from the close vicinity of Deneb. He did not know the activity period of the stream so he noted meteors during the whole year. It is clearly visible from his Table 2 that most of the meteors were noted during July nights. Almost all events observed this month were classified as rapid.

During the next years one can find the different parameters describing α-Cygnids stream in the astronomical literature. Polish meteor publications were giving activity period between June 16th and July 31st. No clear maximum of activity was found (Kosinski 1990).

Photographic data are also poor. Only one possible member was captured in Dushanbe on 1961 July 12. The radiant of this event was $\alpha = 304.5°$, $\delta = +49.7°$ and geocentric velocity $V_\infty = 41.0$ km s^{-1} (Babadzhanov & Kramer 1965).

In the comprehensive work undertaken by Dutch Meteor Society (DMS) and North Australian Planetary Observers – Meteor Section (NAPO–MS) in years 1981-1991 and described in detail by Jenniskens (1994) one can read about weak stream called o-Cygnids. During 98 hours of effective time of observations 8 observers noted 72 possible members of that stream. From this data Jenniskens (1994) estimated the following parameters of the stream:

- equatorial coordinates of the radiant during the maximum of activity: $\alpha = 305°$ $\delta = +47°$,
- drift of the radiant (in units °/day): $\Delta\alpha = +0.6$ $\Delta\delta = +0.2$,
- maximum of activity: $\lambda_{\odot(1950.0)} = 116.0° \pm 0.5°$,
- population index $r = 2.7$, where r is defined as:

$$r = \frac{\Phi(m+1)}{\Phi(m)} \tag{1}$$

where

$$\Phi(m) = \sum_{-\infty}^{m} N(m) \tag{2}$$

and $N(m)$ is the number of meteors with magnitude m corrected for probabilities of perception given by Koschack & Rendtel (1990),

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Table 1. List of visual CMW observers

Observer	1995			1996			1997		
	$t_{\rm eff}$	N_α	$N_{\rm sp}$	$t_{\rm eff}$	N_α	$N_{\rm sp}$	$t_{\rm eff}$	N_α	$N_{\rm sp}$
Maciej Reszelski	$56^{\rm h}51^{\rm m}$	40	278	$27^{\rm h}22^{\rm m}$	35	181	$11^{\rm h}58^{\rm m}$	18	114
Arkadiusz Olech	$32^{\rm h}45^{\rm m}$	35	257	$16^{\rm h}55^{\rm m}$	19	129	$31^{\rm h}31^{\rm m}$	39	234
Tomasz Fajfer	-	-	-	$31^{\rm h}30^{\rm m}$	33	134	$39^{\rm h}30^{\rm m}$	52	341
Konrad Szaruga	-	-	-	$11^{\rm h}28^{\rm m}$	6	84	$50^{\rm h}16^{\rm m}$	85	257
Marcin Gajos	$26^{\rm h}00^{\rm m}$	12	144	$6^{\rm h}18^{\rm m}$	4	38	$10^{\rm h}40^{\rm m}$	11	83
Krzysztof Socha	$17^{\rm h}00^{\rm m}$	21	103	$6^{\rm h}54^{\rm m}$	4	38	$18^{\rm h}16^{\rm m}$	12	142
Maciej Kwinta	$4^{\rm h}00^{\rm m}$	0	13	$8^{\rm h}10^{\rm m}$	0	13	$26^{\rm h}50^{\rm m}$	9	157
Krzysztof Wtorek	$5^{\rm h}42^{\rm m}$	5	32	$10^{\rm h}00^{\rm m}$	14	67	$12^{\rm h}55^{\rm m}$	12	45
Łukasz Sanocki	$14^{\rm h}30^{\rm m}$	17	62	$5^{\rm h}46^{\rm m}$	8	21	$8^{\rm h}04^{\rm m}$	5	27
Tomasz Dziubiński	$15^{\rm h}47^{\rm m}$	16	35	$3^{\rm h}30^{\rm m}$	5	20	$6^{\rm h}00^{\rm m}$	3	25
Jarosław Dygos	-	-	-	-	-	-	$24^{\rm h}30^{\rm m}$	16	157
Gracjan Maciejewski	-	-	-	-	-	-	$21^{\rm h}15^{\rm m}$	8	91
Andrzej Skoczewski	-	-	-	-	-	-	$20^{\rm h}23^{\rm m}$	28	85
Artur Szaruga	-	-	-	-	-	-	$19^{\rm h}55^{\rm m}$	14	71
Wojciech Jonderko	-	-	-	$4^{\rm h}15^{\rm m}$	0	11	$15^{\rm h}24^{\rm m}$	7	67
Marcin Konopka	-	-	-	-	-	-	$18^{\rm h}39^{\rm m}$	17	181
Michał Jurek	-	-	-	$9^{\rm h}31^{\rm m}$	9	80	$7^{\rm h}39^{\rm m}$	9	53
Tomasz Żywczak	-	-	-	-	-	-	$16^{\rm h}38^{\rm m}$	10	43
Maria Woźniak	$13^{\rm h}45^{\rm m}$	18	43	-	-	-	-	-	-
Tomasz Ramza	-	-	-	$6^{\rm h}30^{\rm m}$	5	49	$5^{\rm h}59^{\rm m}$	1	32
Łukasz Pospieszny	-	-	-	$9^{\rm h}44^{\rm m}$	4	62	$3^{\rm h}31^{\rm m}$	1	18
Piotr Grzywacz	$11^{\rm h}30^{\rm m}$	21	55	-	-	-	-	-	-
Robert Szczerba	-	-	-	$5^{\rm h}00^{\rm m}$	6	21	$6^{\rm h}20^{\rm m}$	1	100
Krzysztof Kamiński	-	-	-	-	-	-	$8^{\rm h}47^{\rm m}$	6	60
Łukasz Raurowicz	-	-	-	$1^{\rm h}07^{\rm m}$	2	3	$6^{\rm h}16^{\rm m}$	6	44
Tadeusz Sobczak	-	-	-	-	-	-	$6^{\rm h}10^{\rm m}$	20	46
Rafał Kopacki	-	-	-	$5^{\rm h}30^{\rm m}$	8	45	-	-	-
Michał Marek	-	-	-	$4^{\rm h}00^{\rm m}$	6	5	$0^{\rm h}30^{\rm m}$	1	4
Elżbieta Brembor	$4^{\rm h}00^{\rm m}$	8	5	-	-	-	-	-	-
Ireneusz Sławiński	-	-	-	$3^{\rm h}00^{\rm m}$	0	12	-	-	-
Krzysztof Gdula	-	-	-	$2^{\rm h}30^{\rm m}$	2	11	-	-	-
Marek Piotrowski	-	-	-	-	-	-	$2^{\rm h}25^{\rm m}$	2	14
Paweł Trybus	-	-	-	-	-	-	$2^{\rm h}00^{\rm m}$	0	10
Paweł Musialski	-	-	-	$1^{\rm h}30$	1	7	-	-	-
Paweł Gembara	$1^{\rm h}00^{\rm m}$	0	10	-	-	-	-	-	-
Total	$202^{\rm h}50^{\rm m}$	193	1037	$180^{\rm h}30^{\rm m}$	171	1031	$402^{\rm h}21^{\rm m}$	393	2501

• Maximal Zenithal Hourly Rates (ZHRs) are equal to 2.5 ± 0.8, where ZHR is defined as:

$$ZHR = \frac{N_{\rm h} \cdot r^{(6.5-LM)}}{(\sin H)^{\gamma}} \qquad (3)$$

where $N_{\rm h}$ is the observed number of meteors per hour (corrected for clouds coverage), LM is the limiting magnitude in the field of view, H is an altitude of the radiant of the stream, and γ is a zenith exponent factor,

• geocentric velocity: $V_\infty = 37$ km s^{-1}.

From the Fig. 11 in paper by Jenniskens (1994) it is clearly visible that the activity of o-Cygnids lasts from $\lambda_\odot \approx 105°$ to $\lambda_\odot \approx 127°$ i.e. from around July 5th to July 27th.

2. Observations

2.1. Visual observations

July is a good month for meteor observers in Poland. Polish observers associated in Comets and Meteors Workshop (CMW) are mostly young people studying at secondary schools or universities. July is the first month of summer holidays. The warm nights, a lot of free time, good weather conditions strongly encourage to observations. Finally about $60 - 80\%$ of whole year observations made by CMW members are collected in July and August.

All above facts and rapidly growing interest in meteor observations in Poland during the last few years allowed us to investigate the activity of the stream called α-Cygnids or o-Cygnids. Each July in years 1995-1997 many meteor

Table 2. List of telescopic CMW observers

Observer	1996			1997			Total		
	$t_{\rm eff}$	N_α	$N_{\rm sp}$	$t_{\rm eff}$	N_α	$N_{\rm sp}$	$t_{\rm eff}$	N_α	$N_{\rm sp}$
Tomasz Dziubiński	$4^{\rm h}51^{\rm m}$	7	20	$4^{\rm h}40^{\rm m}$	5	31	$9^{\rm h}31^{\rm m}$	12	51
Michał Jurek	$1^{\rm h}56^{\rm m}$	1	3	$3^{\rm h}31^{\rm m}$	1	13	$5^{\rm h}27^{\rm m}$	2	16
Konrad Szaruga	$1^{\rm h}21^{\rm m}$	3	5	$3^{\rm h}58^{\rm m}$	6	34	$5^{\rm h}19^{\rm m}$	9	39
Marcin Gajos	$1^{\rm h}49^{\rm m}$	1	10	$2^{\rm h}42^{\rm m}$	4	17	$4^{\rm h}31^{\rm m}$	5	27
Jarosław Dygos	-	-	-	$4^{\rm h}09^{\rm m}$	1	10	$4^{\rm h}09^{\rm m}$	1	10
Tomasz Fajfer	$2^{0}5^{\rm m}$	2	9	$2^{\rm h}00^{\rm m}$	2	9	$4^{\rm h}05^{\rm m}$	4	18
Marcin Konopka	-	-	-	$3^{\rm h}31^{\rm m}$	1	13	$3^{\rm h}31^{\rm m}$	1	13
Wojciech Jonderko	-	-	-	$1^{\rm h}23^{\rm m}$	0	0	$1^{\rm h}23^{\rm m}$	0	0
Łukasz Pospieszny	-	-	-	$1^{\rm h}11^{\rm m}$	1	3	$1^{\rm h}11^{\rm m}$	1	3
Rafał Kopacki	$1^{\rm h}00^{\rm m}$	0	3	-	-	-	$1^{\rm h}00^{\rm m}$	0	3
Krzysztof Wtorek	$1^{\rm h}00^{\rm m}$	0	3	-	-	-	$1^{\rm h}00^{\rm m}$	0	3
Maciej Reszelski	-	-	-	$0^{\rm h}59^{\rm m}$	4	6	$0^{\rm h}59^{\rm m}$	4	6
Michał Kopczak	$0^{\rm h}53^{\rm m}$	1	1	-	-	-	$0^{\rm h}53^{\rm m}$	1	1
Andrzej Skoczewski	-	-	-	$0^{\rm h}44^{\rm m}$	0	4	$0^{\rm h}44^{\rm m}$	0	4
Total	$14^{\rm h}55^{\rm m}$	15	54	$28^{\rm h}32^{\rm m}$	26	139	$43^{\rm h}27^{\rm m}$	41	193

observers watched the sky using visual, telescopic and photographic techniques. In order to obtain most reliable results we had to remove observations made incorrectly or in poor conditions. Using our standard methods (Olech & Woźniak 1996; Olech 1997) we required that:

- mean limiting magnitude (LM) in the field of view should be at least 5.0 mag,
- cloud coverage correction factor F should be smaller than 1.7,
- the radiant of the stream should be above 20° over the horizon (in Polish latitudes during whole July this condition is always satisfied),
- the center of the field of view should be at an altitude higher than 40°.

Finally we obtained $785^{\rm h}41^{\rm m}$ of effective time of visual observations. During this time a group of 35 CMW members noted 757 possible meteors from α-Cygnid stream and 4569 sporadic meteors. More detailed statistics with names of CMW observers is given in Table 1.

2.2. Telescopic observations

Telescopic observations present a very useful tool for meteor investigators. Meteors are very often plotted with a larger accuracy than in case of visual observations. It gives the possibility to study the structure and drift of the radiant. We also obtain information about magnitude distribution for fainter events. The main problem with telescopic observations is that this kind of watching meteors requires good equipment (preferably binoculars with a large field of view mounted on tripod), experienced observers and a lot of patience.

Fortunately July is usually the time in which we organize an Astronomical Camp of CMW, which takes place at the Observational Station of Warsaw University Observatory in Ostrowik. The number of participants is always around 15, so we organize two four persons groups observing visually, one or two persons working with a few cameras pointed at different directions, and three–four persons observing telescopically different fields located $10° - 40°$ from the supposed radiant of α-Cygnids. We used mostly 7×50, 10×50 and 20×60 binoculars and Russian AT-1 refractors (5×50, field of view as large as 11°). For plotting meteors we use A-type maps of International Meteor Organization (IMO) or *Uranometria 2000.0* charts. Of course other observers which do not participate in the camp observe α-Cygnids both visually and telescopically at their locations.

Finally 14, our observers obtained $43^{\rm h}27^{\rm m}$ of telescopic observations with 234 meteors detected. The number of possible α-Cygnids is equal to 41. Table 2 summarizes our telescopic observations.

3. Results

3.1. Radiant of α-Cygnids

During July of 1995, 1996 and 1997 CMW observers plotted on gnomonic star maps 2748 paths of meteor events. For each of them the angular velocity was estimated. We used 0–5 scale with 0 corresponding to stationary meteor, 1 to very slow event, 2 to slow, 3 to medium, 4 to fast and 5 to very fast meteor. Equatorial coordinates of the begins and ends of these events and their velocities were put into

Table 3. Magnitude distribution for 1995-1997 α-Cygnids

Year	≤ -5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	Tot.
1995	0	0	3.5	1.5	4	5	32.5	72.5	35	23	14	2	0	193
1996	0	0	0.5	3.5	4	7.5	13	25	45.5	42	25	5	0	171
1997	0	3	0.5	2.5	6	18.5	32	65.5	93	81.5	53	18.5	0	374
Tot.	0	3	4.5	7.5	14	31	77.5	163	173.5	146.5	92	25.5	0	738

Table 4. Magnitude distribution for 1995-1997 sporadics

Year	≤ -5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	Tot.
1995	0	1	4.5	6	16	62.5	139.5	252.5	268.5	173	87.5	16	0	1027
1996	0	0	4.5	10	32	72.5	123.5	197.5	239	202.5	132	17.5	0	1031
1997	5	16	11	25	67.5	123	274.5	405.5	547.5	577.5	348.5	86.5	0.5	2488
Tot.	5	17	20	41	115.5	258	537.5	855.5	1055	953	568	120	0.5	4546

Table 5. Magnitude distribution for 1996-1997 telescopic α-Cygnids

Year	4	5	6	7	8	9	Tot.
1996	0.5	0.5	6	6.5	1.5	0	15
1997	0	2	3	8.5	7.5	5	26
Tot.	0.5	2.5	9	15	9	5	41

the RADIANT software (Arlt 1992). This software as an input also requires the geocentric velocity of the meteors V_∞ and the daily drift of the radiant. Changing both these values we can obtain different density distributions of the probability area near suspected radiant. Choosing the best distribution (this one with smallest χ^2 parameter) we are able to estimate the values of V_∞ and the daily drift. The systematic errors play a role, which are difficult to handle and estimate of the accuracy of the obtained value of V_∞ is difficult but the errors are at minimum ± 5 km s^{-1}. For more details see Arlt (1993).

Before analyzing our sample we decided to analyze also the meteors observed by Denning (1919). However we selected only meteors observed by him during July nights. Number of these events accounted to 20. We performed our calculation using parameters of the stream given by Jenniskens (1994) i.e. $V_\infty = 37$ km s^{-1}, $\lambda_{\odot(\max)} = 116°$, $\Delta\alpha = +0.6$ and $\Delta\delta = +0.2$. Results as probability function distribution of the presence of radiant are presented in Fig. 1. The best fit of the two dimensional Gaussian surface to the density of probability map gives coordinates of the radiant equal to $\alpha = 312.4°$ and $\delta = +48.4°$. The accuracy of this estimate is certainly low due to the small number of events observed by Denning (1919).

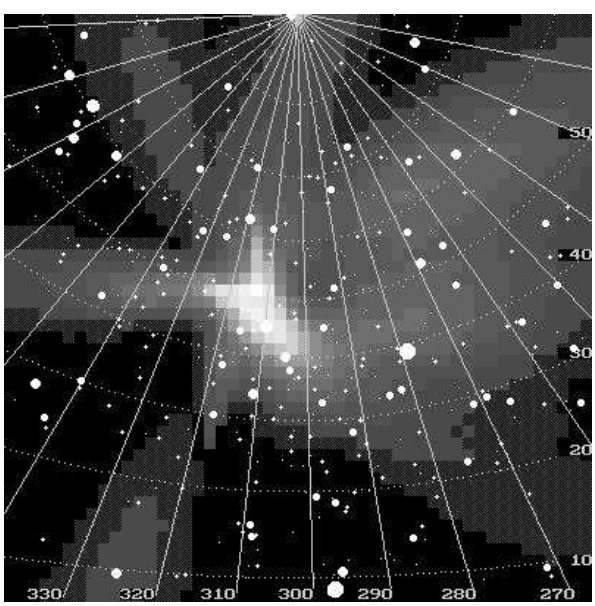

Fig. 1. The radiant of α-Cygnids resulting from Denning's (1919) observations. Assumed parameters are: $V_\infty = 37$ km s^{-1}, $\lambda_{\odot(\max)} = 116°$, $\Delta\alpha = +0.6°$ and $\Delta\delta = +0.2°$. Number of the events is 20

Fortunately, the sample collected by CMW observers in years 1995-1997 is significantly larger. It allows us to derive a few valuable conclusions. First we calculate our sample (2748 meteors including possible members of the stream, sporadics and meteors from other showers) using parameters given by Jenniskens (1994). During calculation we remove meteors observed at a distance larger than 85° from the radiant of the stream. The prominence of the α-Cygnid radiant on the resulting picture is striking. The best fit gives coordinates of the radiant as $\alpha = 302.0°$ and $\delta = +46.1°$. Nevertheless we obtain better results i.e. a more compact shape of the radiant using geocentric velocity $V_\infty = 41$ km s^{-1} and the drift of the radiant $\Delta\alpha = +0.6$, $\Delta\delta = +0.2$. The resulting radiant picture for

Table 6. Magnitude distribution for 1996-1997 telescopic sporadics

Year	1	2	3	4	5	6	7	8	9	10	Tot.
1996	0	0.5	3	1	6.5	8.5	24.5	9	1	0	54
1997	1	0.5	2.5	6	5.5	18.5	51.5	39.5	12	2	139
Tot.	1	1	5.5	7	12	27	76	48.5	13	2	193

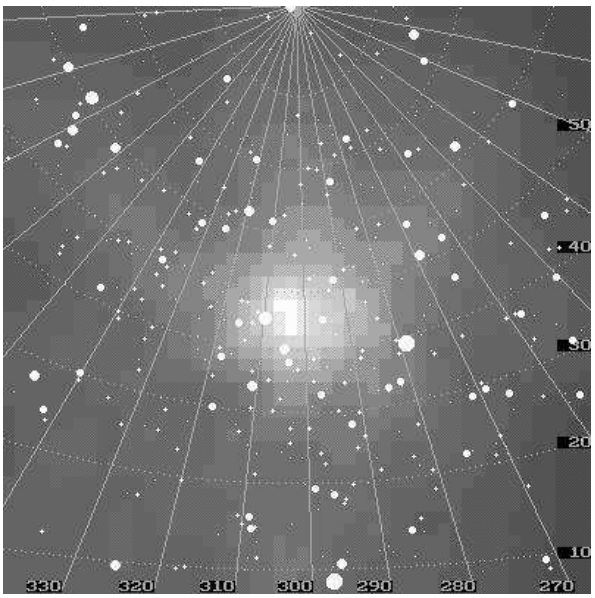

Fig. 2. The radiant of α-Cygnids resulting from CMW visual data. Assumed parameters are: $V_\infty = 41$ km s^{-1}, $\lambda_{\odot(\max)} = 116°$, $\Delta\alpha = +0.6°$ and $\Delta\delta = +0.2°$. Number of the events is 2748

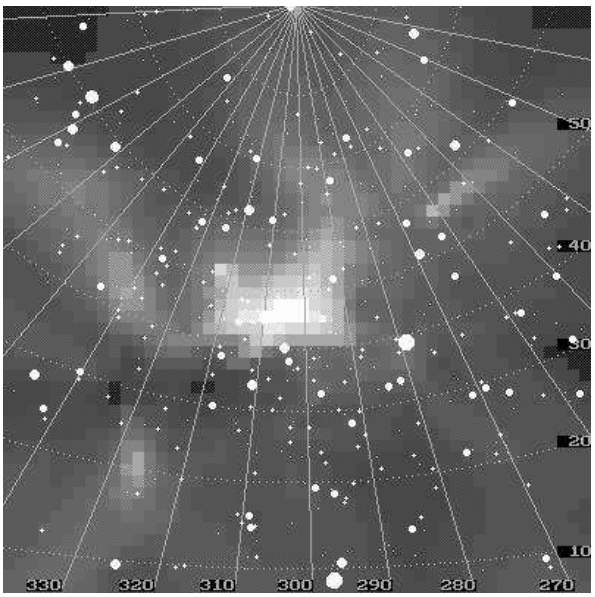

Fig. 3. The radiant of α-Cygnids resulting from CMW telescopic data. Used parameters are: $V_\infty = 40$ km s^{-1}, $\lambda_{\odot(\max)} = 116°$, $\Delta\alpha = +0.6°$ and $\Delta\delta = +0.2°$. Number of the events is 234

the above parameters is displayed in Fig. 2. The final coordinates of the radiant of α-Cygnid stream are $\alpha = 302.5°$ and $\delta = +46.3°$, which do not differ significantly from coordinates obtained for parameters given by Jenniskens (1994).

We also used the RADIANT software for the analysis of the paths of our telescopic meteors. Our sample contains 234 meteors with known paths and velocities. The resulting density distribution from telescopic observations is displayed in Fig. 3. The best fit (with smallest χ^2 value) is obtained for the following parameters: geocentric velocity $V_\infty = 40$ km s^{-1}, the daily drift of the radiant $\Delta\alpha = +0.6°$ and $\Delta\delta = +0.2°$. The coordinates of the center of the radiant are $\alpha = 304.9°$ and $\delta = +46.2°$. One can see that the position of the radiant obtained from telescopic observations differs from the position obtained from visual data by only 1.7°. Taking into account that radii of the majority of radiants vary between 2° and 7° both our results are strictly consistent. It is also clear that our parameters are in very good agreement with the data of the one photographed meteor (Babadzhanov & Kramer 1965).

3.2. Population index r

In years 1995-1997 the CMW observers made as many as 738 and 4546 estimates of the brightness of meteor events from α-Cygnids and sporadics, respectively. The distribution of this quantity is presented in Tables 3 and 4.

Such a large amount of magnitude estimates for α-Cygnids encouraged us to compute the value of the population index r defined in Eq. (1). We obtained $r = 2.55 \pm 0.14$ which is a typical value among meteor streams. Jenniskens (1994) obtained a similar result with r equal to 2.7. The population index obtained from the magnitudes of our 4546 sporadics is equal to $r = 2.61 \pm 0.23$.

Also the telescopic observers estimated the magnitudes of meteor events. The magnitude distributions for 1996 and 1997 α-Cygnids and sporadics are presented in Tables 5 and 6.

3.3. Activity profile

Knowing the value of r we can compute ZHR using the formula given in (3). According to the results of Koschack (1994) and Bellot (1995) who showed that for visual observations with radiant altitudes higher than 20° the zenith exponent factor $\gamma \approx 1.0$, we adopted $\gamma = 1.0$.

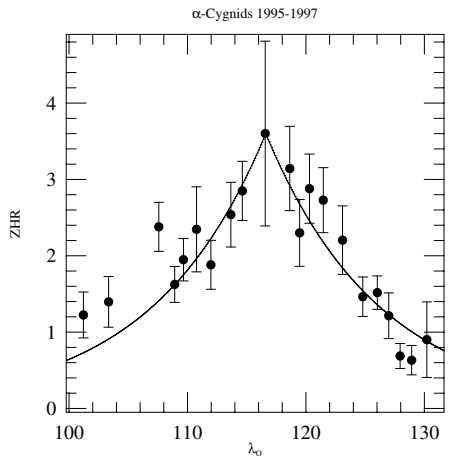

Fig. 4. The activity profile of α-Cygnids during 1995–1997. The solid line represents the fit given in Eq. (4)

The resulting activity profile of α-Cygnids in years 1995–1997 is exhibited in Fig. 4. The activity of the stream lasts from $\lambda_\odot \approx 100°$ (June 30) to $\lambda_\odot \approx 130°$ (July 31). It seems to be slightly wider than the result of Jenniskens (1994) who noted meteors from α-Cygnid stream in interval $\lambda_\odot = 105 - 127°$. The accuracy of the ZHR estimates by Jenniskens (1994) was low due to the small number of his observations, therefore we prefer our result.

Our Fig. 4 one exhibits a clear maximum of activity at $\lambda_\odot \approx 116.5°$ with $ZHR = 3.6 \pm 1.2$. The error of this estimate is large but points in the vicinity of the maximum have smaller errors and their moments and ZHRs are $\lambda_\odot = 114.5°$ with $ZHR = 2.9 \pm 0.4$ and $\lambda_\odot = 118.5°$ with $ZHR = 3.1 \pm 0.6$

The moment of the maximum and its ZHR is in very good agreement with result of Jenniskens (1994) who obtained $\lambda_{\odot(\max)} = 116.0 \pm 0.5°$ with $ZHR_{\max} = 2.5 \pm 0.8$.

Jenniskens (1994) found also that the activity profiles of meteor streams are well represented by the following equation:

$$ZHR = ZHR_{\max} \times 10^{-B \cdot |\lambda_\odot - \lambda_{\odot\max}|}. \quad (4)$$

For α-Cygnids he found $B = 0.13 \pm 0.03$. As we have already written our activity profile is much broader and thus our value of B is smaller and equal to 0.045 ± 0.005. In Fig. 4 the solid line represents fit given in Eq. (4) with $ZHR_{\max} = 3.6$, $\lambda_{\odot\max} = 116.5°$ and $B = 0.045$.

3.4. Velocity distribution

The CMW observers estimated also the angular velocity of the events. The 0–5 scale (defined in Sect. 3.1 of this paper) was used. Finally we obtained 754 estimates of the angular velocity for α-Cygnids and 4339 estimates for sporadics. The velocity distribution from visual observations is presented in Tables 7–8.

Table 7. Velocity distribution for 1995-1997 α-Cygnids

Year	0	1	2	3	4	5	Tot.
1995	0	0	6	63	96	28	193
1996	0	0	9	44	97	20	170
1997	4	2	22	166	172	25	391
Tot.	4	2	37	273	365	73	754

Table 8. Velocity distribution for 1995-1997 sporadics

Year	0	1	2	3	4	5	Tot.
1995	6	17	68	247	418	171	927
1996	4	22	86	243	433	233	1021
1997	42	31	202	710	938	468	2391
Tot.	52	70	356	1200	1789	872	4339

Table 9. Velocity distribution for 1996-1997 telescopic α-Cygnids

Year	0	A	B	C	D	E	F	Tot.
1996	0	0	1	6	6	2	0	15
1997	0	0	4	5	11	4	2	26
Tot.	0	0	5	11	17	6	2	41

We used the above distributions to find another proof for existence of the α-Cygnid stream. We compared empirical velocity distributions of α-Cygnids and sporadics using Kolmogorov–Smirnov and χ^2 tests. We obtained that with the probability larger than 0.999 both distributions are different. Such a large probability is certainly caused by the clear enhancement of meteors with velocity 3 and 4 in α-Cygnid velocity distribution. This result is also is good agreement with the value of geocentric velocity obtained from RADIANT analysis of our visual and telescopic data. The meteors with velocity $V_\infty = 40 - 41$ km s^{-1} given by RADIANT software at mean distance from the radiant of the stream appear mainly with velocities 3 and 4 in $0 - 5$ scale.

The velocity of meteor events was also estimated by our telescopic observers. They used A–F scale with A corresponding to the angular velocity 2°/s and F to over 25°/s. Finally we obtained 41 estimates of the angular velocity for telescopic α-Cygnids and 192 velocity estimates for telescopic sporadics. Both distributions are presented in Tables 9–10.

For telescopic observations the distance from the radiant is generally well defined. Usually it is worthwhile to analyze the mean angular velocity as a function of distance from the radiant. Unfortunately due to the small number of our telescopic α-Cygnids which were observed in as many as 10 fields such an analysis is impossible yet.

Table 10. Velocity distribution for 1996-1997 telescopic sporadics

Year	0	A	B	C	D	E	F	Tot.
1996	1	1	6	13	19	10	4	54
1997	2	4	11	31	43	30	17	138
Tot.	3	5	17	44	62	40	21	192

4. Discussion

We presented here the results of visual and telescopic observations of α-Cygnid stream made by CMW observers in years 1995–1997. This stream is not included in the IMO List of Visual Meteor Showers (Rendtel et al. 1995) due to the lack of photographic, video and radio data confirming its presence. The only continuous (not visual) surveys are the Harvard Super Schmidt Program of the 1952-54 period and the Harvard Radar Project in the 1960's. Both have gaps in coverage due to weather or instrument irregularities. Unfortunately the α-Cygnids seem to fall in such gaps. McCrosky & Posen (1961) presented the orbital elements of 2529 meteors photographed simultaneously from two camera stations of the Harvard Meteor Project. The mean number of meteors captured in periods January–June and August–December is 221 events per month. The number of meteors photographed in July is only 102. It is over two times smaller than in other months and certainly it is the reason of lacking the meteors from α-Cygnid stream in that project. The similar situation occurred during the Harvard Radar Project. However recent radio results obtained by Michael Boschat from Dalhousie University in Canada (Boschat 1998) showed clear enhancement of radio echoes in days 1998 July 19-20.

Analysis of 2748 paths of meteor events observed in July 1995, 1996 and 1997 allowed us to obtain the basic properties of the stream. The geocentric velocity of the α-Cygnid events is $V_\infty = 41$ km s^{-1} and daily drift of the radiant $\Delta\alpha = +0.6°$, $\Delta\delta = +0.2°$. The coordinates of the center of the radiant of α-Cygnid stream are $\alpha = 302.5°$ and $\delta = +46.3°$.

We performed a similar analysis for 234 telescopic meteors plotted also by CMW observers. The parameters of the stream are in very good agreement with the results derived from visual data.

Our results are also consistent with visual observations by Denning (1919) and Jenniskens (1994) and the photographic results obtained by Babadzhanov & Kramer (1965).

From magnitude distribution of 738 α-Cygnids we obtained the population index r equal to 2.55 ± 0.14 which is in good agreement with previously obtained value $r = 2.7$ (Jenniskens 1994).

The velocity distributions of 754 α-Cygnids and 4339 sporadics are different, with a probability higher than 0.999 which gives another proof for reality of the α-Cygnid stream.

From visual observations made by CMW members during the years 1995–1997 we obtained the clear activity profile of the α-Cygnid stream. Meteors belonging to this shower were detected from June 30 to July 31 with clear maximum near July 18 ($\lambda_\odot = 116.5°$). The maximal ZHRs reached the level 3.6 ± 1.2. These results are in very good agreement with results presented by Jenniskens (1994) who obtained $\lambda_{\odot(\max)} = 116.0 \pm 0.5°$ and $ZHR_{\max} = 2.5 \pm 0.8$.

In spite of making many photographic exposures we still have no photographic confirmation of this stream. To confirm of disprove our results further visual, telescopic and particularly video and photographic observations are clearly needed.

Acknowledgements. We would like to thank to all observers who sent us their observations. We are especially grateful to Prof. Jerzy Madej for helpful discussions, reading and commenting on the manuscript and also to Dr. Jacek Chołoniewski for many helpful hints. This work was supported by KBN grants 2 P03D 020 11 and 2 P03D 002 15 to A. Olech.

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A New Stream for Holidays?

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Abstract

We report a discovery of a new possible stream radiating from Ursa Minor during the first part of August.

The first part of each August is the time of the Perseid shower. Many observers work under clear sky at that time. Usually, the Perseids' rates are high, and, therefore, almost all observers observe using the counting method rather than plot the meteors on gnomonic maps. This phenomenon explains why we do not have a good picture of minor stream activity in the first half of August.

On the night August 9-10, 1997, one of us (Maciej Kwinta) was observing the Perseids. Among the sporadic meteors, we detected three very slow meteors, which seemed to radiate from one point placed near Kochab (β UMi). A few other members of this possible shower were observed during subsequent nights.

We decided to pay more attention to these slow meteors in 1998. Between August 2 and 12, 1998, we totaled 19 hours of observing time plotting 17 slow and very slow meteors radiating from the vicinity of β UMi. In addition, we recorded 126 sporadic meteors.

We processed this sample using the RADIANT software. We obtained the best picture of the radiant with the following parameters: atmospheric velocity $V_\infty = 14$ km/s, angular velocity between 0 and 17°/sec, maximum distance from the radiant 85°, daily radiant drift $\Delta\lambda = 1.0°$, time of maximum $\lambda_\odot = 136°$, radiant equatorial coordinates during the night of the maximum $\alpha = 223°$ and $\delta = +73°$. The output picture returned by the RADIANT software with above parameters is shown in Figure 1.

The magnitude distributions for suspected β-Ursa Minorids and for sporadics are presented in Table 1. From these distributions, we computed the values of the population index r. It is equal to 2.8 ± 0.4 for β-Ursa Minorids and 3.6 ± 0.3 for the sporadics.

Magitude distribution of the suspected β-Ursa Minorids and the sporadics.

Knowing the values of the population index r and the coordinates of the radiant, we computed the ZHR profile of the β-Ursa Minorids. It is presented in Fig. 2. The maximum was noted around $\lambda_\odot = 134°$ with ZHR $= 5.1 \pm 1.5$, but the accuracy of our

Table 1: Magitude distribution of the suspected β-Ursa Minorids and the sporadics.

Stream	-1^-	0	1	2	3	4	5	6	Tot
β-UMi	0	0	1	1	6	8	1	0	17
Spor.	1	3.5	7.5	19	41	44	9.5	0.5	126

points is low and it is possible that the real maximum occurred between $\lambda_\odot = 134^\circ$ and $\lambda_\odot = 137^\circ$.

It is clearly visible that we need to know more about this stream. We would like to encourage all *IMO* observers to pay more attention to the slow meteors radiating from Ursa Minor during the first half of August.

Acknowledgment This work was supported by KBN grant number 2 P03D 002 15 to A. Olech.

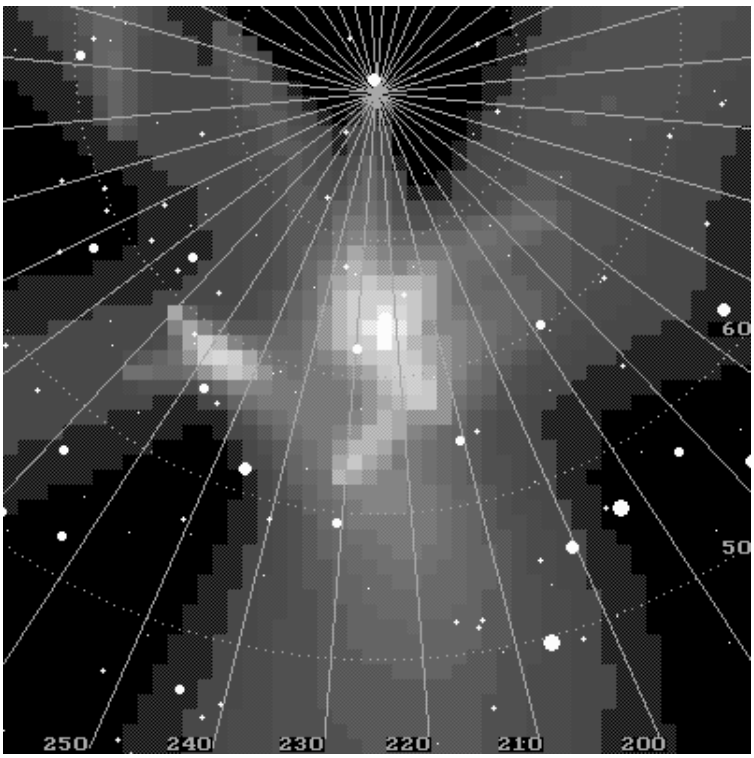

Figure 1: Output of the RADIANT software showing the suspected β-Ursa Minorid radiant.

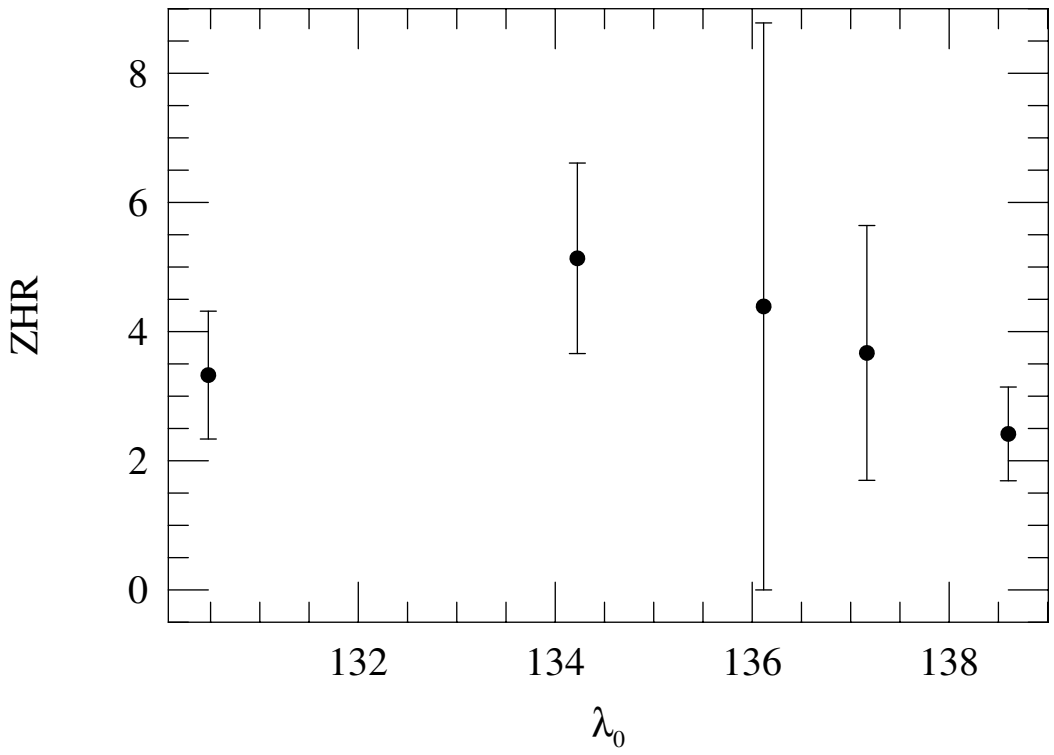

Figure 2: ZHR profile of the suspected β-Ursa Minorids.

Ongoing Meteor Work

Polish Visual Meteor Database 1996–1998

A. Olech, M. Wiśniewski, and M. Gajos

The summary of 1996–1998 visual observations collected by the Polish *Comets and Meteors Workshop* is presented. In total, during 2328.12 effective observing hours, 14 085 meteors were seen and plotted onto gnomonic starmaps by 41 observers. The date, time, magnitude, angular velocity, and equatorial coordinates for each observed event are given. The full data for 1996–1998 in the *Polish Visual Meteor Database* (PVMDB) are accessible via Internet.

1. Introduction

Since 1994, the Polish *Comets and Meteors Workshop* (CMW) has been cooperating with the *International Meteor Organization*. During the first two years, we made mostly visual observations of major showers without plotting the meteors onto the gnomonic star maps. Over time, the experience of our observers grew and, in 1996, we decided to start visual observations with plotting.

Every year, a complete set of our observation reports was sent to the *IMO*, and our results were included in the *IMO Visual Meteor Database* (VMDB) (see, for example, [1]). However, we would like to point out that the *VMDB* contains only the information about hourly rates and magnitude distributions of the observed meteors. Thus, an error in classification of a meteor made by the observer while filling out the report form is included also in the *VMDB*.

Additionally, the *VMDB* contains only data about meteor showers from the *IMO Working List of the Meteor Showers*. Thus it is impossible to get the information about other small or poorly known streams from the *VMDB*.

The solution to the problem is to publish a full database containing all quantities describing a meteor event including its equatorial coordinates and angular velocity. Such a database can be searched for the presence of any shower at any moment of time.

The database of Polish telescopic observations made during the years 1996–1998 was already published by Olech and Jurek [2]. Following this approach, we decided to publish in the same format our visual results from the years 1996–1998. Table 1 summarizes our visual work during this period of time. In total, 14 085 meteors were seen by 41 observers during $2328^{\mathrm{h}}.12$ effective observing hours.

Table 1 – *Polish Visual Meteor Database* (PVMDB) grand totals for 1996–1998.

Year	Observers	T_{eff}	Meteors
1996	18	$247^{\mathrm{h}}.86$	1508
1997	25	$849^{\mathrm{h}}.41$	5269
1998	31	$1230^{\mathrm{h}}.85$	7308
Total	41	$2328^{\mathrm{h}}.12$	14085

Table 2 shows a list of the *CMW* observers with their effective observing time and number of meteors plotted in each of the years 1996–1998.

Table 2 – Total effective observing time in hours ($T_{\rm eff}$) and number of meteors plotted (N) per observer during the years 1996–1998.

Observer	Code	1996		1997		1998		Total	
		$T_{\rm eff}$	N	$T_{\rm eff}$	N	$T_{\rm eff}$	N	$T_{\rm eff}$	N
Jarosław Dygos	DYGJA			$44^{\rm h}.99$	181	$308^{\rm h}.98$	1324	$353^{\rm h}.97$	1505
Tomasz Fajfer	FAJTO	$84^{\rm h}.50$	382	$185^{\rm h}.50$	862	$22^{\rm h}.50$	115	$292^{\rm h}.50$	1359
Konrad Szaruga	SZAKO	$26^{\rm h}.14$	144	$108^{\rm h}.15$	659	$88^{\rm h}.35$	437	$222^{\rm h}.64$	1240
Krzysztof Socha	SOCKR	$17^{\rm h}.31$	102	$87^{\rm h}.47$	616	$105^{\rm h}.11$	769	$209^{\rm h}.89$	1487
Maciej Kwinta	KWIMA	$4^{\rm h}.67$	19	$71^{\rm h}.24$	438	$68^{\rm h}.08$	540	$143^{\rm h}.99$	997
Gracjan Maciejewski	MACGR			$49^{\rm h}.17$	219	$81^{\rm h}.17$	394	$130^{\rm h}.34$	613
Marcin Konopka	KONMA			$36^{\rm h}.39$	349	$81^{\rm h}.59$	450	117.98	799
Arkadiusz Olech	OLEAR	$20^{\rm h}.92$	248	$42^{\rm h}.88$	540	$49^{\rm h}.75$	463	$113^{\rm h}.55$	1251
Andrzej Skoczewski	SKOAN			$46^{\rm h}.68$	276	$56^{\rm h}.84$	380	$103^{\rm h}.52$	656
Paweł Trybus	TRYPA			$2^{\rm h}.17$	8	$90^{\rm h}.55$	587	$92^{\rm h}.72$	595
Wojciech Jonderko	JONWO	$2^{\rm h}.20$	5	$22^{\rm h}.17$	137	$39^{\rm h}.12$	155	$63^{\rm h}.49$	297
Marcin Gajos	GAJMR	$6^{\rm h}.29$	37	$35^{\rm h}.17$	248	$17^{\rm h}.63$	104	$59^{\rm h}.09$	389
Albert Krzyśków	KRZAL			$11^{\rm h}.83$	76	$43^{\rm h}.49$	282	$55^{\rm h}.32$	358
Aleksander Trofimowicz	TROAL					$38^{\rm h}.47$	229	$38^{\rm h}.47$	229
Krzysztof Wtorek	WTOKR	$23^{\rm h}.00$	140	$11^{\rm h}.99$	78			$34^{\rm h}.99$	218
Łukasz Raurowicz	RAULU			$23^{\rm h}.62$	163	$6^{\rm h}.09$	41	$29^{\rm h}.71$	204
Michał Jurek	JURMC	$8^{\rm h}.52$	43	$14^{\rm h}.66$	93	$6^{\rm h}.00$	53	$29^{\rm h}.18$	189
Cezary Gałan	GALCE					$28^{\rm h}.85$	204	$28^{\rm h}.85$	204
Łukasz Pospieszny	POSLU	$20^{\rm h}.68$	158	$6^{\rm h}.91$	30			$27^{\rm h}.59$	188
Luiza Wojciechowska	WOJLU					$25^{\rm h}.32$	168	$25^{\rm h}.32$	168
Mariusz Wiśniewski	WISMA					$20^{\rm h}.86$	342	$20^{\rm h}.86$	342
Maciej Reszelski	RESMA	$7^{\rm h}.86$	89	$8^{\rm h}.77$	99			$16^{\rm h}.63$	188
Paweł Brewczak	BREPA					$16^{\rm h}.52$	81	$16^{\rm h}.52$	81
Łukasz Sanocki	SANLU	$5^{\rm h}.77$	39	$4^{\rm h}.34$	40	$6^{\rm h}.17$	28	$16^{\rm h}.28$	107
Tomasz Ramza	RAMTO	$7^{\rm h}.00$	32	$5^{\rm h}.98$	19			$12^{\rm h}.98$	51
Artur Szaruga	SZAAR			$10^{\rm h}.17$	37	$2^{\rm h}.12$	8	$12^{\rm h}.29$	45
Tomasz Dziubiński	DZITO	$3^{\rm h}.50$	21	$8^{\rm h}.00$	42			$11^{\rm h}.50$	63
Krzysztof Kamiński	KAMKR			$7^{\rm h}.60$	45	$1^{\rm h}.35$	8	$8^{\rm h}.95$	53
Jarosław Nocoń	NOCJA					$6^{\rm h}.53$	21	$6^{\rm h}.53$	21
Waldemar Drozdowski	DROWA			$1^{\rm h}.00$	3	$5^{\rm h}.40$	19	$6^{\rm h}.40$	22
Rafał Kopacki	KOPRA	$5^{\rm h}.50$	30					$5^{\rm h}.50$	30
Krzysztof Mularczyk	MULKR					$4^{\rm h}.00$	17	$4^{\rm h}.00$	17
Mariola Czubaszek	CZUMA					$2^{\rm h}.80$	40	$2^{\rm h}.80$	40
Adam Pisarek	PISAD					$2^{\rm h}.71$	8	$2^{\rm h}.71$	8
Marek Piotrowski	PIOMA			$2^{\rm h}.56$	11			$2^{\rm h}.56$	11
Jacek Kluczewski	KLUJA					$2^{\rm h}.00$	21	$2^{\rm h}.00$	21
Sylwia Chełmoniak	CHESY					$1^{\rm h}.50$	11	$1^{\rm h}.50$	11
Krzysztof Gdula	GDUKR	$1^{\rm h}.50$	4					$1^{\rm h}.50$	4
Paweł Musialski	MUSPA	$1^{\rm h}.50$	11					$1^{\rm h}.50$	11
Sylwia Hołowacz	HOLSY					$1^{\rm h}.00$	9	$1^{\rm h}.00$	9
Robert Sołtys	SOLRO	$1^{\rm h}.00$	4					$1^{\rm h}.00$	4
Total		$247^{\rm h}.86$	1508	$849^{\rm h}.41$	5269	$1230^{\rm h}.85$	7308	$2328^{\rm h}.12$	14085

2. Coordinate files

The files `coor96.txt`, `coor97.txt`, and `coor98.txt` contain data for each observed meteor such as the date of appearance, serial number of meteor, its magnitude, its angular velocity (in scale from A to F), time of appearance, equatorial coordinates of beginning and end, *IMO* code of the observer and three-letter code.

Below, we show a small sample of such a file:

```
1998 01 01/02   1   4.5 C 00:47 219.20  76.42 237.00  72.38 SKOAN ABZ
1998 01 01/02   2   2.0 B 00:47 321.66  66.76 005.76  59.44 SKOAN ABZ
1998 01 01/02   3   1.5 C 00:47 216.55  52.21 236.21  56.24 SKOAN ABZ
1998 01 01/02   4   1.5 C 00:47 257.92  50.32 266.80  48.49 SKOAN ABZ
1998 01 01/02   5   4.0 D 00:47 211.86  50.55 206.85  51.73 SKOAN ABZ
1998 01 01/02   6  -2.0 B 00:47 097.50  87.00 312.50  81.00 SKOAN ABZ
1998 01 01/02   7   2.0 B 01:37 206.19  78.68 251.99  65.72 SKOAN ACA
1998 01 01/02   8   4.0 C 01:37 181.14  73.42 171.16  74.95 SKOAN ACA
1998 01 01/02  10   4.0 D 01:37 273.52  52.78 269.18  49.60 SKOAN ACA
1998 01 02/03   1   4.5 D 17:01 028.60  43.07 017.24  43.14 OLEAR ACB
```

In Table 3, we give byte-by-byte description of these files.

Table 3 – Byte-by-byte description of `coor9?.txt` files. Right ascension and declination are in degrees.

Bytes	Format	Explanations
1– 4	I4	Year
6– 7	I2	Month
9–13	A5	Day/Day
15–17	I3	Number of meteor in report
19–21	F5.1	Meteor magnitude
25	I1	Velocity in scale from A to F
27–31	A5	Time of meteor (UT)
33–38	F6.2	RA of beginning of meteor (J2000)
40–45	F6.2	Decl. of beginning of meteor (J2000)
47–52	F6.2	RA of end of meteor (J2000)
54–59	F6.2	Decl. of end of meteor (J2000)
61–65	A5	*IMO* code of observer
67–69	A3	Three-letter code

The three-letter code shown in the last column of `coor9?.txt` file is used for connecting each meteor with the information about the observation stored in the `head9?.txt` file. The time of appearance of a meteor, when it is not given exactly in the report form, is assumed as the middle time of each observing period. All equatorial coordinates were entered using the CooReader software [3].

3. Header files

The files `head96.txt`, `head97.txt`, and `head98.txt` contain information about each observing run, such as three-letter code allowing to connect each observation with data on meteors presented in coordinate files, *IMO* code of observer, longitude and latitude of place of observation, date, UT time of begin and end of observation, solar longitude (J2000) of middle time of each run, equatorial coordinates of observed field, effective time of observation, cloud correction factor F, stellar limiting magnitude estimated by the naked eye and the *IMO* code of the place of observation.

Below we show a small sample of such a file:

```
ABZ SKOAN  21.0 E 50.0 N 02 01 98 0016 0118 281.444 210  75 1.00 1.00 5.80 34029
ACA SKOAN  21.0 E 50.0 N 02 01 98 0118 0156 281.479 210  75 0.60 1.00 5.72 34029
ACB OLEAR  23.5 E 51.1 N 02 01 98 1630 1732 282.133 000  70 1.00 1.00 5.42 34012
ACC OLEAR  23.5 E 51.1 N 02 01 98 2026 2134 282.302 000  70 1.00 1.00 5.70 34012
ACD OLEAR  23.5 E 51.1 N 03 01 98 0005 0108 282.456 000  70 1.00 1.00 6.18 34012
ACE OLEAR  23.5 E 51.1 N 03 01 98 0110 0214 282.502 000  70 1.00 1.00 6.13 34012
ACF OLEAR  23.5 E 51.1 N 03 01 98 0214 0305 282.543 000  70 0.75 1.00 6.15 34012
ACG SZAKO  23.2 E 50.5 N 02 01 98 2003 2124 282.291 181  53 1.30 1.00 6.40 34040
```

Table 4 gives a byte-by-byte description of the header files.

Table 4 – Byte-by-byte description of `head9?.txt` files. Solar longitude, right ascension, and declination are in degrees; effective observing time in hours.

Bytes	Format	Explanations
1– 3	A3	Three-letter code
5– 9	A5	*IMO* Code of observer
11–15	F5.1	Longitude of observing site
17	A1	Hemisphere designation
19–22	F4.1	Latitude of observing site
24	A1	Hemisphere designation
26–27	I2	Day
29–30	I2	Month
32–33	I2	Year
35–38	I4	Begin time of observation (UT)
40–43	I4	End time of observation (UT)
45–51	F7.3	Solar longitude of middle time of observation (J2000)
53–55	I3	RA of center of field of view (J2000)
57–59	I3	Decl. of center of field of view (J2000)
61–64	F4.2	Effective observing time
66–69	F4.2	Cloud correction factor F
71–74	F4.2	Limiting magnitude estimated in field of view
76–80	I5	*IMO* code of observing site

4. Summary

We have presented the summary of the 1996–1998 visual observations made by the Polish *Comets and Meteors Workshop*. In total, 14 085 meteors were observed during $2328^{\mathrm{h}}.12$ effective observing hours collected by 41 observers. The date, time, magnitude, angular velocity, and equatorial coordinates for each observed event is given. The full 1996–1998 *Polish Visual Meteor Database* (PVMDB) is accessible via Internet at `http://www.astrouw.edu.pl/~olech/VIS/`.

The 1999–2000 data are still under review, but they will be available to the astronomical community as soon as possible.

Acknowledgments

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An artificial meteor database as a test for the presence of weak showers

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Abstract. We have constructed an artificial meteor database resembling in all details the real sample collected by the observers of the *Comets and Meteors Workshop* in the years 1996–1999. The artificial database includes the sporadic meteors and also events from the following showers: Perseids, Aquarid complex, α-Capricornids, July Pegasids and Sagittarids. This database was searched for the presence of the radiants of two weak showers: α-Cygnids and Delphinids. The lack of these radiants in the artificial database and their existence in the real observations suggests that α-Cygnids and Delphinids are real showers and their radiants could not be formed as an effect of intersections of back prolongated paths of meteors belonging to other showers.

Key words. solar system: general – meteors, meteoroids

1. Introduction

Recently, Polish observers taking part in the *Comets and Meteors Workshop (CMW)* reported the rediscovery of two July meteor showers – α-Cygnids and Delphinids (Olech et al. 1999a, 1999b; Stelmach & Olech 2000; Wiśniewski & Olech 2000, 2001). Both of these showers are weak with maximum Zenithal Hourly Rates (*ZHR*s) slightly exceeding or below the sporadic background.

The α-Cygnids are active from the end of June until the end of July. The highest activity with $ZHR = 2.4 \pm 0.1$ is observed at a solar longitude $\lambda_\odot = 114.8 \pm 0.5°$. The radiant of the shower at this moment is placed at $\alpha = 305°$ and $\delta = +45°$.

The activity period of the Delphinids is still quite uncertain with the first meteors from this shower detected around July 10 and the last ones as late as the middle of August. According to the recent work of Wiśniewski & Olech (2001) the maximum hourly rates are observed at $\lambda_\odot = 125.0 \pm 0.1°$. The activity at this moment is equal to $ZHR = 2.2 \pm 0.2$ and the radiant of the shower has the equatorial coordinates equal to $\alpha = 312°$ and $\delta = +12°$.

The equatorial coordinates of the beginnings and ends of meteor paths and the angular velocities for both showers were carefully analyzed using the RADIANT software (Arlt 1992). This software takes into account the properties of the observed meteors and computes the maps of probability for the presence of a radiant (hereafter PPR maps).

Although PPR maps computed for both of these showers showed distinct features, the resulting radiants were polluted by the influence of the meteors from other showers. A quite strong tail reaching the radiant of the Perseids was detected in the case of the α-Cygnids. There is also a trace of the weak o-Draconids radiant in the close vicinity of the radiant of the α-Cygnids (Olech et al. in preparation).

An even more complicated situation is present in the case of the Delphinids. The radiant of this shower is placed not far from the series of ecliptic radiants of the Aquarids complex, α-Capricornids and the Sagittarids.

The radiants of these showers are large and have a complex structure often showing several maxima of activity.

Thus one can suspect that both the α-Cygnids and Delphinids are not real showers and their radiants produced by RADIANT software come from crossing the back-prolongated paths of the meteors from other showers active in July and also from sporadic events.

To check this possibility, we decided to construct a realistic database of artificial meteors which thoroughly resembled the real sample analyzed in the above mentioned papers.

2. July showers

There are many meteor showers active in July. The most active of them are the Perseids and δ-Aquarids S but there

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Table 1. VMDB statistics for each July shower from years 1996–1999.

Shower	Activity period	$N_{\rm met}$	$N_{\rm spor}$	$T_{\rm eff}$
Sagittarids	Jul. 1-15	302	3072	400.6
July Pegasids	Jul. 5–15	649	5237	612.8
α-Capricor.	Jul. 1–Aug. 25	5403	68 735	7469.3
δ-Aquarids N	Jul. 10–Aug. 28	4091	48 782	5244.9
δ-Aquarids S	Jul. 6–Aug. 22	3841	28 355	2746.6
ι-Aquarids S	Jul. 14–Aug. 25	1241	25 808	2404.3
Perseids	Jul. 13–Aug. 5	13 953	38 060	3937.2

are also several minor showers such as the Sagittarids, the July Pegasids, α-Capricornids, δ-Aquarids N and the ι-Aquarids N (Rendtel et al. 1995).

Recent compilations of meteor shower activity were done by Jenniskens (1994) and Rendtel et al. (1995). The first of these papers presented the results obtained in the years 1981–1991 and the second the results from the period 1988–1995. On the other hand, the databases used by Olech et al. (1999a, 1999b), Stelmach & Olech (2000) and Wiśniewski & Olech (2000, 2001) were obtained using observations collected in the years 1996–1999. Because this period does not overlap with those mentioned above we decided to make a new compilation of meteor activity in July.

We used the Visual Meteor Databases (VMDB) constructed each year by the *International Meteor Organization (IMO)* and accessible via the *IMO* web pages (Arlt 1997, 1998, 1999, 2000).

The observations from the databases were selected according to the following criteria:

- data with limiting magnitudes less than 5.5 are omitted;
- observing intervals should be longer than 0.5 hour;
- radiant altitude should be at least 20 degrees;
- field of view has less than 50% cloud obstruction.

The numbers of meteors from each shower, the numbers of sporadic events, the activity periods used for computation of activity profiles and the effective time of observations in these periods are summarized in Table 1.

Following the example of Jenniskens (1994) we fitted the following equation format to each activity profile:

$$ZHR = ZHR_{\rm max} \cdot 10^{-B|\lambda_\odot - \lambda_\odot^{\rm max}|} \quad (1)$$

where $\lambda_\odot$ denotes the solar longitude for the epoch of 2000.0, and Zenithal Hourly Rates (ZHRs) are computed as follows:

$$ZHR = \frac{N \cdot F \cdot r^{(6.5-LM)}}{T_{\rm eff} \cdot \sin(H_{\rm rad})} \quad (2)$$

where N is a number of meteors observed during $T_{\rm eff}$, F is the cloud correction factor, $H_{\rm rad}$ is the altitude of the radiant, LM is the limiting magnitude in the field of view and r is the population index, which values are taken from Rendtel et al. (1995).

Table 2. $ZHR_{\rm max}$, $\lambda_\odot^{\rm max}$, B parameters and assumed radiant radii R for July showers.

Shower	$ZHR_{\rm max}$	$\lambda_\odot^{\rm max}$ [°]	B [1/°]	R [°]
July Pegasids	3.11	108.52	0.0760	0.8
	±0.13	±0.24	±0.0101	
α-Capricornids	3.41	126.23	0.0352	2.5
	±0.05	±0.17	±0.0008	
δ-Aquarids N	2.62	130.03	0.0213	1.0
	±0.05	±0.33	±0.0009	
δ-Aquarids S	8.99	127.05	0.0666	1.0
	±0.16	±0.11	±0.0013	
ι-Aquarids S	2.49	126.92	0.0491	1.0
	±0.08	±0.27	±0.0020	
Sagittarids	3.00	90.00	0.0351	3.0
	–	–	±0.0015	
Perseids	17.0	136.70	0.0430	0.8
	–	–	±0.0010	

For each of the analyzed showers we computed $ZHR-\lambda_\odot$ dependence and we fitted it using the formula given in Eq. (1). Free parameters $ZHR_{\rm max}$, $\lambda_\odot^{\rm max}$ and B were determined using the least squares method.

The results obtained for all July showers are presented in Table 2 and their activity profiles drawn using the Eq. (1) shown in Fig. 1.

Two showers from our sample required special treatment. As was shown by Jenniskens (1994) in the case of the Perseids, a nearly exponential increase in activity is observed only between $\lambda_\odot = 120°$ and $\lambda_\odot = 137°$ with $B = 0.050 \pm 0.005$ and ZHR at the end of this period is equal to 18. After $\lambda_\odot = 137°$ the slope B changes to 0.20 ± 0.01, and after $\lambda_\odot = 141.8°$ changes again to 0.083 ± 0.017. Thus, we cannot describe the activity of the Perseids using only one formula in the form of (1). Fortunately we are interested only in the Perseids activity in July and therefore we analyzed data for this stream only for $\lambda_\odot < 137°$. For this shower we obtained that at $\lambda_\odot = 136.7°$ the $ZHR_{\rm max}$ is equal to 17.0. Thus in the case of the Perseids, the only free parameter in the Eq. (1) is B.

Another unusual shower is the Sagittarids for which Rendtel et al. (1995) found several maxima of activity. In this case, we computed the ZHR for the beginning of July and assumed this moment as the maximum. Thus again the only free parameter was the slope B.

A completely different approach we performed in the case of sporadic meteors. As was shown in Znojil (1995) the hourly rates of sporadic events increase almost linearly between 22 and 2 at local time with a slope equal to 2.1 meteors per hour. Using VMDB of IMO we also computed the mean value of HR for sporadic meteors in July. Thus the sporadic background for each night was described by the following equation:

$$HR_{\rm spor} = 2.12 \cdot {\rm UT} - 33.64. \quad (3)$$

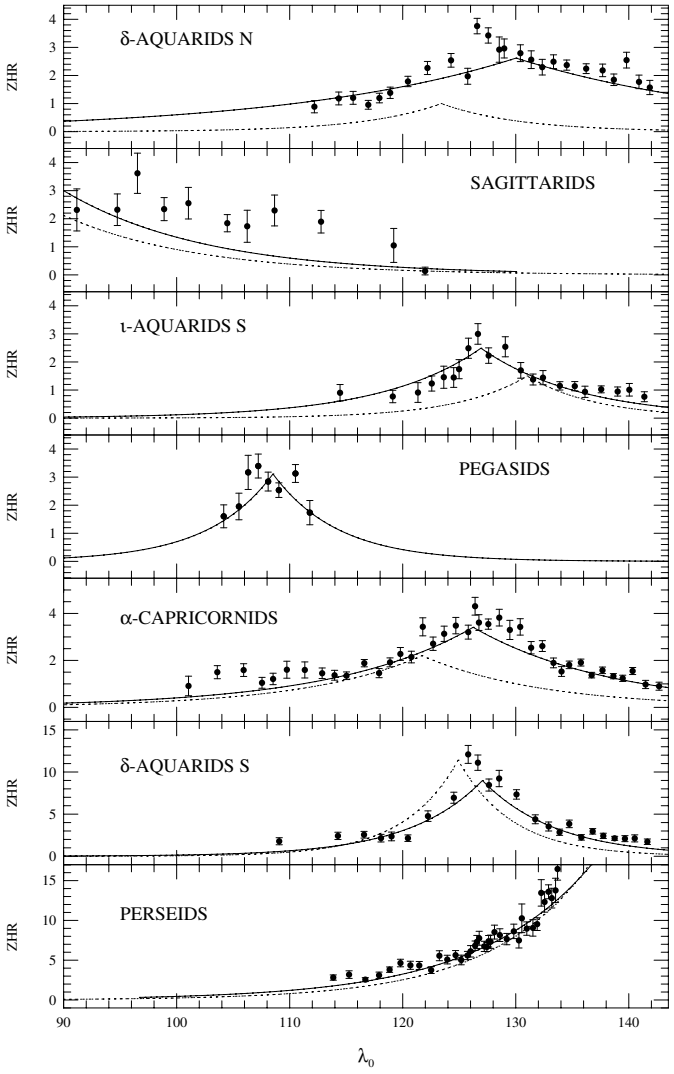

Fig. 1. Activity profiles for July showers. The solid lines correspond to the fits based on the Eq. (1). The dotted lines are the activity profiles given by Jenniskens (1994).

3. Observations

The sample analyzed by Wiśniewski & Olech (2001) contained 1372 hours of effective time of observations collected in 1996–1999. Due to the poor weather conditions in Poland these observations were not distributed uniformly. Thus the artificial database, which we want to construct should take into account the distribution of real observations. This distribution is presented in Fig. 2.

Due to the fact that the majority of the *CMW* observations were made during the astronomical camps, which took place in the Observational Station of Warsaw University Observatory in Ostrowik, we assumed that all observations in the artificial sample were collected in Ostrowik ($\lambda = 21.4^\circ$ E, $\phi = 52.1^\circ$ N). We also assumed that the limiting magnitude LM was the same for all observations and was at the level of 6.3 mag, a value typical for Ostrowik conditions.

Knowing the number of observations collected on each July night we distributed them uniformly from 20:00 to

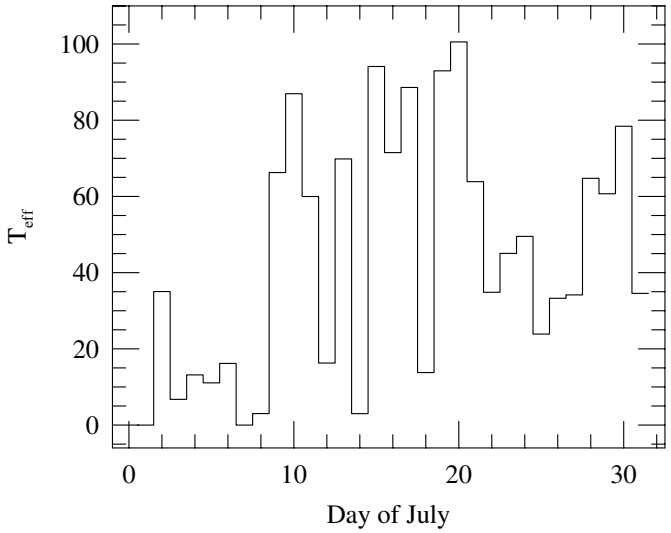

Fig. 2. Distribution of real observations collected by the *CMW* observers in the years 1996–1999.

24:00 UT–the period of time in which the Sun is sufficiently enough below the horizon for meteor observations in Poland.

For each moment, using values from Table 2 and the Eq. (1), we can compute the expected value of ZHR for each shower. Knowing the ZHRs, and also the values of altitudes of the radiants for each hour, and using Eq. (2), we can calculate the expected numbers of observed meteors N. Of course, due to the different perception of the observers, some of them, even in the same conditions, detect a higher number of meteors than others. Thus we modified the expected numbers N using Gaussian distribution with the mean at N and the standard deviation equal to $\sqrt{N}$.

As a result we obtained a file containing the date of the observation, the UT time at the middle of the observation and the numbers of meteors from each shower and also the number of sporadic meteors.

Finally in our artificial sample we included 1042 α-Capricornids, 750 δ-Aquarids N, 605 July Pegasids, 803 δ-Aquarids S, 396 ι-Aquarids S, 121 Sagittarids, 2465 Perseids and 15394 sporadics. This sample is clearly more numerous than the real database. It is due to the fact that during the construction of the artificial sample we assumed a constant and quite high value of the limiting magnitude ($LM = 6.3$ mag) and additionally assumed that all artificial observations were taken under a clear sky.

4. Distribution of shower meteors over the celestial sphere

4.1. Locations of meteor paths

Due to the small perturbations caused by the bodies of the Solar System, paths of the meteoroids from a particular stream are not ideally parallel in the Earth atmosphere. Thus the radiants of meteor showers are

not the ideal points. According to recent video results (Molau 2000, 2001) the radiant radii of the Perseids and the Leonids are around 1 degree. For more complex ecliptic radiants like the α-Capricornids, the Sagittarids and the Taurids, these radii are around 3 degrees (Molau 2000; Triglav 2001). In our artificial database we have to take into account these radiant sizes. Thus for showers like the Perseids and the July Pegasids, which are rich in young material, assumed radiant radii were equal to 0.8 degree. Other normal showers have these radii equal to 1 degree. For the Sagittarids and the α-Capricornids we assumed radii equal to 3.0 and 2.5 degrees, respectively. These values are summarized in Table 2.

Knowing the theoretical radiant center and its radius, for each event from a given shower we calculated its real radiant position using the two dimensional Gaussian surfaces with a center at the theoretical radiant center and standard deviations in right ascension and declination equal to the radiant radius given in Table 2.

During the real observation each observer of the *CMW* was looking in a specific direction. These details are noted in observational report form by giving the equatorial coordinates of the center of the field of view. This center should be always at an elevation of at least 40 degrees.

The artificial database should take into account a location of the field of view of an observer. Therefore we constructed a list of the centers of view used in the real sample. In the first step, for each artificial observation, we randomly drew a center of the field of view from our list.

Having a center we can analyze the distribution of the meteors in the field of view. Using the real observations we calculated the distances of the beginnings of the meteor paths from the center of the field of view. The distribution of these distances is presented in Fig. 3. The best fit to this distribution was obtained using the Gaussian function with the mean value equal to 24.9° and $\sigma = 15.2°$, shown as a solid line in Fig. 3.

Of course meteors appear irrespective of the distance from the field of view. Another factor which we should take into account is the location of the radiant. Thus, finding the beginning of the meteor path was done as follows:

1. knowing the center of the field of view, the distance of the beginning of the meteor path was drawn using the distribution presented in Fig. 3;
2. the line between the center of the field of view and the radiant of the shower was found;
3. the angle between the line mentioned above and the line connecting the center of the field of view with the beginning of the meteor path was found using the Gaussian distribution with a mean equal to zero and a standard deviation equal to 60°;
4. to have a quite uniform distribution of meteors around the center of the field in 40% of the cases, the angle mentioned above was increased by 180°.

In the next step, after finding the beginning of a meteor, we computed the length of the meteor path. For this purpose we used equations given in Rendtel et al. (1995).

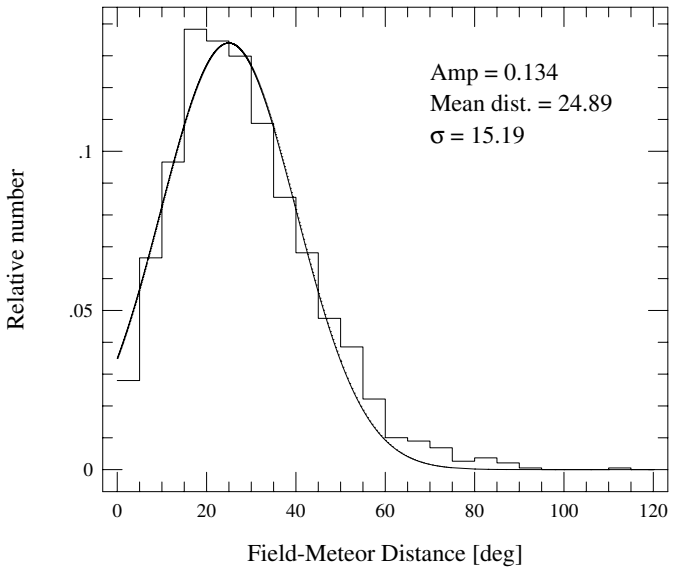

Fig. 3. The distribution of distances between the center of the observed field and the beginning of the meteor path for real data collected by the *CMW* observers.

Knowing the radiant position, the beginning of the meteor path and its length we were able to find the equatorial coordinates of the end of the meteor.

4.2. Introducing the errors

During a real observation no one is capable of exactly determining the meteor's path and velocity. Thus in an artificial database we have to modify the paths and velocities of the events introducing the errors caused by the observers.

There are two error components which affect the direction and position of the meteor path. They are a tilt ϵ and a parallel shift d as is shown in Fig. 4. An analysis of these quantities in visual observations made by experienced observers was done by Koschack (1991). Their distributions, according to that paper, are shown in Fig. 5. The solid lines correspond to the Gaussian fits described by the parameters given also in Fig. 5.

We used these fits for randomly drawing the tilt and shift for each meteor and modifying its path.

Due to the errors made by the observer the path of the meteor is not only tilted and shifted. Additionally observers often change the length of the meteor path, plotting it as shorter or longer in comparison with its real length.

In our approach we calculated the observed length of the meteor path l and modified its beginning and end using the Gaussian distributions with a mean value equal to zero and a standard deviation equal to $l/10$.

More than just the direction and length of the meteor are modified due to the errors inputted by the observer. Another factor which is randomly changed during

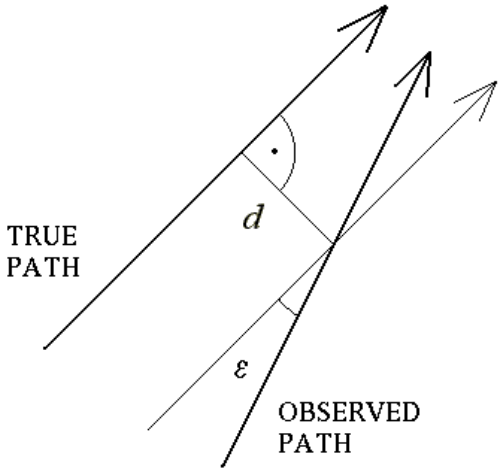

Fig. 4. The plotting errors a tilt ϵ and a parallel shift d.

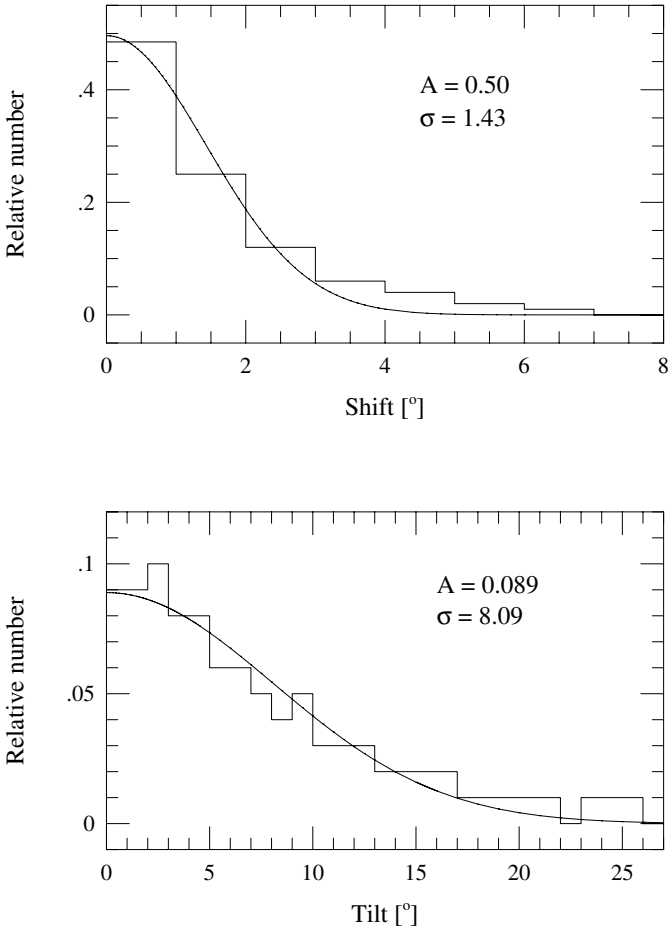

Fig. 5. The distribution of tilts and shifts obtained from observations by experienced observers according to Koschack (1991). Solid lines denote the Gaussian functions with amplitude and standard deviation given in each panel.

an observation is the meteor's angular velocity. Knowing the entry velocity V_∞ of the event and its location on the celestial sphere we can calculate its theoretical angular velocity.

As was shown by Koschack (1991) the error in angular velocity inputted by the observer depends on the angular velocity itself. The distribution of these errors in different ranges of velocities is shown in Fig. 6. Each of these distributions was fitted with a Gaussian function shown as solid line. The mean values of these Gaussian functions were assumed as zero and the obtained standard deviations are given in each panel.

These distributions were used for randomly modifying the angular velocities of the meteors in our artificial sample.

As an example of a result, in Figs. 7 and 8, we show different kinds of maps produced by RADIANT software for our sample of 2465 Perseids. Figure 7 shows results obtained for paths of the Perseids before introducing the errors made by the observer. In the upper panel of this figure we show the paths of the meteors in the sky. The map is centered at the radiant of the Perseids for $\lambda_\odot = 125°$. The largest circle has a radius equal to 90°. One can note that some meteors do not radiate exactly from the center of the picture. This is caused by the fact that the radiant of the Perseids moves across the celestial sphere and meteors observed at the middle of July radiate from another point than meteors noted one or two weeks later.

In the middle panel of Fig. 7 we show an intersection map obtained using the tracings mode of the RADIANT software. Due to the assumed almost one degree radius of the radiant, not all meteors intersect in the center of the radiant. The elongated shape of the radiant is caused by the distribution of the meteors which are observed mostly at the western side of the radiant at this time of the year.

In the lower panel of Fig. 7 we show the PPR map for our artificial sample of Perseids. It is clear that the radiant is compact and circular and its position is correct.

The same analysis was made for the Perseids with meteor paths and velocities randomly changed using the observational errors and the result is shown in three panels of Fig. 8. At the upper panel one can notice that meteors do not always radiate exactly from the center of the radiant.

Although the radiant obtained using the tracings method, shown in the middle panel, is still very clear it is also more diffuse in comparison with the middle panel of Fig. 7. It is worth noting that there is a different scale used in both middle panels. In Fig. 7 the highest number of intersections detected in the center of the radiant is 1066 and in Fig. 8 it reaches only 180.

The PPR map obtained for the sample of Perseids with introduced observational errors shows a radiant which is still circular and at the correct position but significantly more diffuse than in previous case.

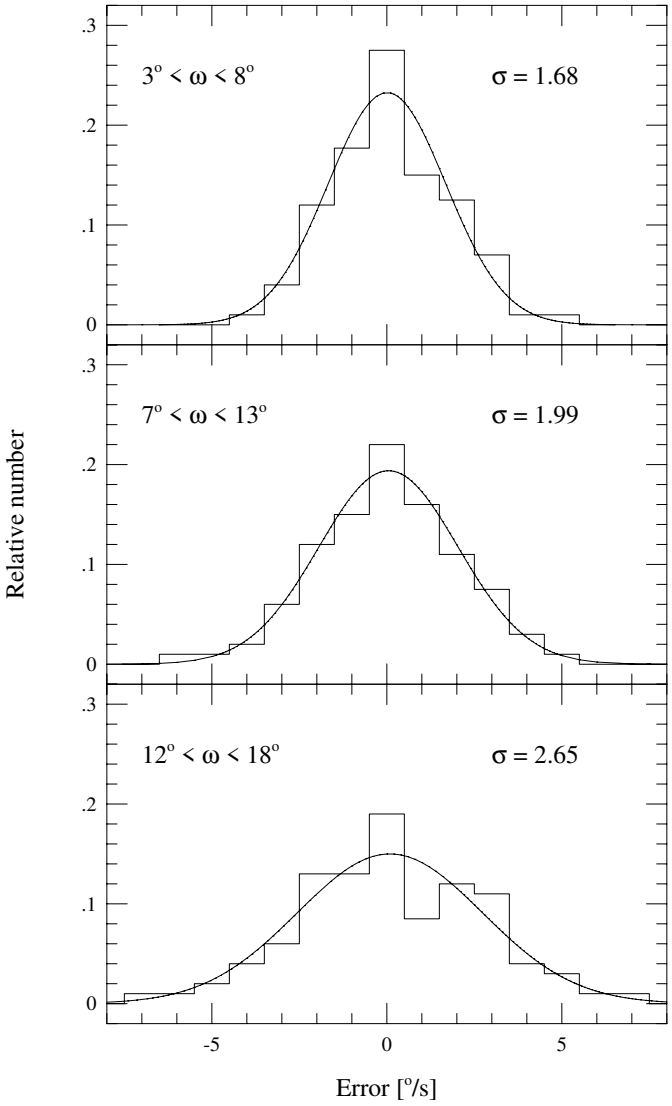

Fig. 6. The distribution of errors in angular velocities for observations of experienced observers according to Koschack (1991). Solid lines denote the Gaussian functions with a standard deviation given in each panel.

5. Distribution of sporadic meteors over the celestial sphere

Since the 1950s we know that sporadic meteor radiants are not distributed uniformly over the celestial sphere, but they are concentrated in particular regions which are similar to radiants with radii slightly larger than 20° and positions approximately fixed relative to the Sun. The first three sources associated with the ecliptic plane were discovered by Hawkins (1957). According to the latest papers (Jones & Brown 1993; Brown & Jones 1995; Poole 1997) we now identify six such sources. They are antihelion, helion, northern and southern toroidal centers and also the northern and southern apex.

When constructing the sample database of meteors we have taken into account the above mentioned sources.

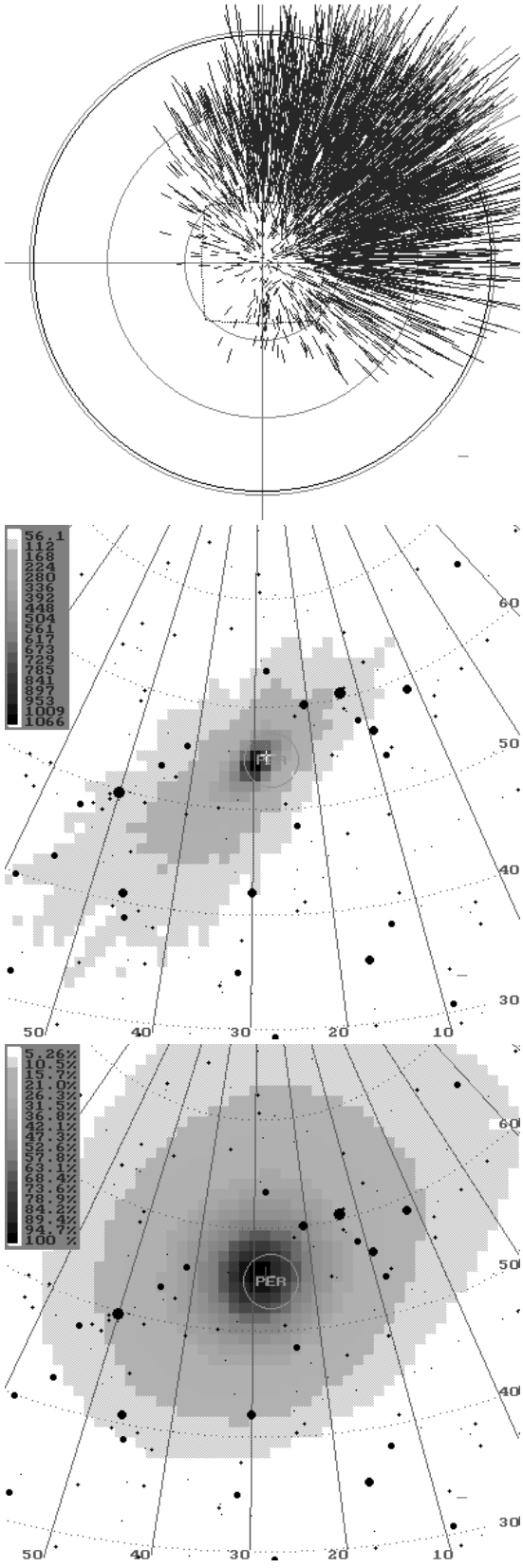

Fig. 7. *Upper panel*: sample distribution of the Perseid shower meteor paths (observational errors not included yet). The center of the figure is at the radiant of the Perseids. *Middle panel*: the radiant of the Perseids obtained using the tracings method of the RADIANT software. *Lower panel*: PPR map of the Perseids.

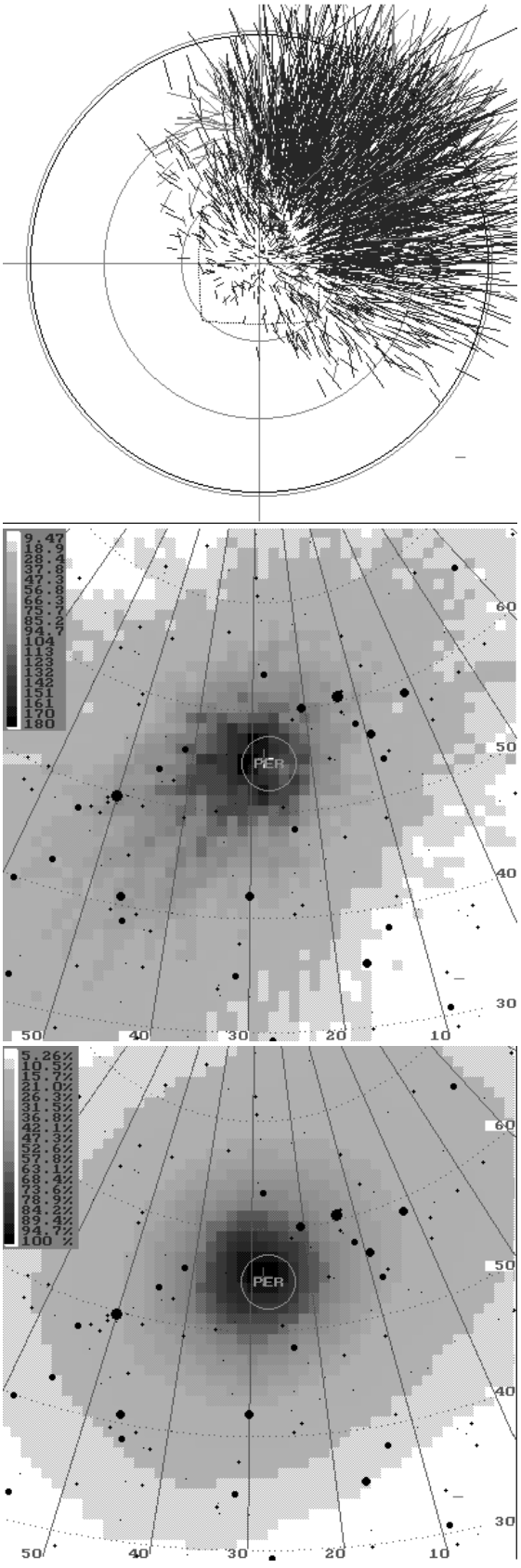

Fig. 8. *Upper panel*: sample distribution of the Perseid shower meteor paths with observational errors included. The center of the figure is at the radiant of the Perseids. *Middle panel*: the radiant of the Perseids obtained using the tracings method of the RADIANT software. *Lower panel*: PPR map of Perseids.

Table 3. The ecliptic coordinates and radii of the sporadic meteor sources included in our artificial database.

Source	λ–$\lambda_\odot$	β	R [°]
Antihelion	198°	0°	18°
Northern Toroidal Source	271°	+57°	19°
Norther Apex	271°	+19°	21°

We decided to omit the helion, southern toroidal center and the southern apex. These radiants in July at Polish geographical coordinates are always either very close to the Sun or below the horizon. The remaining three sources were included into the database and their properties taken from Jones & Brown (1993) are summarized in Table 4.

According to the work of Jones & Brown (1993) and Poole (1997) all sources seem to have similar activity. Thus we assumed that the number of the sporadic events radiating from each center is proportional only to the sine function of the center altitude. The whole number of sporadics observed during each hour was divided between these sources. Especially in the evening hours, when all centers are either below the horizon or only slightly over it, we assumed the existence of another source. It was centered at the zenith and its radiant had a radius equal to 60°.

Knowing the positions and the radii of all four sources, for the purpose of finding the location of sporadic meteor paths, we followed the procedures applied for shower meteors described in Sect. 4.1.

Also the procedures for introducing the errors into the meteor paths was the same as described in Sect. 4.2.

The sporadic sources, contrary to the shower radiants, are not characterized by meteors with a common entry velocity. Thus for each sporadic source we used the entry velocity distributions given by Jones & Brown (1993) (see their Figs. 7–9). These velocities were also changed according to the error distributions presented in Fig. 6.

6. α-Cygnids

The α-Cygnid shower was discovered by W. F. Denning (1919). After his observations we have rather poor information about the activity of this shower. A reasonable determination of the position of the radiant was done using photographic observations, and based on the one captured event, the equatorial coordinates of the radiant were $\alpha = 304.5°$ and $\delta = +48.7°$ with a geocentric velocity equal to $V_\infty = 41.0$ km s^{-1} (Babadzhanov & Kramer 1961)

The first comprehensive study of the α-Cygnids, based on the 11 years of visual observations, was presented by Jenniskens (1994). According to this work the α-Cygnids are a weak shower with maximum ZHRs equal to 2.5 ± 0.8 occurring at a solar longitude $\lambda_\odot = 116.0°$. The meteors from this shower are observed from $\lambda_\odot = 105°$ to $\lambda_\odot = 127°$.

In recent years the α-Cygnid shower was intensively analyzed by the Polish *Comets and Meteors Workshop* (Olech et al. 1999a, 1999b; Stelmach & Olech 2000). Here we only briefly mention the results presented in the latest of these papers, which is based on the most comprehensive sample. According to Stelmach & Olech (2000) the radiant of the α-Cygnids is at $\alpha = 305°$ and $\delta = +45°$. The activity of this shower lasts from the beginning to the end of July with a quite obvious maximum at $\lambda_\odot = 114.8° \pm 0.5°$. Maximal ZHRs are equal to 2.4 ± 0.1.

As was pointed out by Olech et al. (1999a) the α-Cygnid shower was probably not recognized before the study of Jenniskens (1994) because of a lack of data in photographic meteor databases around the peak date of the shower.

Stelmach & Olech (2000) presented only the preliminary results for year 1999. As the *CMW* database from period 1996–1999 is complete now, we decided to recalculate PPR maps for α-Cygnids. We selected 6772 meteors observed in period June 30–July 31. The PPR maps were centered at $\alpha = 303°$ and $\delta = +45°$. According to earlier results, computations were performed for the moment of $\lambda_{\odot(\max)} = 115°$ with daily drift of the radiant equal to $\Delta\lambda = +1.0°$. The assumed entry velocity was $V_\infty = 41$ km s^{-1}. From our sample we excluded meteors slower than 1°/s and faster than 30°/s. The calculations were done rejecting meteors placed at distances larger than 50 and 85 degrees from the radiant. The final results are shown in Fig. 9.

One can clearly detect the circular radiant close to the center of each map. The RADIANT software allows two ways of estimating the radiant position from the PPR map. The first of them uses the framed part of a PPR map and computes the simple mean position of the radiant weighted by the values of computed probability. The second one also uses the framed part of a PPR map but in this case the probability distribution is fitted with a two-dimensional Gaussian function. These options were used for each of our two PPR maps resulting with four radiant position determinations. The simple mean of these values is $\alpha = 303.9° \pm 0.5°$ and $\delta = +45.3° \pm 0.6°$. The quoted errors are simple standard deviations of the mean and due to the fact that our four determinations are not completely independent, the real errors might be from two to three times larger.

A similar approach was undertaken using the artificial sample and the results are shown in two panels of Fig. 10, where we presented the PPR maps calculated rejecting meteors placed at distances larger than 50 and 85 degrees from the suspected position of the radiant. There is no trace of any circular structure as was detected in the case of real meteors. High probabilities (black areas) at these figures are caused by two reasons. First, the PPR map is always scaled to the highest probability point and its value is assumed to be 100%. Taking into account that we assumed the diffuse sporadic source placed at a zenith with a radius equal to 60°, we should expect the presence of this feature in our maps. The zenith, at Polish latitudes in July,

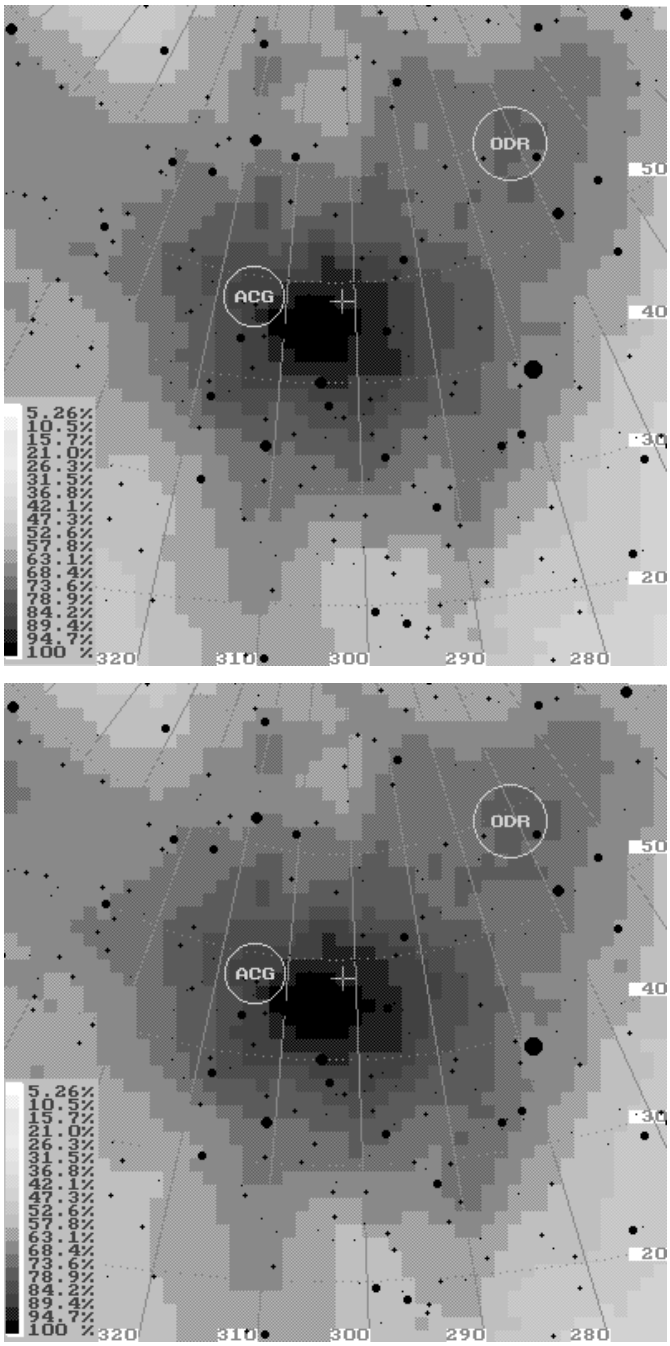

Fig. 9. PPR maps for a real sample of 6772 meteors observed in years 1996–1999. All maps are computed for the following parameters: $\lambda_\odot = 115°$, $\Delta\lambda = 1.0°$ and $V_\infty = 41$ km s^{-1}. The maximum distance of the meteor from the radiant is 50 and 85°, respectively from the upper to lower panel.

lies near Deneb (α Cyg) thus we are not surprised by the high probabilities of detecting the meteors radiating from this region of the sky. But, as we mentioned, the PPR map for the artificial sample does not show any circular radiant as in the case of the real sample, strongly suggesting that the α-Cygnids are the real shower.

Our conclusions are confirmed by a comparison of the real and artificial sample maps obtained by the tracings

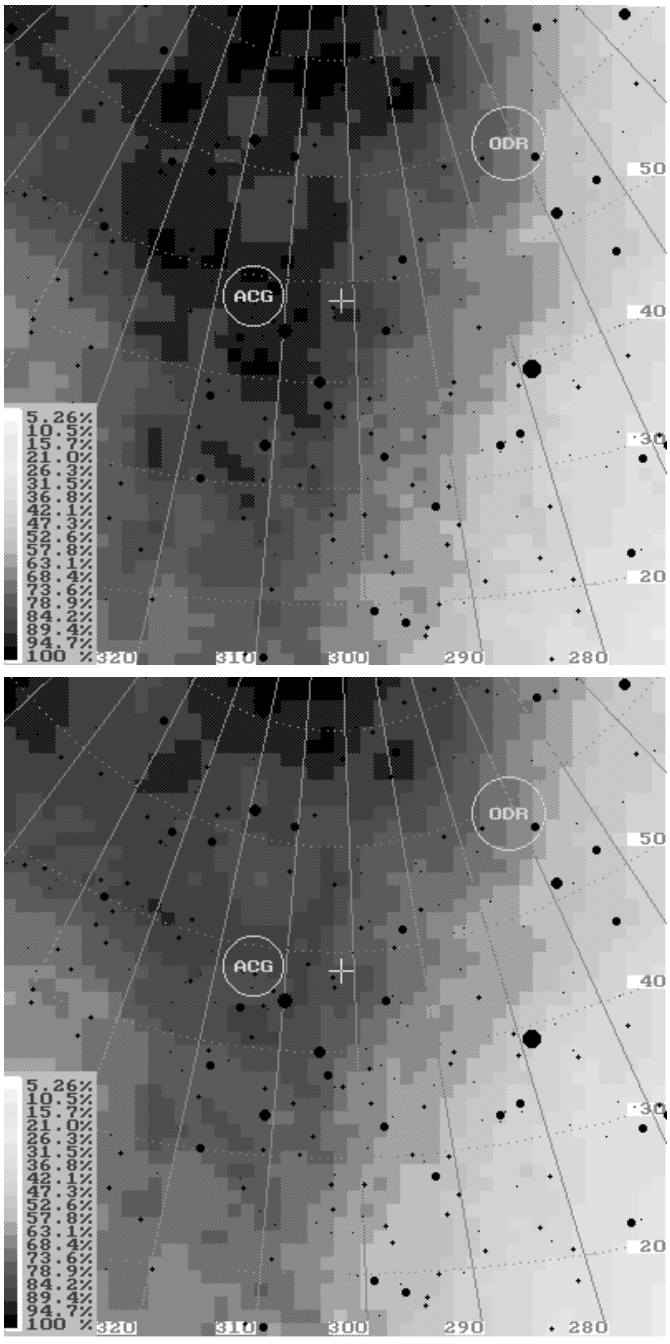

Fig. 10. PPR maps for an artificial sample of 21 516 meteors. All maps are computed for the following parameters: $\lambda_\odot = 115^\circ$, $\Delta\lambda = 1.0^\circ$ and $V_\infty = 41\ \mathrm{km\,s^{-1}}$. The maximum distance of the meteor from the radiant is 50 and 85°, respectively from the upper to lower panel.

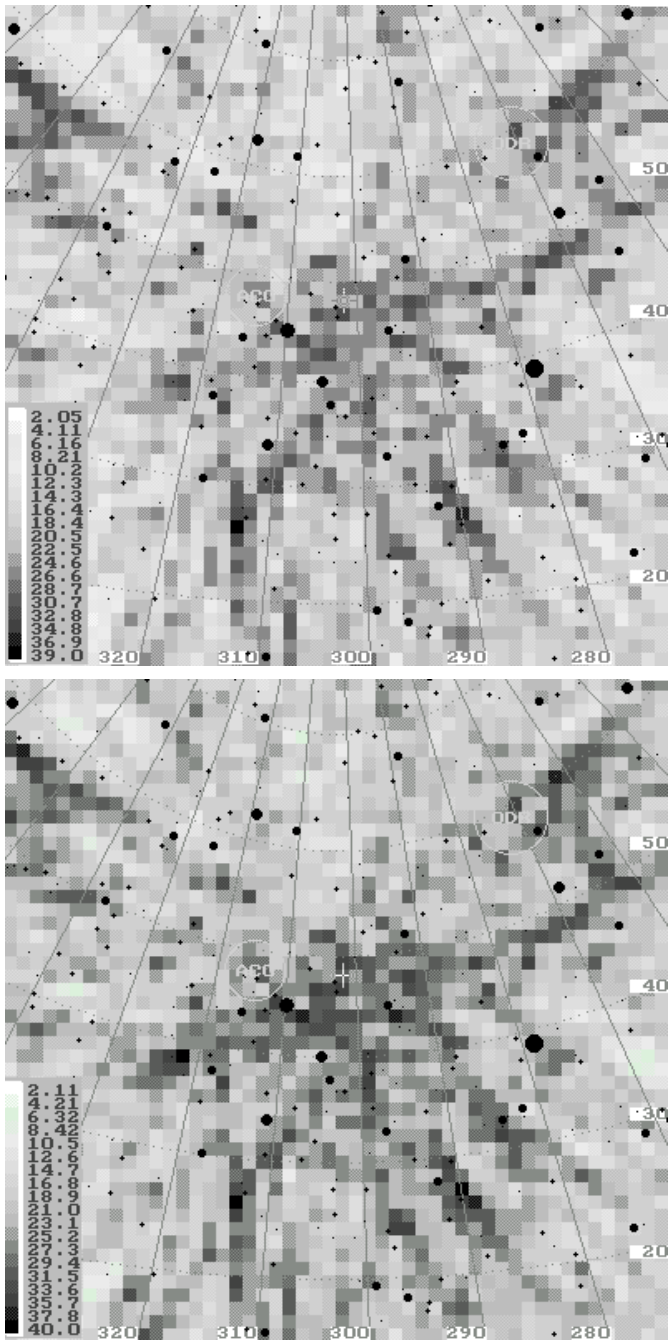

Fig. 11. Tracings maps for a real sample of 6772 meteors observed in the years 1996–1999. All maps are computed for the following parameters: $\lambda_\odot = 115^\circ$, $\Delta\lambda = 1.0^\circ$ and $V_\infty = 41\ \mathrm{km\,s^{-1}}$. The maximum distance of the meteor from the radiant is 50 and 85°, respectively from the upper to lower panel.

method of the RADIANT software. In Fig. 11 we have presented tracings maps for real sample meteors placed respectively within 50 and 85 degrees from the center of the map. In both cases one can see a clear enhancement of the intersections (about 30–40) at the radiant of the α-Cygnids. No such picture is present in the case of the artificial sample for which the results are shown in Fig. 12. Now, the distribution of intersections is more diffuse and is centered mostly at the zenith rather than at the center of the map.

Finally, we conclude that we are unable to reproduce the circular and high quality picture of the radiant of the α-Cygnids using the artificial sample. Such a structure is clearly detected in the real database strongly suggesting that the α-Cygnid shower indeed exists.

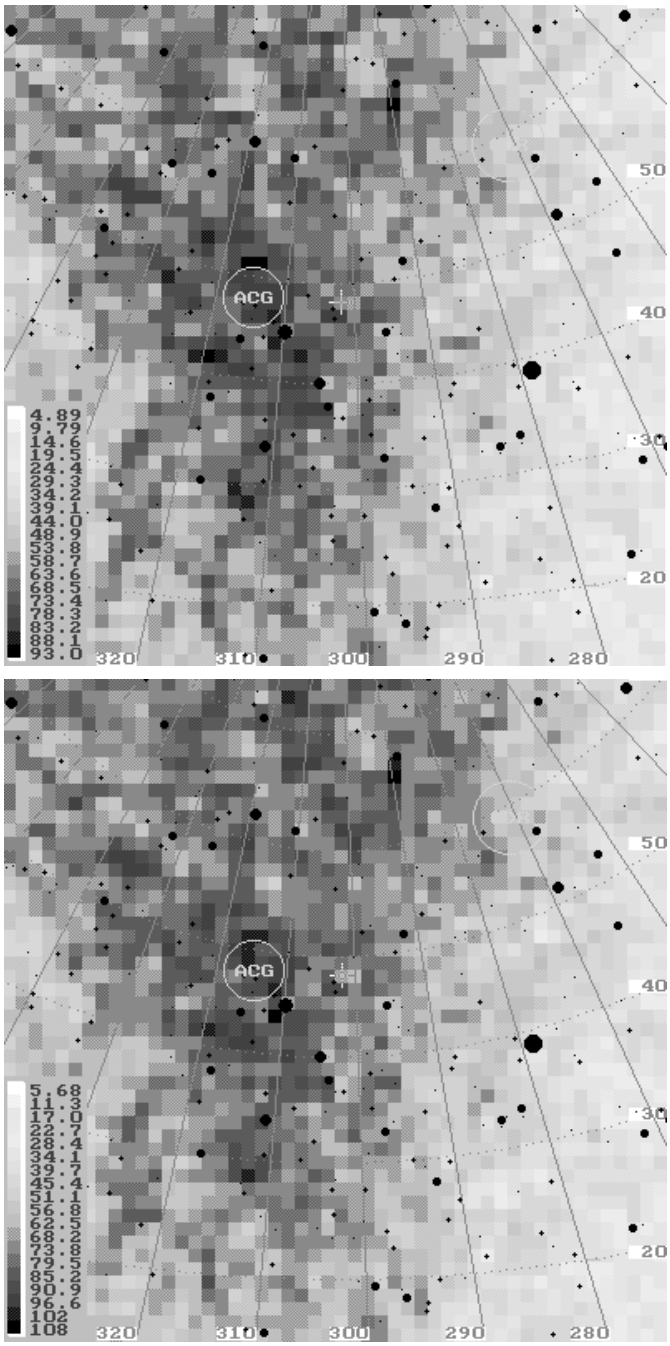

Fig. 12. Tracings maps for an artificial sample of 21 516 meteors. All maps are computed for the following parameters: $\lambda_\odot = 115^\circ$, $\Delta\lambda = 1.0^\circ$ and $V_\infty = 41$ km s^{-1}. The maximum distance of the meteor from the radiant is 50 and 85°, respectively from the upper to lower panel.

7. Delphinids

The Delphinids are not a new shower. The existence of meteors radiating from the constellation of Delphinus was suggested by Russian and Polish meteor sources (Abalakin 1981; Kosinski 1990). In the beginning of the 1990s the shower was studied by Bulgarian observers (Velkov 1996). The comprehensive analysis of this shower was undertaken by the *Comets and Meteors Workshop* (Olech et al. 1999b; Wiśniewski & Olech 2000, 2001). It showed that the Delphinids are a very weak shower with the maximum at $\lambda_\odot = 125^\circ$ with $ZHR = 2.2 \pm 0.2$.

The estimated radiant position was $\alpha = 312^\circ$ and $\delta = +12^\circ$. It is very close to the antihelion source of sporadic meteors, whose position for $\lambda_\odot = 125^\circ$ is $\alpha = 325^\circ$ and $\delta = +14^\circ$. Thus one can presume that the radiant of the Delphinids obtained by Wiśniewski & Olech (2000, 2001) is not real but rather comes from crossing the paths of meteors from the antihelion source and other ecliptic showers active during the second part of July.

To clarify this situation we decided to reanalyze the real sample of Wiśniewski & Olech (2001) collected in the years 1996–1999. We selected 6468 meteors observed between July 9th and July 31st and then computed PPR maps for meteors within 50 and 85 degrees from the radiant. We also assumed that the entry velocity V_∞ is equal to 35 km s^{-1} and meteors in the sky are slower than 30°/s. The assumed daily drift of the radiant was $\Delta\lambda = 1.0^\circ$.

The results of our computation are presented in two panels of Fig. 13. The upper panel shows the radiant of the Delphinids for meteors closer than 50° from the center of the map. The big cross marks the position of the antihelion source. As in the case of the α-Cygnids we computed the mean position of the Delphinids' radiant combining the estimates obtained for different PPR maps shown in Fig. 13. This mean position, equal to $\alpha = 313.4^\circ \pm 0.6^\circ$ and $\delta = +8.6^\circ \pm 2.7^\circ$, is marked by the asterisk.

A similar computation was performed for 20 376 meteors from the artificial sample. All parameters were the same as in the case of the real sample. The results are shown in Fig. 14. Again the big cross denotes the position of the antihelion source and the asterisk the radiant of the Delphinids obtained from visual observations of the *CMW*.

A comparison of Figs. 13 and 14 shows clear differences. First, in the case of the real sample, the radiant of the Delphinids is quite compact and suffers from intense pollution from ecliptic showers and the α-Cygnids only in PPR maps shown in the lower panel. The first panel, showing only the closest meteors, gives a quite circular radiant in a clearly different position from the antihelion source. All panels obtained for the artificial sample, at the position of the radiant of the Delphinids, give the probability of detecting the radiant around 70%. This is significantly lower comparing with almost 100% probability at the position of the δ-Aquarids N radiant and also at the antihelion source. High probabilities are also detected in the northern part of all figures caused by the putting a large and diffuse radiant in the zenith.

All these PPR maps strongly suggest that Delphinids indeed exist but detecting this shower, due to the vicinity of ecliptic showers and the antihelion source, requires a large sample of good quality data.

Following the approach done for the α-Cygnids and described in the previous paragraph, we computed the tracings maps for both real and simulated samples. The results are shown in Figs. 15 and. 16. Because the top panels,

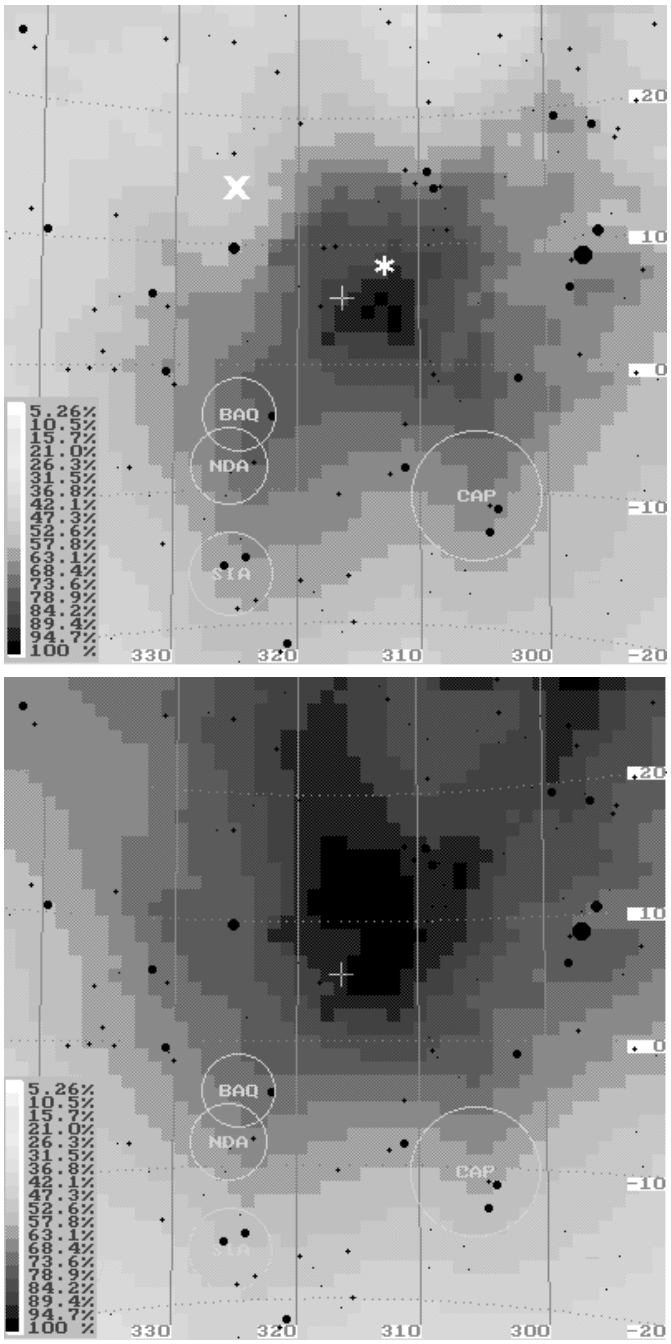

Fig. 13. PPR maps for a real sample of 6468 meteors observed in the years 1996–1999. All maps are computed for the following parameters: $\lambda_\odot = 125°$, $\Delta\lambda = 1.0°$ and $V_\infty = 35$ km s^{-1}. The maximum distance of the meteor from the radiant is 50 and 85°, respectively from the upper to lower panel. The big cross marks the position of antihelion source and the asterisk the mean position of Delpninids' radiant derived from real observations of *CMW*.

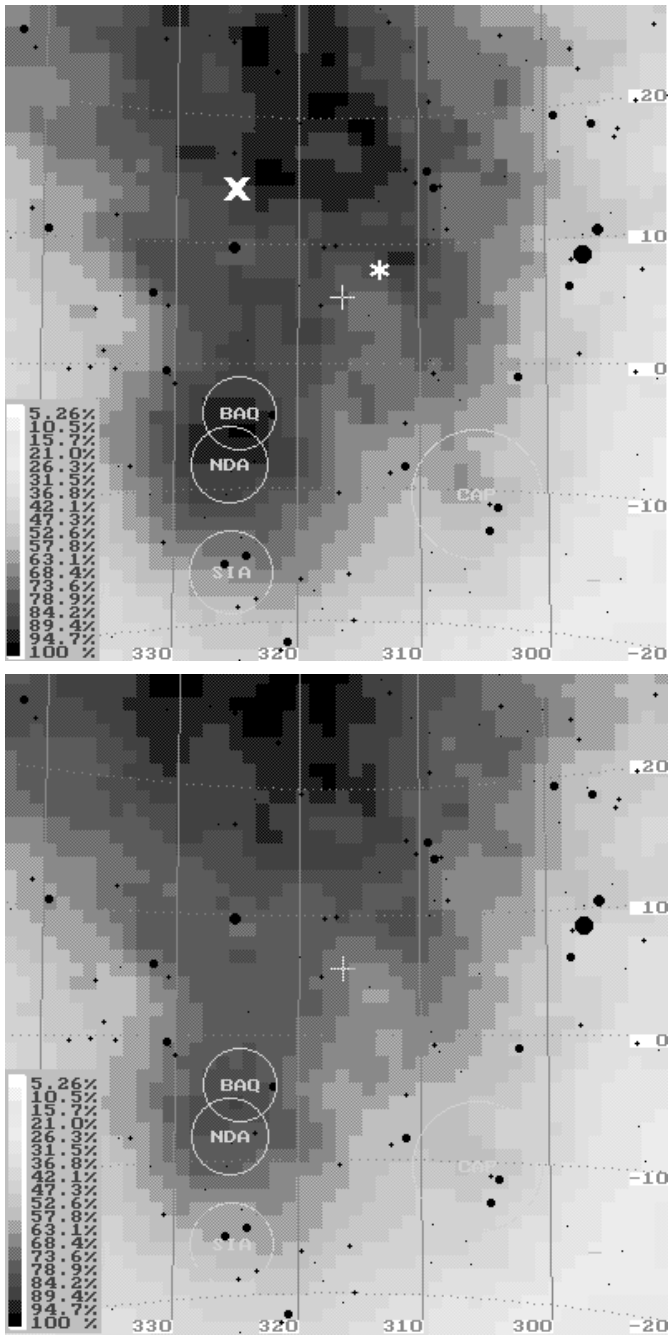

Fig. 14. PPR maps for an artificial sample of 20 376 meteors observed in the period July 8–31. All maps are computed for the following parameters: $\lambda_\odot = 125°$, $\Delta\lambda = 1.0°$ and $V_\infty = 35$ km s^{-1}. The maximum distance of the meteor from the radiant is 50 and 85°, respectively from the upper to lower panel. The big cross marks the position of antihelion source and the asterisk the mean position of Delpninids' radiant derived from real observations of *CMW*.

computed for meteors placed within 50 degrees from the center of the map, suffer less from the meteors radiating from other showers and sources, we focus our discussion on them.

In the upper panel of Fig. 15 (we do not mark the position of the Delphinids' radiant for clarity) we detect a clear clump of bright pixels at the Delphinids' radiant. They correspond to 15–18 intersections suggesting the presence of the real radiant.

In the tracings map obtained from the simulated sample the strongest traces, indicating a high number of intersections, come from the real radiants of the Aquarid

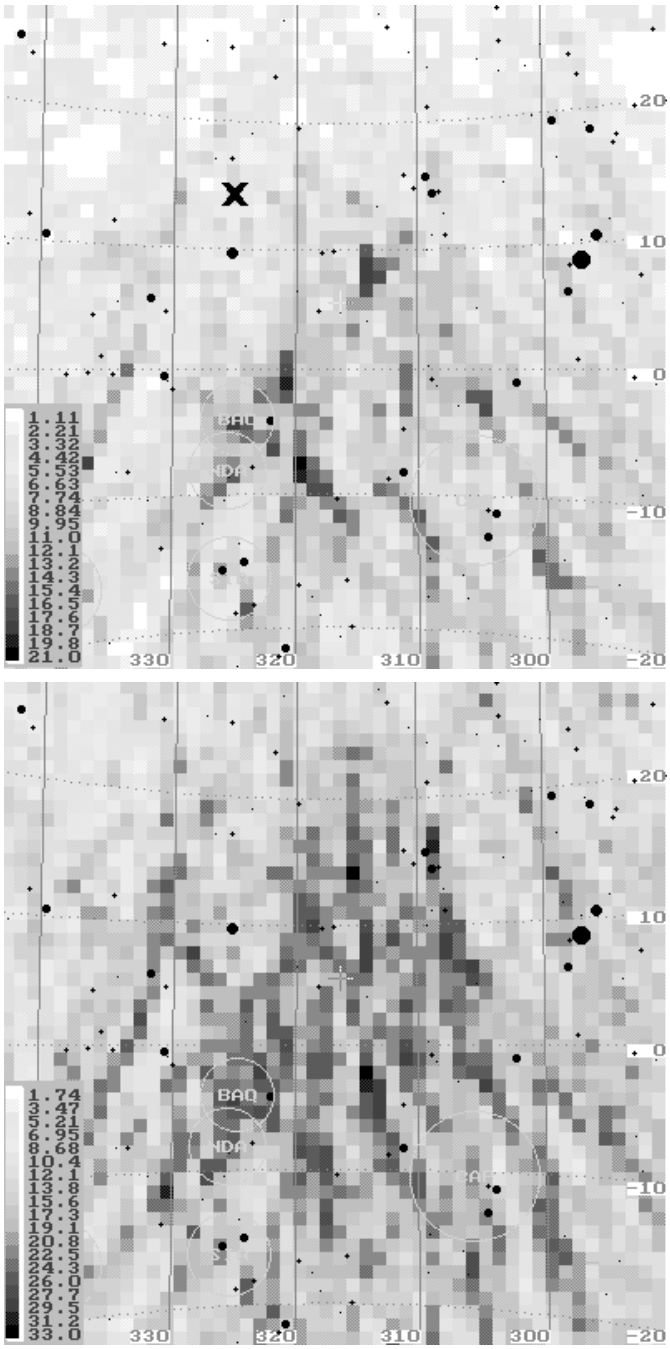

Fig. 15. Tracing maps for a real sample of 6468 meteors observed in the years 1996–1999. All maps are computed for the following parameters: $\lambda_\odot = 125°$, $\Delta\lambda = 1.0°$ and $V_\infty = 35\ \mathrm{km\,s^{-1}}$. The maximum distance of the meteor from the radiant is 50 and 85°, respectively from the upper to lower panel. The big cross marks the position of antihelion source.

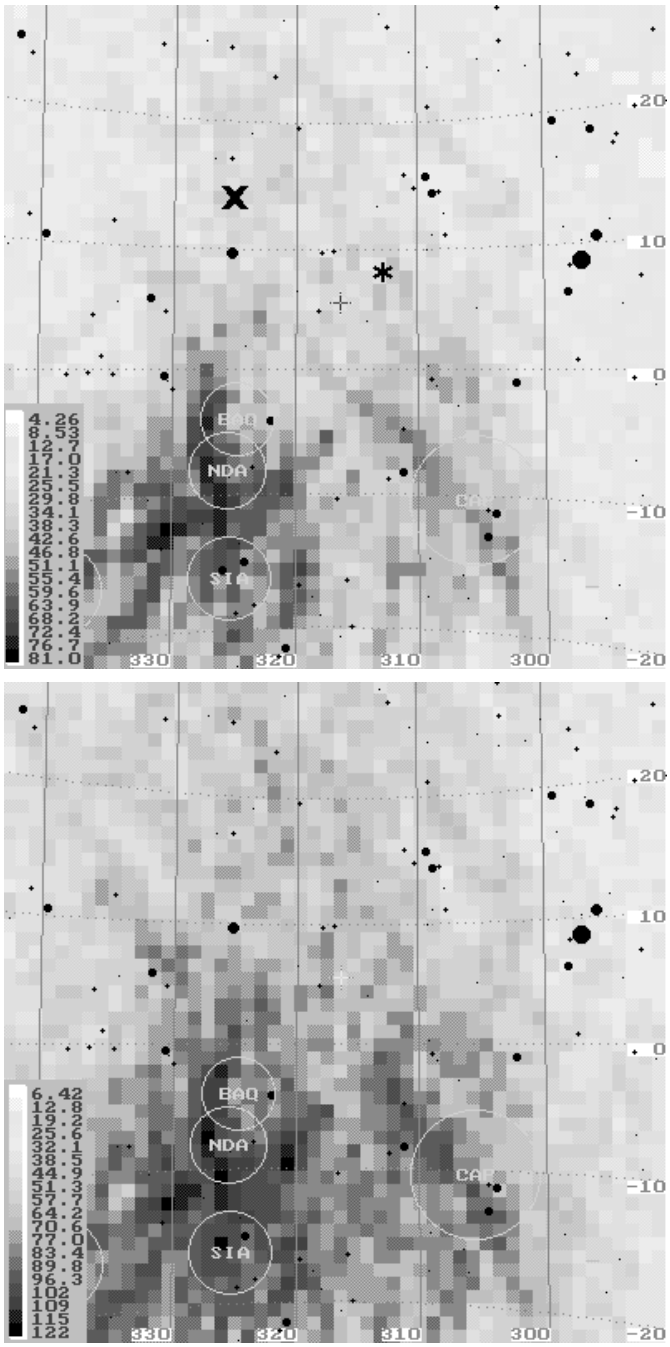

Fig. 16. Tracing maps for an artificial sample of 20 376 meteors. All maps are computed for the following parameters: $\lambda_\odot = 125°$, $\Delta\lambda = 1.0°$ and $V_\infty = 35\ \mathrm{km\,s^{-1}}$. The maximum distance of the meteor from the radiant is 50 and 85°, respectively from the upper to lower panel. The big cross marks the position of antihelion source and the asterisk the mean position of Delpninids' radiant derived from real observations of *CMW*.

complex. We also detect a wide and significantly less clear tail elongated toward the antihelion source. This tail reaches to the position of the radiant of the Delphinids shower and at this location shows about 30–40 intersections. It is less than half of the number of intersections detected in the area around the radiant of the Aquarid complex. In the case of the real sample, the trace of the Delphinids radiant was at the same level as the Aquarids and therefore we conclude that the tracings maps also indicate that the Delphinids are a real shower.

8. Discussion

We have compared two samples containing meteors observed in July in years 1996–1999. In the real sample,

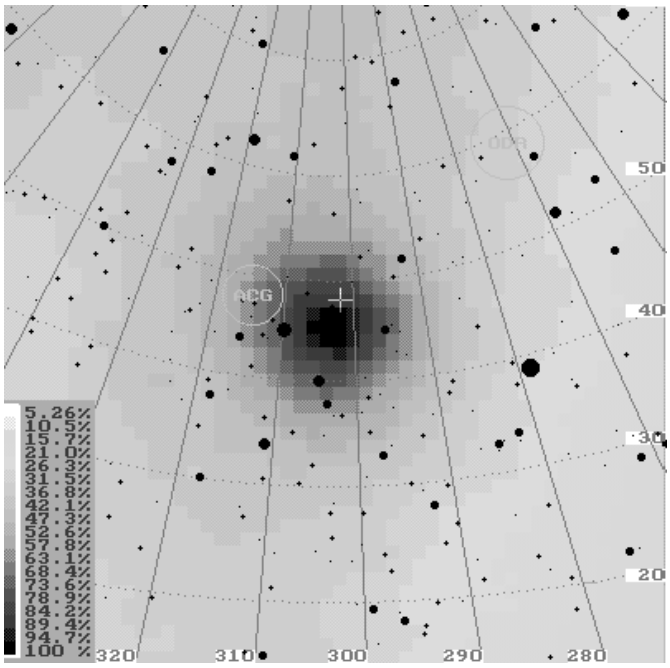

Fig. 17. The PPR map for an artificial sample of 24 341 meteors with the α-Cygnids and the Delphinids included and computed for the following parameters: $\lambda_{\odot} = 115^{\circ}$, $\Delta\lambda = 1.0^{\circ}$ and $V_{\infty} = 41$ km s^{-1}. The maximum distance of the meteor from the radiant is 70°.

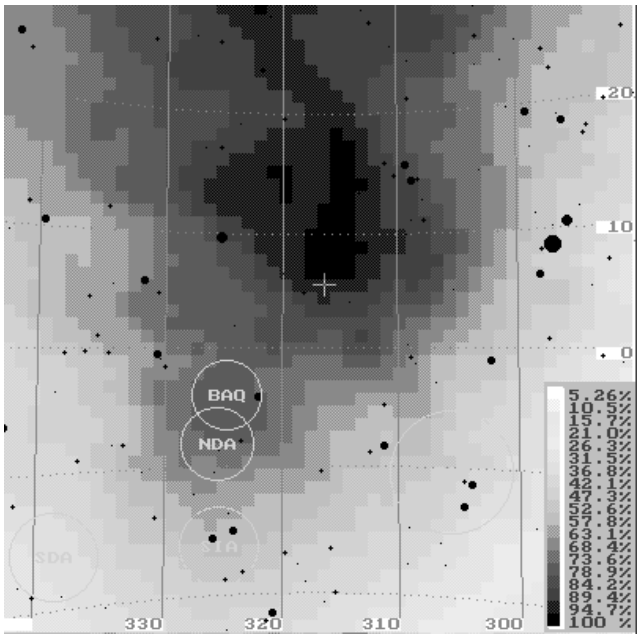

Fig. 18. The PPR map for an artificial sample of 23 076 meteors with the α-Cygnids and the Delphinids included and computed for the following parameters: $\lambda_{\odot} = 125^{\circ}$, $\Delta\lambda = 1.0^{\circ}$ and $V_{\infty} = 35$ km s^{-1}. The maximum distance of the meteor from the radiant is 70°.

obtained from real visual observations made by Polish amateur astronomers, we detected clear radiants of α-Cygnid and Delphinid showers. The question that we wanted to answer was whether these radiants can be produced as the intersections of paths of meteors radiating from the real showers active in July. Thus we constructed the artificial sample resembling in all details the real observations and we included all meteor showers except the α-Cygnids and the Delphinids. These radiants, assuming that they are artificial formations created by intersections of meteors from real showers, should also be seen in the simulated sample. A comparison of both databases showed that it is very difficult to produce circular and clear radiants of the α-Cygnids and the Delphinids using the meteors from an artificial sample. On the other hand such radiants are easy detected in the real sample. This strongly supports the hypothesis that the α-Cygnids and the Delphinids indeed exist.

Finally, we decided to perform another test. To the artificial sample we added the meteors from the α-Cygnids and the Delphinids. These showers were described by the parameters $ZHR_{\max}$, B and $\lambda_{\odot(\max)}$ given by Stelmach & Olech (2000) and Wiśniewski & Olech (2001). The numbers of our artificial sample were then increased by 2035 α-Cygnids and 704 Delphinids.

We calculated the PPR maps for this new database and they are presented in Figs. 17 and 18 (for simplicity we decided to compute the maps for meteors within 70 degrees from the radiant only). Assuming that there are no other showers in July than the Delphinids, α-Cygnids and these listed in Table 1 we expect that our artificial sample should produce the same PPR maps as the real sample (shown in Figs. 9 and 13).

In the case of the α-Cygnids we see that the artificial radiant is more compact than the one obtained from the real sample. However we should expect that there are few poorly known or even unknown showers which are present in the real sample and which were not included in the artificial sample. A good example is the o-Draconids shower, which is not listed in the IMO Working List of Meteor Showers, and as it is clearly visible from Fig. 9 is detected in our visual data causing a strong disturbance into the shape of the α-Cygnids radiant.

In the case of the Delphinids both Fig. 18 and especially lower panel of Fig. 13 are similar. The radiant of the Delphinid shower is elongated toward the α-Cygnids radiant. Also the influence of the Aquarid complex is present in both cases.

The similarity of the PPR maps obtained from the new artificial and real samples is another argument for the existence of the α-Cygnids and the Delphinids.

Our artificial databases are accessible via the Internet and can be downloaded from the following URL: `http://www.astrouw.edu.pl/~olech/SIM/`. Detailed information about these databases are included in the README file.

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Small bodies of the Solar System in the data of the ASAS project

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Abstract

The data collected during the three stages of the All Sky Automated Survey (ASAS) project are reviewed from the point of view of searching for traces of small bodies of the Solar System. There are over 400 000 frames collected during the first five years of the project activity. There are many traces of meteors, asteroids and comets on these images. It is a potential source of valuable information about meteor showers of the southern hemisphere, orbital elements of newly discovered asteroids and comets. We point out on the possibility of discovering new comets and Near-Earth asteroids analyzing the ASAS data using newly developed image subtraction method.

1 The ASAS Project

As was suggested by Paczyński (1997) many interesting scientific programs can be done even with surveys covering only the brightest observable objects. The main topics include variable stars, comets, asteroids, meteors, near-Earth objects (NEOs), supernovae, AGNs and optical afterglows of gamma ray bursts.

One of such projects is the All Sky Automated Survey (ASAS). Its final goal is photometric monitoring of $\approx 10^7$ stars brighter than 14 magnitude all over the sky. The initial idea for the project is due to Prof. Bohdan Paczyński of Princeton University. The prototype instrument, located at the Las Campanas Observatory (operated by the Carnegie Institution of Washington), and the data pipeline were developed by Dr. Grzegorz Pojmański of the Warsaw University Observatory (Pojmański 1997).

Low cost prototype instrument (ASAS-1, ASAS-2), equipped with 768×512 Kodak CCD and 135/1.8 Sigmatel telephoto lens, mounted on the robotic mount (developed at the Warsaw University Astronomical Observatory) operated at the Las Campanas Observatory, Chile since April 7, 1997 till June 6, 2000. It was taking over 120 3-minute exposures per night, continuously monitoring about 300 sq. degs of the sky.

The instrument had the scale of 14.2 arcsec/pixel and 3×2 deg field of view. The I-band Cousins (Schott RG-9, 3mm) filter was used giving the limiting magnitude around 13 mag.

Figure 1: *The ASAS prototype instrument in Las Campanas Observatory, Chile*

The mount, camera and electronic box were housed in the 0.6-m × 0.6-m × 0.8-m water-proof ply-wood box (Fig. 1). During the second stage of the project (ASAS-2) the instrument was moved to the 10-inch astrograph dome of the Las Campanas Observatory.

During over three years of operation (April 7, 1997 – June 6, 2000) ASAS-1 and ASAS-2 collected over 80 000 frames.

2 Current Status of the ASAS

Since August 2000 the ASAS project started its third phase. Since that time it consist of four instruments: two twin wide-field telescopes each equipped with 200/2.8 Minolta telephoto lens and 2048 × 2048 Apogee AP-10 CCD camera covering 8.8 × 8.8 deg of the sky through the Johnson V and Cousins I filters, the narrow-field telescope which is $F = 750$ mm, $D = 250$ mm, $F/3.3$ Cassegrain-like instrument with 3-element Wyne corrector. It has the same 2048 × 2048 Apogee AP-10 CCD camera and I filter. The field of view is 2.2 × 2.2 deg, but correct PSF ($FWHM < 2.5$ pixels) is currently available only inside the circular field of ≈ 1 deg radius. Additionally the sky is monitored using very-wide-field scope equipped with Minolta 50/4 lens and also 2048 × 2048 Apogee AP-10 CCD camera giving the field of view as large as 36 × 26 deg. The technical informations of all ASAS-3 instruments are summarized in Table 1.

In August 2000 ASAS-3 system was installed in the 10-inch astrograph dome of the Las Campanas Observatory. In April 2002 ASAS-3 moved to the separate, custom made enclosure housing all four instruments placed in front of the 1.3-meter Polish telescope (Fig. 2).

Table 1: *Table 1. Technical information about ASAS-3 instruments*

	wide-field instruments	**narrow-field telescope**	**very-wide-field scope**
Optics	Minolta 200/2.8 lens	25-cm Cassegrain 250/3.3	Minolta 50/4 lens
FOV	$8.8^\circ \times 8.8^\circ$	$2.2^\circ \times 2.2^\circ$	$36^\circ \times 26^\circ$
LM	13 mag.	16 mag.	10 mag.
Filter	V, I	I	I

More information, pictures and scientific data can be found on the ASAS Home Page at `http://www.astrouw.edu.pl/~gp/asas/asas.html`.

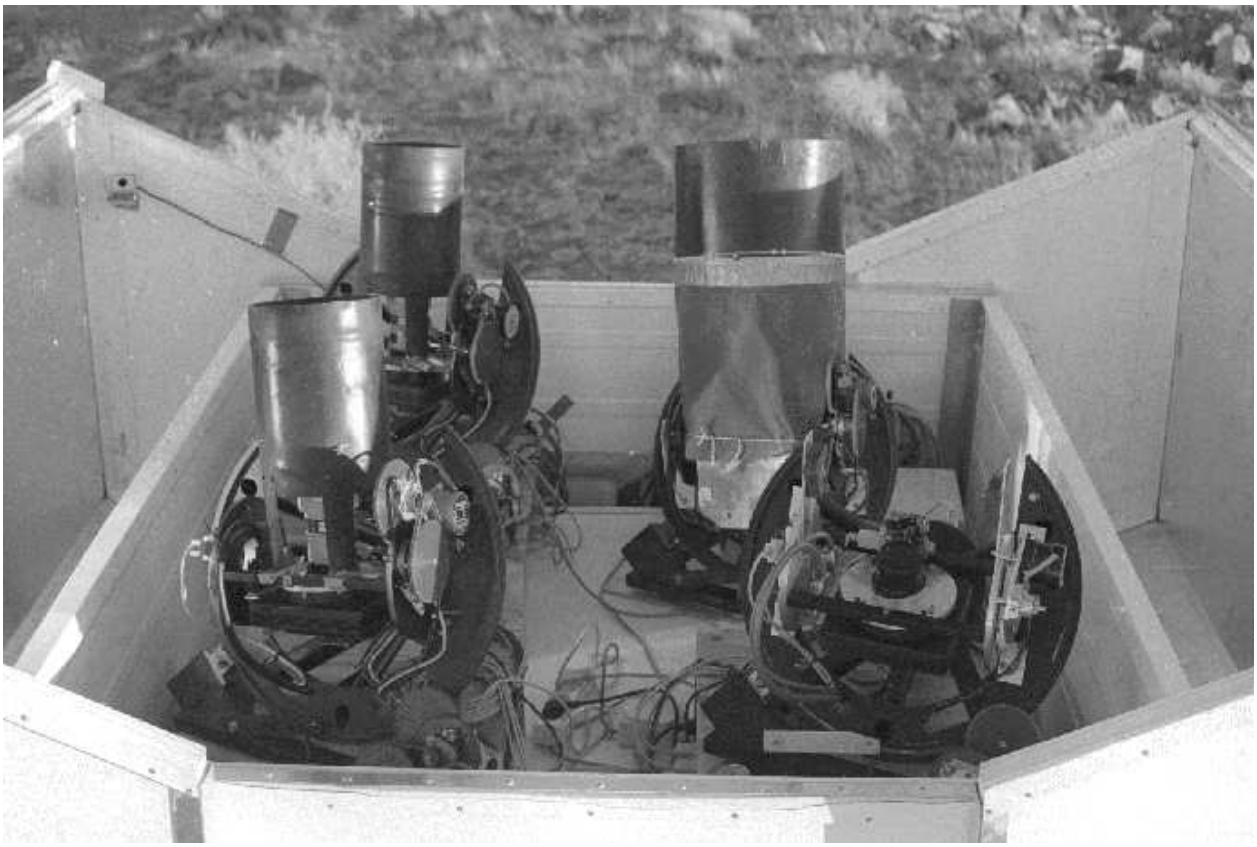

Figure 2: *The ASAS-3 instruments in the custom made automated enclosure*

3 Scientific Results of the ASAS

The main results of the ASAS projects were presented by Pojmanski (1998, 2000). The first of these papers describes results of the first two months of observations when 45 000 stars in 24 fields covering 140 square degrees were monitored. Period search revealed 126 variable stars brighter than 13 mag and only 30 of them were previously known. The other objects were newly discovered variables - mainly eclipsing binaries (75%) and pulsating stars (17%). Pojmański (1998), based on the ASAS data estimated also that the completeness of the current variable stars catalogs is smaller than 50% for the stars brighter than 9 mag.

The results of the first stage of the ASAS project were given by Pojmański (2000). More than 140 000 stars in 50 fields covering 300 square degrees were monitored resulting in the ASAS Photometric I-band Catalog containing over 5×10^7 individual measurements. The Catalog is available on-line at the ASAS Home Page.

Search for the variable stars revealed over 350 periodic and 3500 miscellaneous variables brighter than 13 mag. Only 630 of them were known or suspected variables included in the General Catalogue of Variable Stars.

Additionally six stars included in the list of Landolt (1992) standard stars were found to be variables in the ASAS data.

The first results of the third stage of the ASAS project were recently published by Pojmański (2002). In this paper over 1.3 million stars brighter than $V = 15$ mag detected on 40 000 frames were analyzed and 3126 objects were found to be variable.

Up to now the ASAS project collected 400 000 frames.

4 Small bodies of the Solar System in the ASAS data

4.1 Asteroids

The limiting magnitude of the main ASAS instruments ranging from 13 to 16 mag is to low to allow a discovery the new asteroids from the main belt. However it is sufficient to detect and make follow-up observations of Near-Earth Objects.

According to the currently operating searches for minor bodies of the Solar System such as Spacewatch, LINEAR, NEAT, LONEOS there are few dozens of NEOs brighter than 16 mag and discovered per year. The large database of the ASAS containing over 400 000 frames is a potential source of many pre-discovery observations of these objects. The pre-discovery observations give the possibility of better determination of the orbital parameters of these bodies which is crucial information allowing to estimate the potential impact risks.

Due to the fact that majority of projects searching for NEOs work under the northern sky we hope that data of the ASAS collected continuously over the period of five years will allow us to discover some previously unknown NEOs swifting over the southern sky.

4.2 Comets

In recent years the number of comets appearing on our sky was varying from 20 to 40 per year. We have reviewed the *IAU Circulars* from years 1999-2002 looking for the notes describing the discovery of a comet. We found 137 such notes. This number does not include the discoveries made by the SOHO mission. The comets detected by SOHO are always discovered very close to the Sun and therefore are out of range of other projects and astronomy amateurs searching for comets.

Fig. 3 shows the distribution of the brightness of the comet during the discovery. The vertical solid line denotes the limiting magnitude of the ASAS narrow-field telescope. It is clearly visible that as many as 34% of comets could be discovered analyzing the ASAS images. The

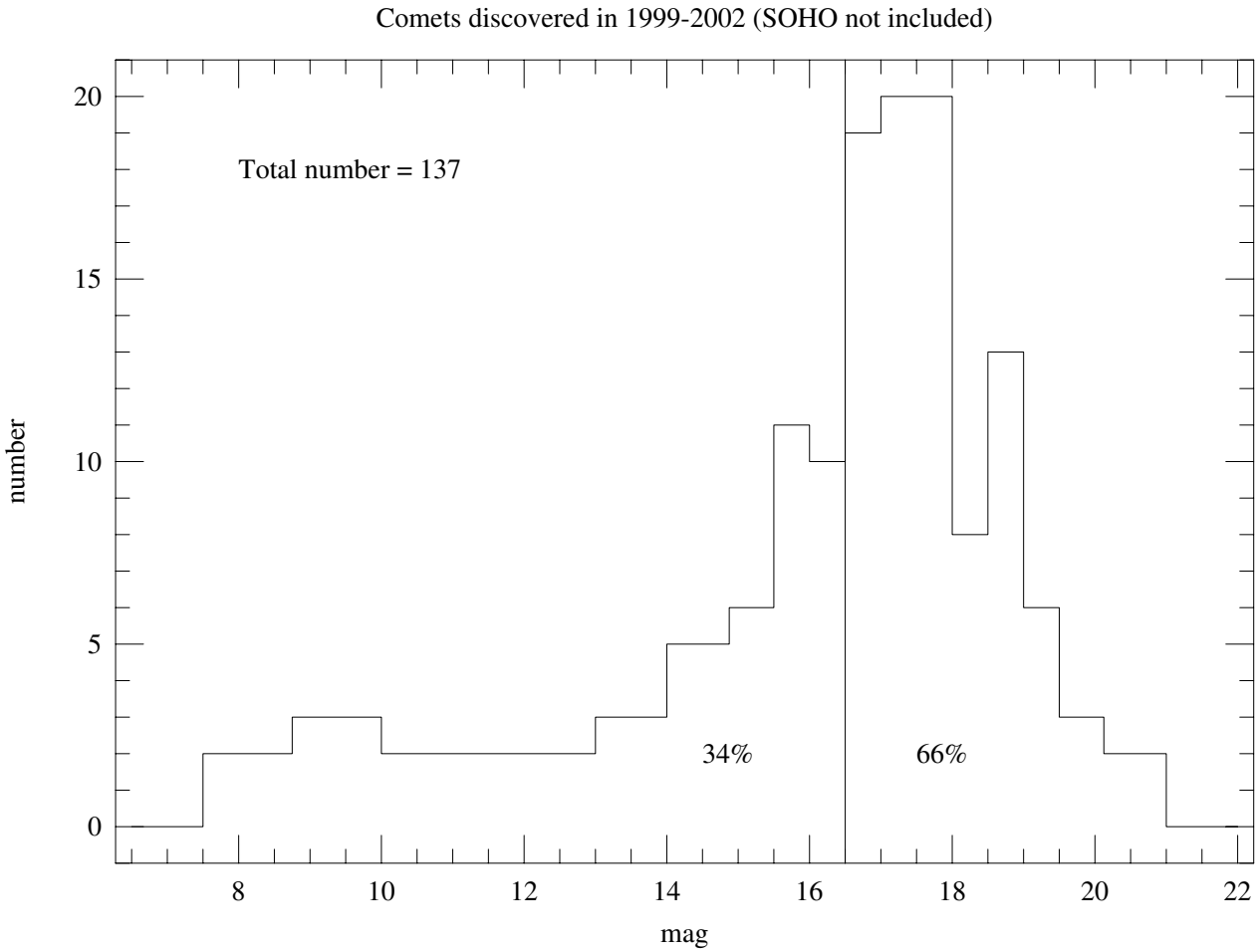

Figure 3: *The distribution of the comet brightnesses during the discovery based on the data published in IAU Circulars*

probability of a detection of a new bright comet in ASAS data is quite high taking into account two facts: at first, the field of view of the ASAS instrument is significantly larger than fields of view of the telescopes used by NEAT, LONEOS, Spacewatch, LINEAR and others and secondly the ASAS operates under the southern sky while majority of above mentioned surveys cover only the northern sky. Also the number of astronomy amateurs looking for comets is significantly higher on the northern hemisphere than on the southern one.

4.3 Meteors

The large field of view of the ASAS instruments and their reasonable limiting magnitudes give us certainty that we will be able to detect large number of meteor paths. The data collected by the ASAS have several advantages in comparison with ordinary photographic observations. First of all whole set of images is already in digital form not needing film buying, developing and scanning pictures. Additionally very-wide-field scope has field of view comparable to a typical photographic equipment but significantly higher limiting magnitude. Wide-field and narrow-field telescopes have fields of view of the same size as in telescopic meteor observations but in case of the ASAS, the detector is not a human eye but CCD chip giving significantly higher limiting magnitude and good precision in determining coordinates of meteor paths.

The only serious disadvantage of the ASAS instruments is a lack of the shutter making impossible the determination of the meteor angular velocities. In spite of this we will be still able to detect and analyze the meteors from showers with medium and high geocentric velocities. For example, in RADIANT software (Arlt 1992) we can assume all angular velocities to be of type D (i.e. fast). Taking into account that typical error of angular velocity estimate made by visual observer is around 5-8 deg/second (i.e. one class of velocity on five or six steps scale - see Koschack 1991 for detailed discussion) our assumption includes within errors the meteors from C, D and E classes i.e. with angular velocities from around 10 to 25 deg/second. The number of meteors with angular velocities from that range is significantly higher that number of meteors with 0-10 deg/second velocities giving us hope we can detect and analyze all meteor showers characterized by geocentric velocities higher than 30 km/s. According to the *IMO Working List of Meteor Showers* given by McBeath (2002) as many as 70% of meteor showers have the geocentric velocities of at least 30 km/s.

To summarize, data of the ASAS are of the same quality as meteor telescopic observations taking into account only angular velocity estimates. On the other hand, the precision of determining the beginnings and ends of meteor paths and its magnitudes is significantly higher using the ASAS data. Additionally the sample of the meteors captured on the ASAS images is free from the biases and errors typical for telescopic work such as errors in plotting and missing some fraction of the events.

One of the meteors captured during the first stage of the ASAS project is shown in Fig. 4.

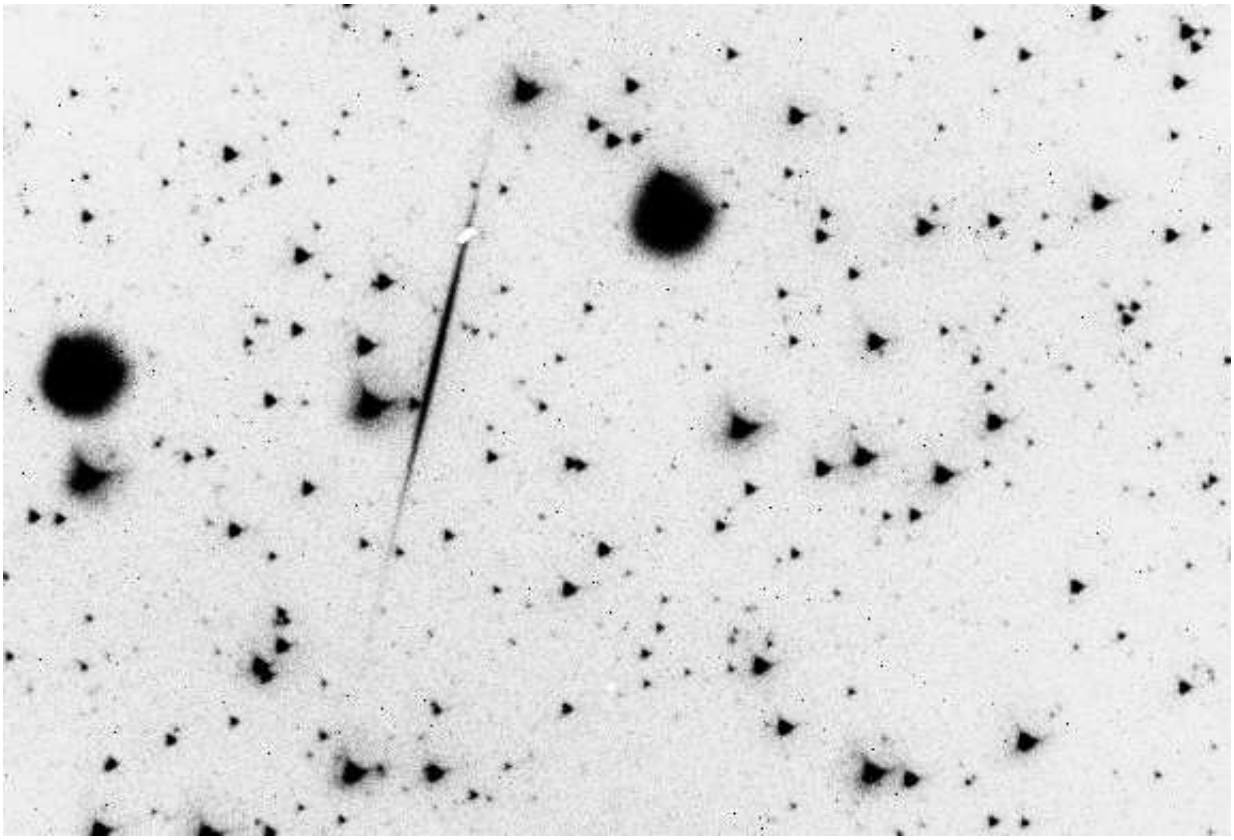

Figure 4: *One of the meteors captured during the first stage of the ASAS project*

5 Data reduction

The initial reduction of the CCD frames (subtracting BIAS, DARK and FLAT-FIELD images) will be done using the standard routines in the IRAF CCDPROC package. [1]

A further reduction will be done using a newly developed image subtraction method ISIS (Alard and Lupton 1998, Alard 2000). ISIS is based on the fast optimal image subtraction algorithm. Subtraction is done between the reference image (obtained by stacking several best seeing and low background images) and each image from the data set transformed to the coordinate grid of the reference image. Before subtraction the reference image is modified to exactly match the seeing of each image from the data set. This is done by finding the convolution kernel and difference in background levels between the reference and subtracted image. There are more details in the papers of Alard and Lupton (1998) and Alard (2000).

It was shown by Alard (1999) and Olech et al. (1999) that ISIS works very well even in very dense regions of the Galactic bulge and in the cores of the globular clusters. In the first applications ISIS produced light curves with a quality significantly better than obtained by traditional methods such as DAOPHOT and DOPHOT.

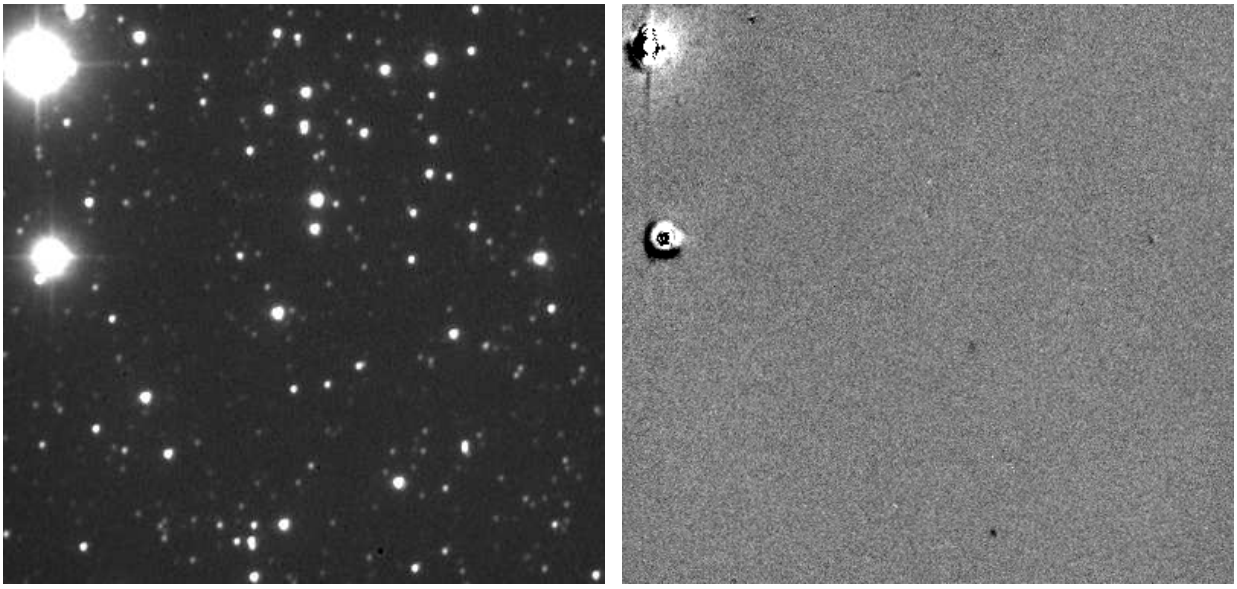

Figure 5: *Left panel: Raw image of the field placed in the Galactic planet. Right panel: Image obtained after the subtraction of the reference frame from the raw one*

A simple example of the ISIS results is shown in Fig. 5. There is a raw image of the Galactic field quite rich in stars on the left panel. On the right panel one can see the image obtained after the subtraction of the reference frame from the raw one. It is clearly visible that we can detect only residuals left after subtraction of saturated stars and few black dots which are in fact the variable stars candidates.

In case of the ASAS data the images produced by the ISIS software should contain almost no traces of constant stars and only black and white dots corresponding to variable stars,

[1] IRAF is distributed by the National Optical Astronomy Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under a cooperative agreement with the National Science Foundation.

comets and asteroids and straight lines with traces of meteors and satellites. The subtracted images always contain small number of easy detectable objects thus are ideal for looking for traces of the small bodies of the Solar System. The stellar objects such as asteroids and comets could be easy traced using for example `find` algorithm of the DAOPHOT software (Stetson 1987) and straight lines we could detect using the Hough transform (Trayner et al 1998).

Additionally it is also easy to determine the equatorial coordinates of all detected objects because whole set of images is transformed onto the common coordinate grid and we should only once find the conversion from (x, y) to (α, δ) plane.

6 Expected results

We are going to publish the orbital elements of newly discovered comets and Near-Earth asteroids and also submit our observations of minor bodies of the Solar System to *Minor Planet Center* allowing the better determination of their orbits.

We would also like to publish the catalogue of recorded meteor paths and magnitudes and analyze the activity and radiant distribution of the meteor showers from the southern hemisphere.

The automated software for detection of the comets, asteroids and meteors paths we will make available to other projects such as ASAS and Optical Gravitational Lensing Experiment (OGLE).

Acknowledgments

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On the existence of the September Taurid shower

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An analysis of paths of 1906 meteors observed in the middle of September 1996-2000 during almost 400 hours collected by Polish *Comets and Meteors Workshop (CMW)* shows no trace of September Taurids activity. The maps computed by RADIANT and COMZHR software show existence of δ-Aurigids and α-Triangulids radiants but no signature of September Taurids. Also the ZHR profile computed using the radiant position given in [1] shows only scatter at the level of ZHR ≈ 1 with no clear enhancement around predicted maximum of the activity of the shower.

1. Introduction

Recently S.J. O'Meara [1] reported a discovery of new meteor shower. In the middle of 2001 September he observed quite fast meteors radiating from area around $\alpha = 61^\circ$ and $\delta = +22^\circ$.

This shower, called September Taurids, attracted attention of two Bulgarian observers who during the night of 2002 September 14/15 witnessed its quite strong activity. Among 35 plotted meteors as many as 9 seemed to radiate from the radiant at $\alpha = 61^\circ$ and $\delta = +21^\circ$ [2].

Both these investigations derived similar parameters of the stream independently, suggesting that the September Taurid shower indeed exits. On the other hand, small number of observed meteors, small number of analyzed observations and vicinity of large radiants of sporadic meteors connected with northern and southern branches of the apex source made this discovery questionable.

We decided to verify the results described in [1] and [2] using the data from the *Polish Visual Meteor Database (PVMDB)* [3]. Beside of the already published data from 1996-1998 we used also unpublished entries from interval 1999-2000 [4].

2. Observations

We investigated the behavior of the September Taurids in period September 5-25. There are 397.56 hours of effective time of observation and 1906 meteors recorded in *PVMDB* in years 1996-2000 for this interval. These observations were collected by 25 observers whose names with effective times of their observation are listed below:

> Paweł Brewczak (2.00), Dariusz Dorosz (32.66), Ewa Dygos (31.10), Jarosław Dygos (40.92), Tomasz Fajfer (76.50), Izabela Fitoł (5.00), Michał Jurek (6.84), Maciej Kwinta (21.83), Mariusz Lemiecha (16.00), Krzysztof Mularczyk (37.00), Jarosław Nocoń (6.22), Arkadiusz Olech (8.50), Dorota Pietruszko (3.41), Łukasz Pospieszny (1.00), Karolina Pyrek (23.00), Andrzej Skoczewski (14.76), Krzysztof Socha (13.63), Dominik Stelmach (5.68), Piotr Szakacz (6.43), Konrad Szaruga (11.24), Paweł Trybus (5.32), Mariusz Wiśniewski (6.94), Albert Witczak (18.08), Luiza Wojciechowska (2.00), Krzysztof Wtorek (1.50)

Basing of this material we obtained 410 hourly rate estimates.

3. Radiant

All meteors from the *PVMDB* were transformed into the `DBF` format and then analyzed using the RADIANT software [4]. This software takes into account the properties of the observed meteors such as angular velocities and coordinates of the beginning and the end of the meteor path and computes the maps of probability for the presence of a radiant (hereafter PPR maps).

We have chosen the maps centered at the radiant of September Taurids and having the size $60^\circ \times 60^\circ$ with resolution of 50×50 pixels. The angular velocity of the meteors taken into consideration was in range $1 - 30^\circ$/s. We have analyzed only these meteors with distance from the center of the map smaller than 90°. The PPR maps were computed for geocentric velocity

from 30 to 55 km/s with step equal to 5 km/s and for solar longitude $\lambda_\odot = 172°$ corresponding approximately to September 15. Daily drift of the radiant was assumed to be $\Delta\lambda = 1.0°$.

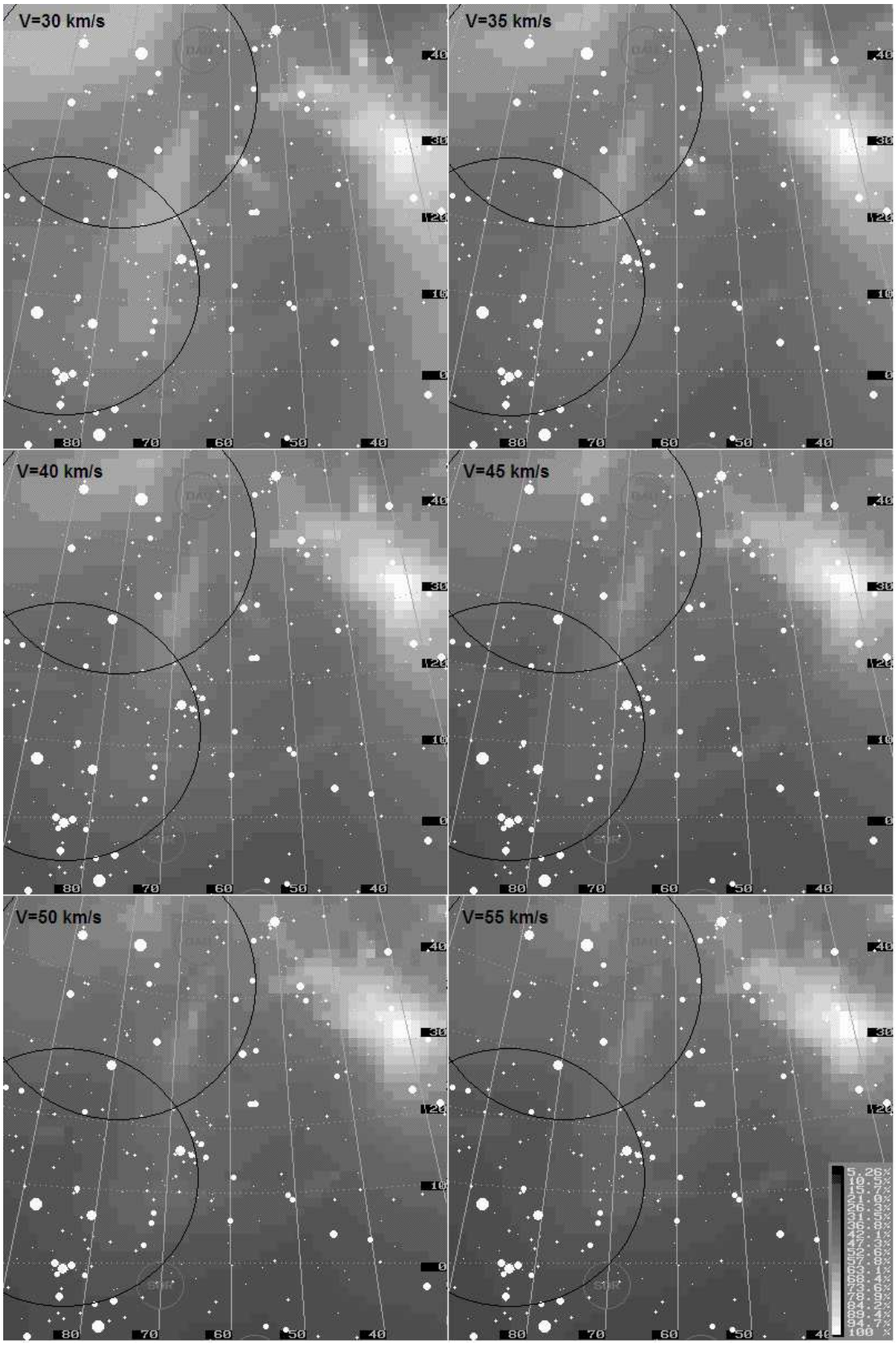

Figure 1 – PPR maps for a sample of 1906 meteor observed around September 15 in years 1996-2000. All maps are computed for the following parameters: $\lambda_\odot = 172°$, $\Delta\lambda = 1.0°$. The maximum distance of the meteor from the radiant is 90°.

The results are presented in Fig. 1 where we show PPR maps for different geocentric velocities. All maps show the position of the other radiants active around September 15 i.e. δ-Aurigids and σ-Orionids.

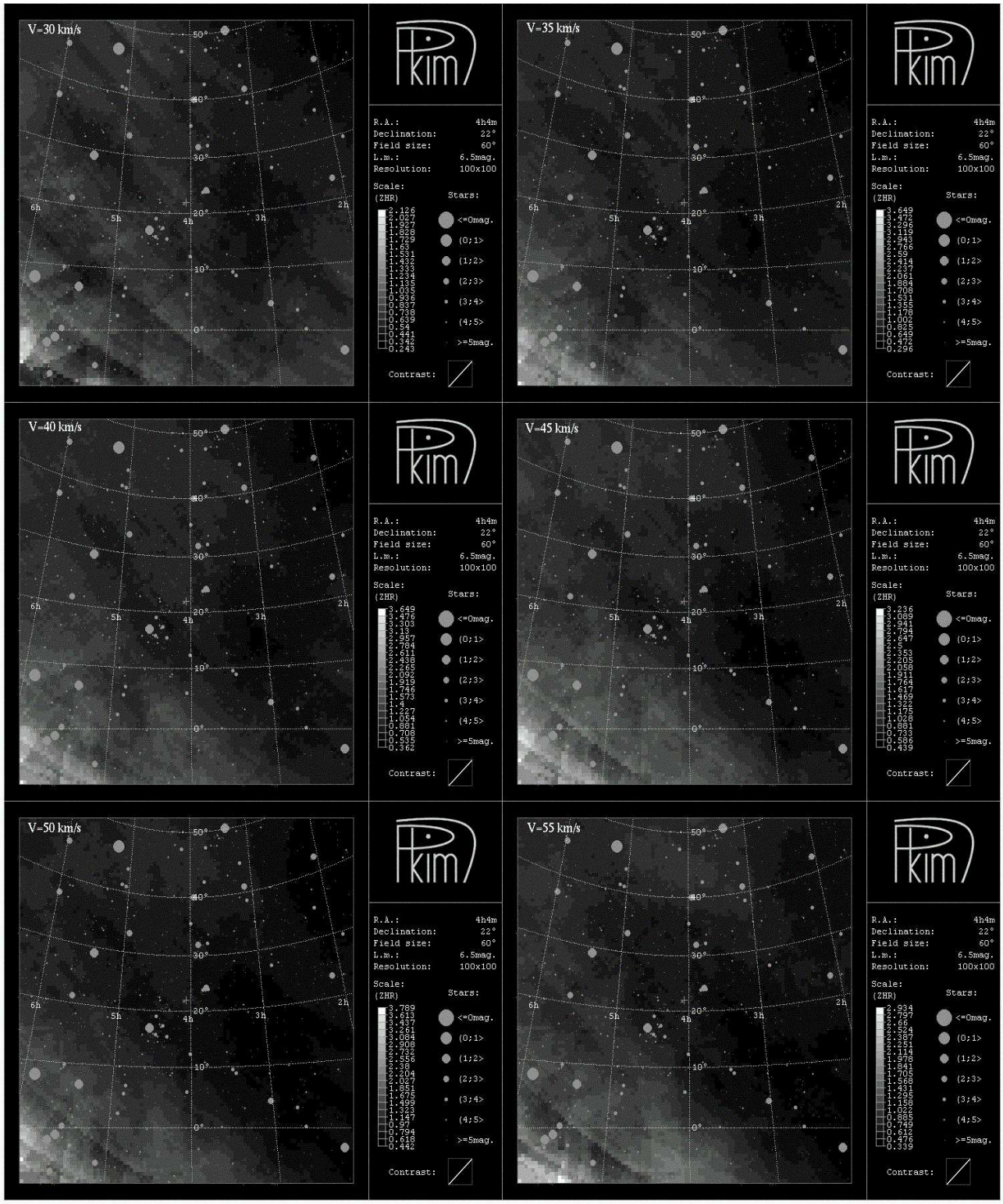

Figure 2 – ZHR maps for a sample of 1906 meteor observed around September 15 in years 1996-2000. All maps are computed for the following parameters: moment of the maximum $\lambda_\odot = 172°$, daily drift $\Delta\lambda = 1.0°$.

Since the 1950s we know that sporadic meteor radiants are not distributed uniformly over the celestial sphere, but they are concentrated in particular regions which are similar to radiants with radii around 20° and positions approximately fixed relative to the Sun. The first three sources associated with the ecliptic plane were discovered by Hawkins [5]. According to the latest papers [6,7,8] we now identify six such sources. They are antihelion, helion, northern and southern toroidal centers and also the northern and southern apex. In this work we focus only on apex sources due to the fact that they are relatively close to the suggested position of the September Taurid radiant.

In Fig. 1 northern and southern apex sources are denoted by open circles with radius 20°.

The highest PPR is observed in the border line between Aries and Triangulum constellations and it can be connected with the activity of the α-Triangulid shower [9,10]. One can also detect weak signature of δ-Aurigid radiant, slightly shifted most probably due to the influence of the northern apex source.

There is no signature of any radiant close to the center of the map where we expect to find the radiant of September Taurids.

Recently Olech & Jurek [11] introduced a new ComZHR software which for a given geocentric velocity, computes maps of mean Zenithal Hourly Rates (ZHRs) averaged over a given time interval. The pixels of this map where true radiants exist should have high mean ZHRs comparing to others, making the detection of new showers possible.

We decided to use the ComZHR for looking for the September Taurid radiant. The maps we computed have the same parameters as in case of the analysis performed using the RADIANT software. Only the resolution was increased to 100×100 pixels. The pixel was considered for analysis only when its altitude during the time of observation was over 20°.

The results obtained using the ComZHR software are shown in Fig. 2.

This time the strongest signature of the radiant is observed in the Orion constellation. It can be combination of two factors: activity of the Southern Apex and high ZHRs produced by low elevation of this part of the map during September nights. Additionally, on all ComZHR maps one can see the same pattern with higher ZHRs at left part of each map. These higher ZHRs are most probably connected with activity of both apex sources.

There is a weak signature of the radiant at the center of the map but its weakness does not allow us to derive any valuable conclusions about its connection with September Taurids.

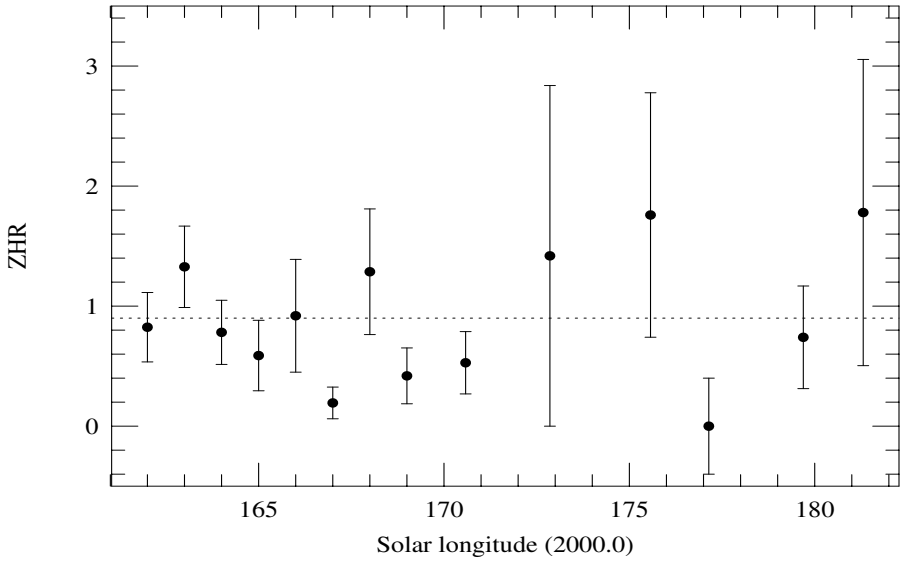

Figure 3 – The activity profile of September Taurids resulting from the *CMW* data. Dotted line denotes mean ZHR value for all points in the graph.

4. Activity profile

Knowing the position of the radiant of September Taurids given in [1,2] we can compute the activity profile of the shower. We assumed that the geocentric velocity and population index r are equal to 40 km/s and 2.6, respectively. The resulting activity profile for September Taurid shower for the period September 5-25 is shown in Fig. 3. There is no any clear trend visible on this graph and one can see only scatter around the mean value of ZHR ≈ 1. The lack of the enhancement of the ZHRs around predicted time of the maximum ($\lambda_\odot \approx 172°$) is another argument for non existence of the September Taurids.

5. Conclusions

Our analysis of paths of 1906 meteors observed in the middle of September 1996-2000 during almost 400 hours collected by Polish *Comets and Meteors Workshop* shows no trace of September Taurids activity. The maps computed by RADIANT and ComZHR software show existence of δ-Aurigids and α-Triangulids radiants but no signature of September Taurids. Also the ZHR profile computed using the radiant position given in [1,2] shows only scatter at the level of ZHR ≈ 1 with no clear enhancement around predicted maximum of the activity of the shower.

Thus we conclude that presently available observational data does not give any proof for the existence of the September Taurid shower. The conclusions about its presence described in [1] and [2] were based on the very modest observational material and were, in our opinion, to eager.

Acknowledgments

I would like to thank to Konrad Szaruga and Michał Jurek for their big effort with inputing the 1999-2000 data.

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Radio observations

First results of radio observations by CMW: the 2003 Perseids

Kamil Złoczewski [1] *and Kamil Szewc* [2]

The first results of radio meteor observations made by the Polish Comets and Meteors Workshop (CMW) using the forward scatter technique are presented. Full coverage of the 2003 Perseid maximum showed a peak around $\lambda_\odot = 139\overset{\circ}{.}87$.

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1 Introduction

The aim of forward scatter radio observations is the recording of meteor phenomena by receiving the signal of a distant radio station (about 500 – 2000 km from the receiver). Normally it is impossible to receive it directly due to the curvature of the Earth. When meteoroid matter burns it ionizes the surrounding atmosphere. This allows it to reflect the signal from the radio station (at a frequency in the range 40–180 MHz) so it can be detected by the receiver. The first long-term CMW observations using forward scatter were made during the 2003 Perseid maximum at Rybnik Kamień ($\varphi = 18°36'$ E, $\delta = 50°08'$ N).

2 Equipment description

We decided to make observations in the VHF sound broadcast band (87.5–108 MHz) using a 3-element Yagi antenna connected by co-axial cable a to car digital tuner. The antenna and receiver were situated far away from each other to avoid interference. An eight-bit analogue-to-digital converter (ADC) was made by ourselves to feed the computer with the radio signal. We used a Pentium 200 MHz, 16 MB RAM computer with about 500 MB of hard disk space. This can be seen in Figure 1.

In our first attempt at forward scatter we decided to make only counting observations. We used free software Meteor v8.2 a written by Pierre Terrier and available via the Internet (`http://radio.meteor.free.fr`).

3 Results of 2003 Perseid peak observations

The equipment preparations were finished a day before main Perseid peak. First we had to find an appropriate frequency to detect meteor signals. We found a free channel at about 103.3 MHz, with the antenna directed south, at which we could detect meteor phenomena but with no direct reception of any radio station from the Czech Republic.

We started our observations on 2003 August 12 at 20:00 UT and covered the whole Perseid maximum. Continuous observations were continued until August 21 to reduce daily variations in meteor activity (see Figure 2). We corrected the Perseid peak using those data and took into account the radiant elevation using the formula given by (Ogawa, 2002) (Figure 3).

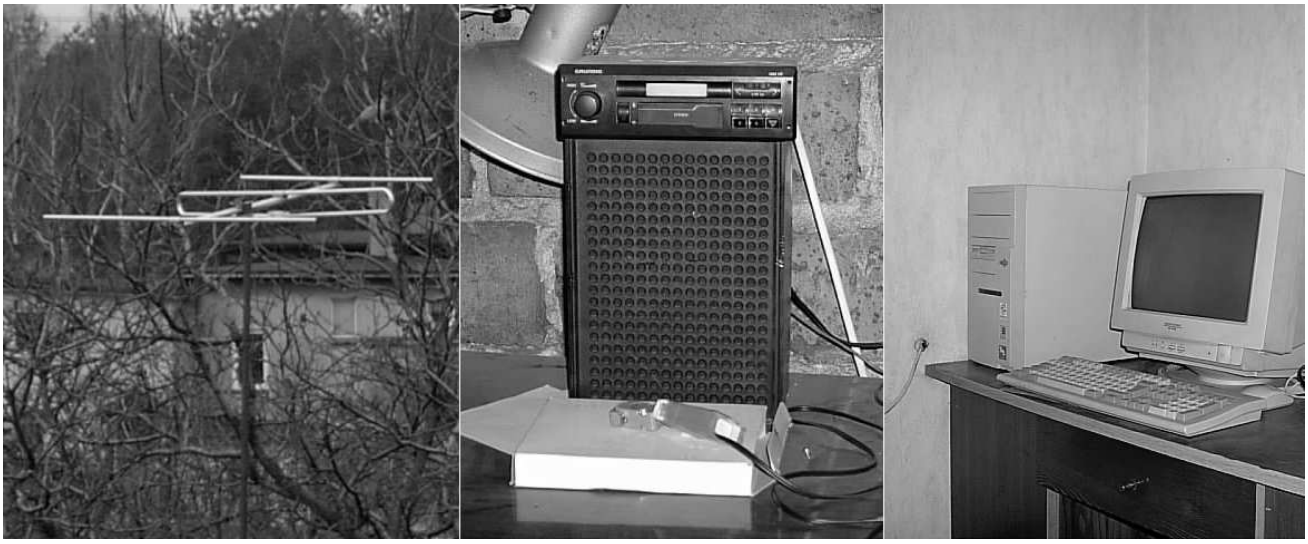

Figure 1 – Equipment used, left to right: antenna, receiver with ADC below and computer.

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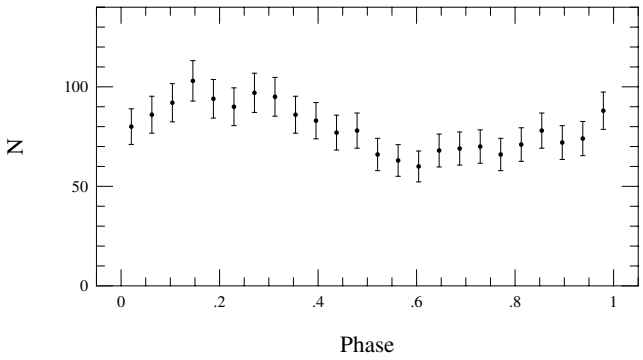

Figure 2 – Average number N of meteor echoes throughout the day, observed between 2003 August 13 and 21. Phases 0.0 and 1.0 correspond to $00^{\mathrm{h}}00^{\mathrm{m}}$ UT, 0.5 to $12^{\mathrm{h}}00^{\mathrm{m}}$ UT.

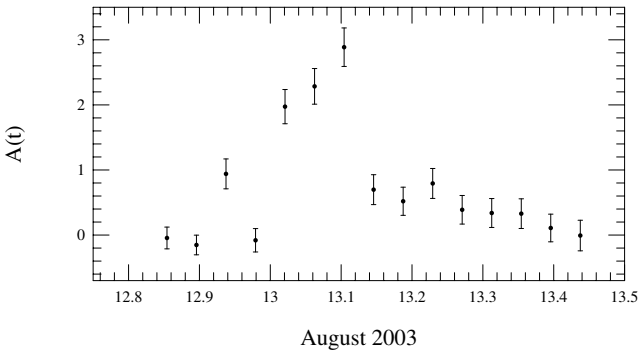

Figure 3 – Radio activity function **A(t)** during the Perseid maximum.

Esko Lyytinen predicted that the 2003 Perseid peak would be between $\lambda_{\odot} = 139\overset{\circ}{.}81$ and $139\overset{\circ}{.}82$ (`http://groups.yahoo.com/group/imo-news/message/1202`). We detected higher activity at $\lambda_{\odot} = 139\overset{\circ}{.}87 \pm 0\overset{\circ}{.}04$, which is about 1.5 hours after the predictions.

Acknowledgments

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