The 1998 June Bootid Outburst Observed in Bulgaria

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Abstract

A brief review of June Bootid observations carried out by the Astroclub *Canopus*, Varna, Bulgaria, during the last 23 years is given. Visual and photographic data about the complex radiant structure of the shower are discussed. The results of the observed activity outburst on June 27-28 are presented including a ZHR profile and data about the change of the population index during the same night.

1 History

The June Bootids are a relatively young stream generated by Comet Pons-Winnecke. The comet was first discovered by Pons in 1819 and rediscovered by Winnecke in 1852. At the comet's aphelion passages its motion is systematically disturbed by the planet Jupiter due to the comet's short orbital period (5.9 years) and the small inclination of only 18°. This leads to significant changes of its orbital elements.

The first records of meteor shower activity related to 7P/Pons-Winnecke date from 1916 when its ascending node came as close as 6000 000 km to the Earth's orbit. On June 28, 1916 Denning registered hourly rates between 32 and 100, while American observers reported an activity comparable with the sporadic background level in the same night (Roggemans 1987). The probable explanation is that most of the meteor particles were concentrated in a narrow filament, crossed by the Earth in only about 6 hours, which is very typical for the young streams. This concept is confirmed also by the fact that in 1921, when Japanese observers saw a powerful shower of faint meteors, no activity was observed in Europe and America.

According to Russian data, an impressive appearance was seen in 1921, too (Abalakin 1981). Russian observations (Astapovitch) of 1927 show that the time of the maximum had shifted from solar longitude 98° to 104°1. The hourly rate reached the value of 300 for that year and remained still high in the next 1928. In 1930 the radiant already dissipated into a number of subradiants scattered in a large region of the sky. From 1933 on, the hourly rate decreased and the activity period experienced great changes. In 1944 also according to Russian data, the time of the maximum had shifted to June 13 and single subradiants were spread over an area of approximately 20° diameter (Abalakin 1981).

There is no information about any later appearances of the June Bootids in the literature. In the Handbook for Visual Meteor Observations (Roggemans 1987) it is mentioned that: "Currently the Pons-Winneckid meteor stream is lost to observers on the Earth. We do not know whether or not planetary perturbations will ever restore the favorable conditions of 1916, but it gives rise to some imagination: Who knows how many cometary meteor showers exist in the Solar System which do not even meet the Earth!" In the *IMO* list of the meteor showers the June Bootids are not included at all.

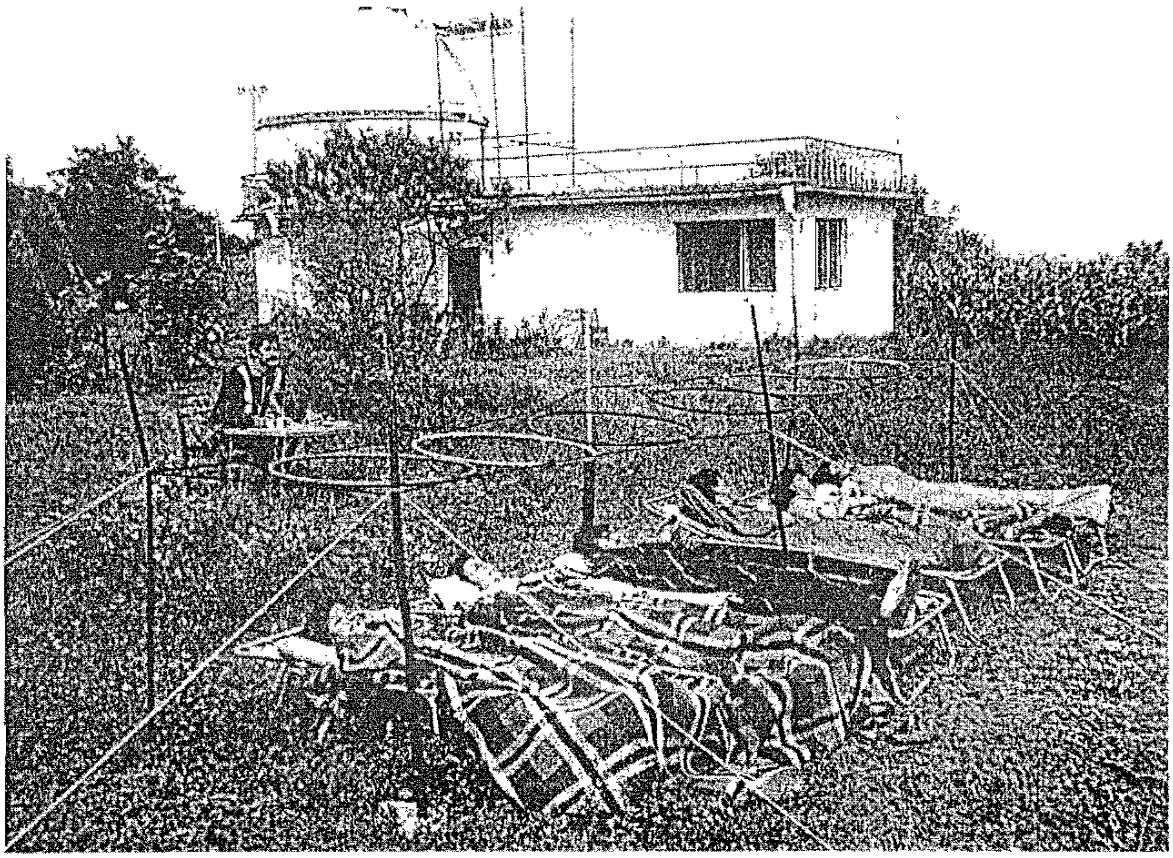


Figure 1: *The ring method.*

2 Observations in the Astroclub *Canopus*

The June Bootids are an important shower in our club's observing program. Its activity period, conveniently timed at the end of the school year, allows many of our members — mostly 14–19-year old students — to take part in the expeditions devoted to the shower. Unfortunately a great part of the data has been lost during the years and in some cases the only sources of information are the reports prepared for our national amateur astronomical conferences organized annually since 1975. There are also a lot fragmentary and incomplete raw data. On the basis of the observing material we have, we can get some information about the shower activity and the radiant positions during the past 23 years of our observations.

2.1 Activity

Until 1991 we used the Russian observing method. This makes it difficult to compare our older data with those obtained by the standard *IMO* method we adopted later. The Russian method implies group observations over a certain sky region with a diameter of 60°. It is limited by a special ring hanging over each observer in the group (Figure 1). Only the meteors appearing in the limited area are counted, all others are ignored. A secretary notes down the data of all observers. The ZHR is computed by the number of the physically different observed meteors and correction factors for cloudiness, zenithal distance of the radiant and limiting magnitude (the mean limiting magnitude for all observers). So a group ZHR is calculated

much like the individual ZHR in the *IMO* method, but the whole group is considered a single observer, having a higher perception coefficient than anyone of the members of the group. That is why the group ZHR values, obtained in the above mentioned way, are always higher than the individual ones.

Using the numbers of meteors seen by one, two, three or more observers, the group perception coefficient for different magnitude classes are determined. Based on them a corrected group magnitude distribution is created and the population index r is calculated. Then taking into account the geocentric velocity of the stream and the atmospheric area, covered by the 60° field of view corresponding to the height at which the meteors become visible, the spatial density and the mean distance between the meteor flux are calculated.

The first June Bootid observations in Astroclub *Canopus* were carried out in 1976. Having in mind that the parent comet's perihelion passage occurred in the same year, it can be said that the activity was quite low. The group ZHR was about 9 for the night of June 26-27 (Astroclub Canopus 1977).

The next year of June Bootid observations was 1979. In the nights of June 26-27 and 27-28 for a total effective time of 6 hours 57 meteors were recorded and 10 of them were June Bootids. The hourly rates were HR = 2.2 for the June Bootids and HR = 9.4 for the sporadic meteors. A mean distance between the meteor particles of 620 km was calculated (Astroclub Canopus 1980).

The June Bootid observations of 1981 were lost. The only information left is that a fireball of magnitude −8 was seen, probably belonging to the shower. It was slow and changed its colour from red to bluish.

In 1984 observations only for determining the radiant positions were carried out.

In 1986 during the night of June 27-28 for $T_{\rm eff} = 2^{\rm h}37$ and average Lm = +5.5, a group of 8 observers recorded 5 June Bootids and 21 sporadic meteors in the 60° field. This would give a ZHR of 9.4 for the June Bootids and 26 for the sporadic meteors. A possible explanation for the unlikely high sporadic ZHR value could be that due to their lack of experience, the observers underestimated their limting magnitude and also that they did not classify some June Bootids as shower meteors because of the greatly scattered radiant area. In the night of June 29-30 for $T_{\rm eff} = 2^{\rm h}23$ and Lm = +5.0 the group saw 8 June Bootids and 9 sporadic meteors which would result in a ZHR = 32.5 (!) for the June Bootids and 12.1 for the sporadic meteors, but these are obviously unreliable values.

In 1987 the shower was watched by a group of 6 observers. During the whole period from 25 June to 1 July only one June Bootid was seen. It appeared in the night of June 26-27 when the limiting magnitude was +6.1 and the effective observing time was 3 h.

1989 was much more favorable. In the period between June 25 and July 1 for a total $T_{\rm eff} = 10^{\rm h}75$ in the 60° field 203 meteors were recorded, 32 of them originating from various June Bootid subradiants.

In 1995 observations were carried out between June 30 and July 3. No June Bootids were seen. In 1997 during the night of June 28-29 for $T_{\rm eff} = 0^{\rm h}8$ and Lm = +6.15 two probably June Bootids were recorded. This gives ZHR = 5.2. The ZHR of the sporadic meteors was 9.2.

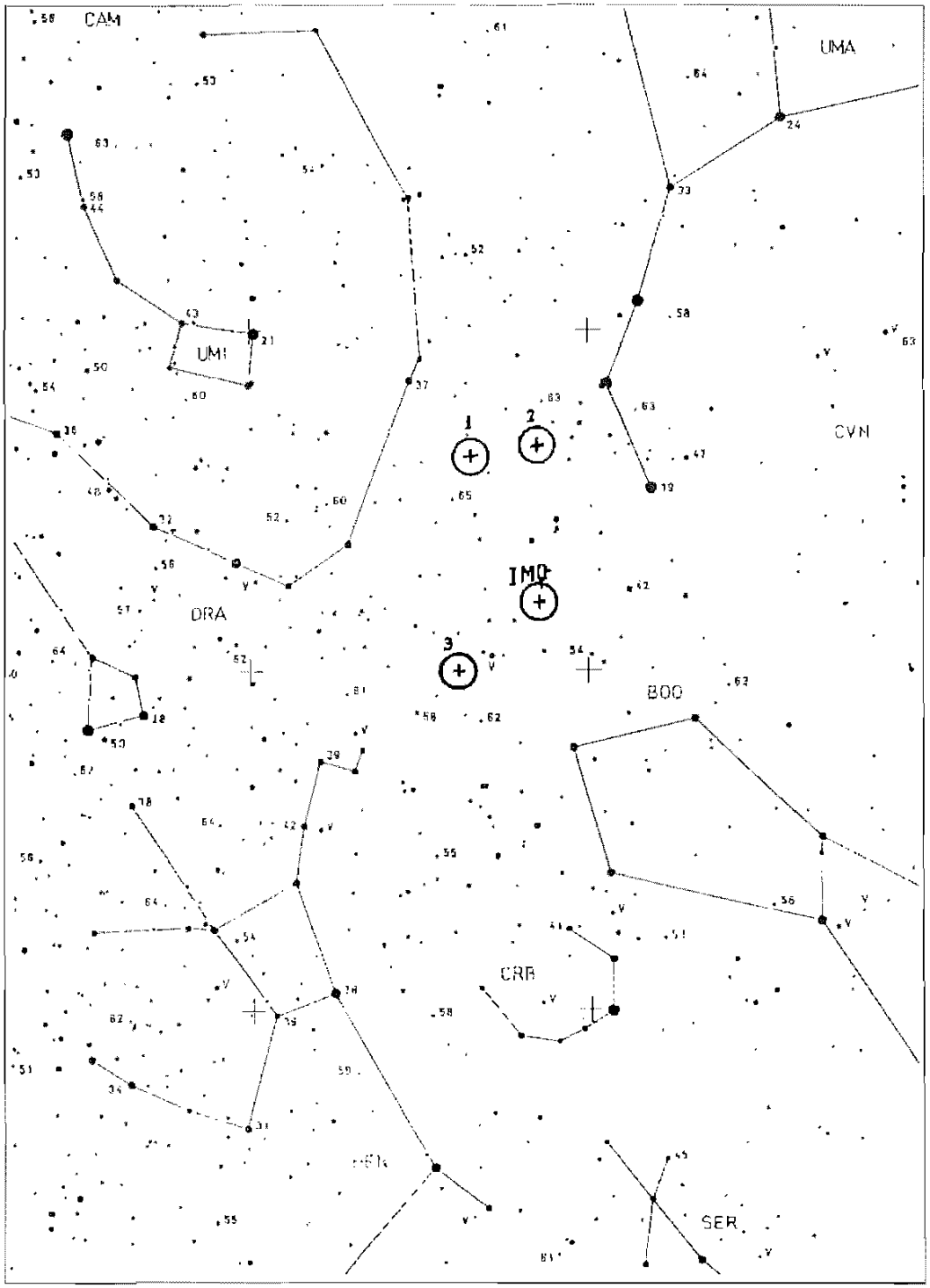


Figure 2: *Radiants derived from past events.*

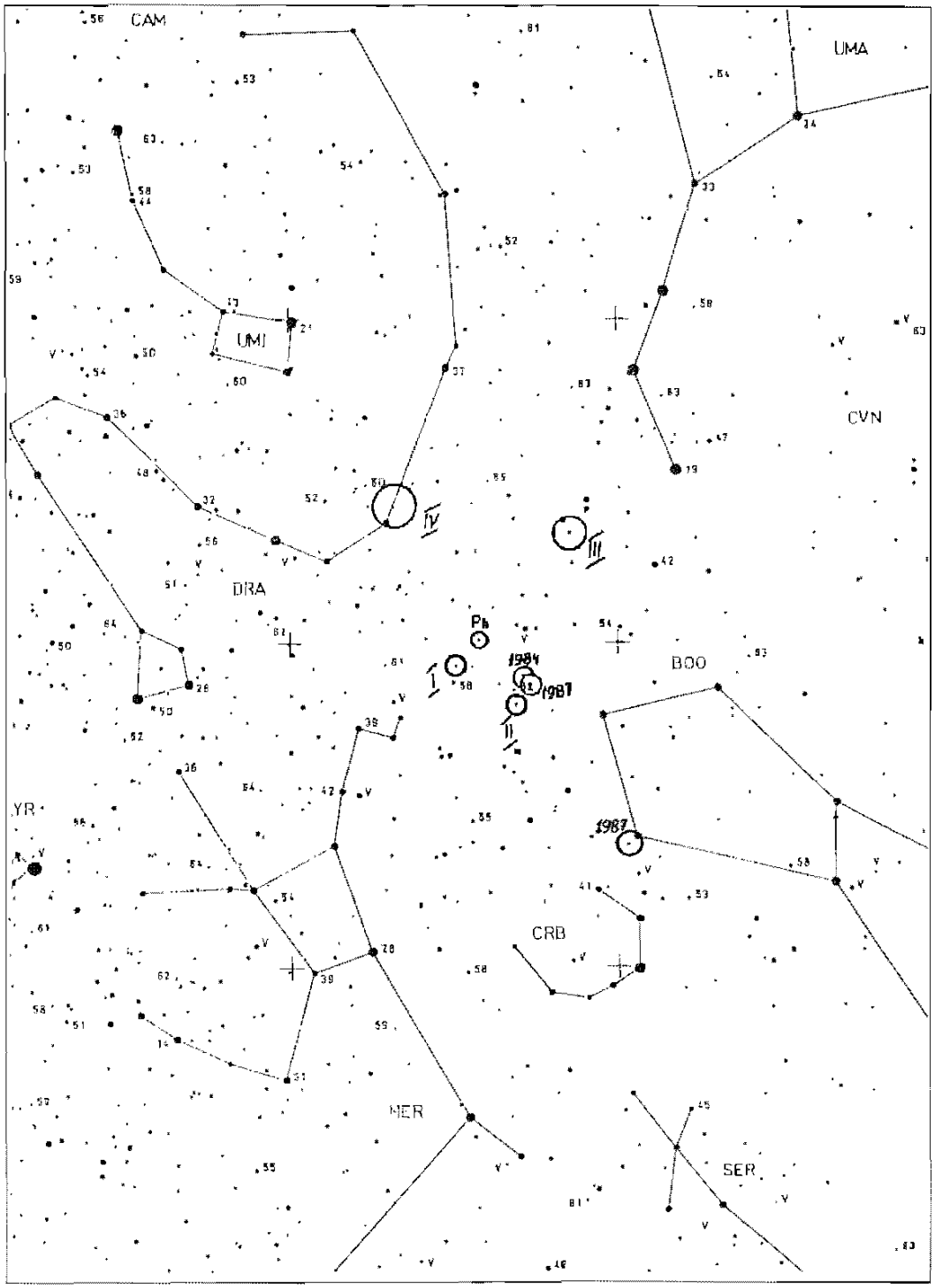


Figure 3: *Radiants derived in 1998.*

2.2 Radiant positions

There is no unified view about the position of the June Bootid radiant and even about the shower's name. A great part of the observers call it June Draconids. In the Handbook for Visual Meteor Observation the following radiant coordinates are given: $\alpha = 219^\circ$, $\delta = 49^\circ$ (Figure 2). In the Invariable Part of the Russian Astronomical Calendar (Abalakin 1981) three different positions are specified, which could be related to the shower. The first is in the table of the major meteor showers: $\alpha = 212^\circ$, $\delta = 58^\circ$ with an activity period June 27–30, maximum on June 27 and $V_g = 19$ km/s. The second is in the catalogue of the comet radiants, with coordinates $\alpha = 208^\circ.5$, $\delta = 55^\circ.5$, active on July 1 and related to a comet mentioned as 1909 II. The third position can be found in the list of the photographic radiants of the minor showers and has coordinates $\alpha = 229^\circ$, $\delta = 48^\circ$, activity period June 13–July 3 and $V_g = 18$ km/s. It can be supposed that due to the continuous gravitational influence of Jupiter causing frequent changes of the orbital elements, single subradiants spread over a large area have formed. In the different years different subradiants were active and so the contradictory data about the radiant position appear. The discrepancies are additionally increased because of the low geocentric velocity of the shower which makes the zenith attraction very strong and leads to great shifts in the apparent radiant positions for different radiant elevations.

Our data from various years confirm the existing of a multitude of scattered subradiants.

During the observing campaign in 1979 the meteors were only counted but the author, for whom it was the first meteor expedition, remembers the comments of the experienced observers sharing their impression that the radiant have been shifted from its catalogue position in the direction of the Corona Borealis.

For 1984 only the author's plotting data exist. A radiant position was determined with coordinates $\alpha = 228^\circ.8$, $\delta = 44^\circ.8$ (Velkov 1990), which is close to the subradiant obtained by us in 1998 and denoted as centre II (Fig. 3). Single meteors may be originate from the subradiants III and IV, whose position were determined in 1998, located near the stars θ Bootis and ι Draconis. Based on the data of 1984 another subradiant is also suspected with $\alpha = 229^\circ.2$, $\delta = 33^\circ.2$ near the star δ Bootis.

In 1987 again subradiants with positions close to 1998's centres II, III, IV were active and non of them was noticed to dominate over the others (Velkov 1990).

During the June Bootid observing campaign in 1989 only the counting method was used and no radiant positions were determined.

Since 1989 the shower's activity was very low. The number of the observed meteors was quite small to make possible the obtaining of a radiant position. In 1997 for example, only two June Bootids were seen.

3 The observations in 1998

3.1 Visual data

In 1998 we organized our traditional June Bootid expedition in Avren village from July 26 to 29. The majority of the participants — more than 20 people — were inexperienced, for

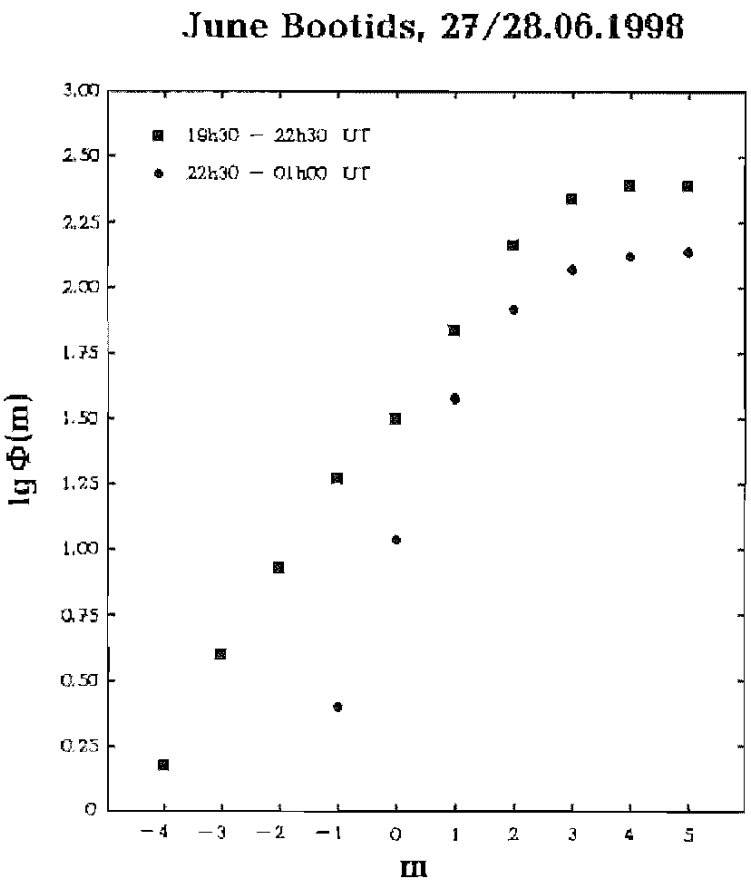


Figure 4: *Magnitude distributions of the 1998 June Bootids*

most of them these were their first observations and their data can not be representative. In the same time another group of absolute beginners watched meteors in the National Astronomical Observatory, Rozhen. They were led by a colleague of ours who was engaged in a scientific programme completely different from meteor observations. Fortunately some photographic observations were carried out.

During the night of June 26-27 the June Bootids did not show up among the other active minor showers: Sagittarids, α-Cygnids, α-Lyrids, the first Perseids, whose radiant was near α Andromedae, and the sporadic meteors. The ZHR of the June Bootids for this night varies between 1.1 and 6.3, and the average for the whole night is 3.7.

In the second night we went out early, still at dusk, so that we could observe the Corvid meteor shower (Abalakin 1981), whose maximum should have to occur on June 27 according to the literature. It should have to be observed very early in the evening only for one hour before the setting of the radiant. We even had to give up watching the football match Brazil–Chile but the sacrifice was worthwhile!

Already when the sky was still too light for observing, we were impressed by the appearance of a great number of bright June Bootids. It was at 19^h00^m–19^h15^m UT. Installing the cameras and the light sky prevented us from serious observations until 19^h35^m UT. Two of the four experienced observers taking part in the expedition (Eva Bojurova and Katya Koleva) plotted all seen meteors. The other two — Lina Rashkova and the author — just noted down the characteristics of the most meteors and plotted only some of them. Unfortunately nobody was prepared with paper rolls for blind writing and so we had some dead time, although it was significantly shorter than the time used for plotting. The shower kept showing a high

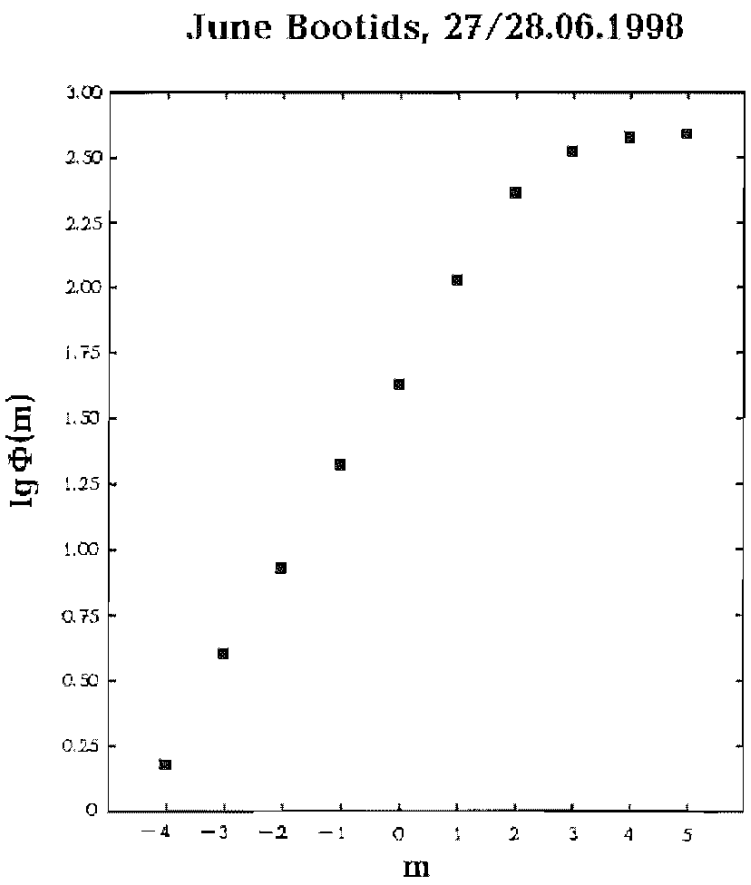


Figure 5: *Total Magnitude distribution of the 1998 June Bootids.*

activity during the whole night. There were temporary peaks and drops but as a whole the activity tended to decrease (Figure 4). Our impression was that the deal of the bright meteors was greater in the first part of the night when the ZHR values were higher too. This can be seen also in the magnitude distributions for the two intervals into which we divided our observing time (Figure 5).

For the first interval from 19^h30^m UT to 22^h30^m UT the mean magnitude of the total number of 248 meteors, seen by four observers, is +2.02. Using the magnitude classes from magnitude −2 to +2 of the collective magnitude distribution, which include 144 meteors, the population index was calculated and it is $r = 2.01$. The brightest among these June Bootids is of −4.

For the second interval between 22^h30^m UT and 01^h00^m UT the average June Bootid magnitude is +2.23 and their number is only 83. The brightest shower meteor is of −1. The population index, calculated using the magnitude classes from 0 to +2, is $r = 2.85$! This is not quite a reliable value, however, since it is computed on the basis of only three magnitude classes. Nevertheless, we still can say that the value of r for the second interval is definitely higher than in the first interval, although we can not found out how great its increase is exactly. Probably there is a quick change of the June Bootid population index around their maximum much like in the case of the Geminids.

For the whole night, based on the magnitude distribution of 387 June Bootids, we get a value of the population index $r = 2.27$ (Figure 6). To calculate it the magnitude classes from −2 to +2, including 228 meteors, are used. The mean limiting magnitude of the observers for that night was roughly +6.1. In such sky conditions the perception coefficient for the magnitude +2 class is about 80%. Taking this into account it can be supposed that the real

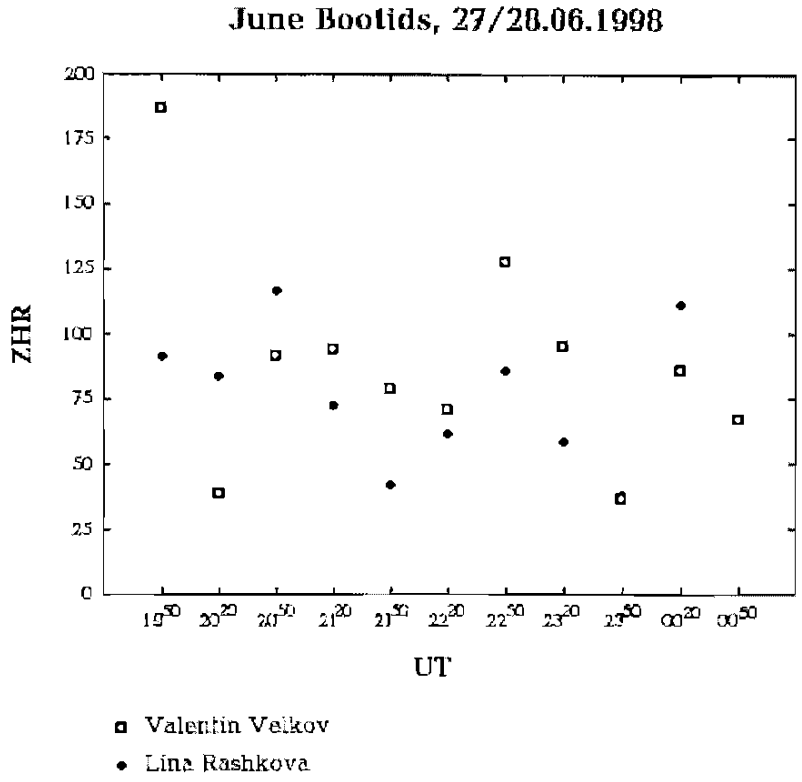


Figure 6: *Individual ZHR values of the 1998 June Bootids.*

value of r is somewhat higher but perhaps not more than 2.4.

As it is already known the Japanese observers were the first who saw the June Bootid outburst. It we assume they observed till 14^h00^m UT, taking into account that they recorded hourly rates close too the ones we got for the beginning of our observing night, our suggestion is that the actual maximum should have been in the interval between 14^h00^m and 19^h00^m UT, around solar longitude 95°.85. That is why if there are some observing data from Central Asia, Russia or China, they would be of great importance.

Data from observers in Jordan would be very valuable as well, since this is one hour to the East of Eastern Europe in longitude.

As a result of the graphical analysis of our data, several subradiants were distinguished. They

Table 1: *Visual characteristics of the photographic meteors*

No.	Time (UT)	M_v	ω [°/s]	Train	Color	Site
1	20^h38^m	−0.5	1.5	+	orange	Avren
2	21^h27^m	+0.5	/	+	/	Avren
3	21^h28^m	−1	/	+	/	Avren
4	22^h04^m	−0.5	2	+	/	Avren
5	22^h08^m	−1	2	+	/	Avren
6	21^h33^m –21^h53^m	?	?	?	?	Rozhen

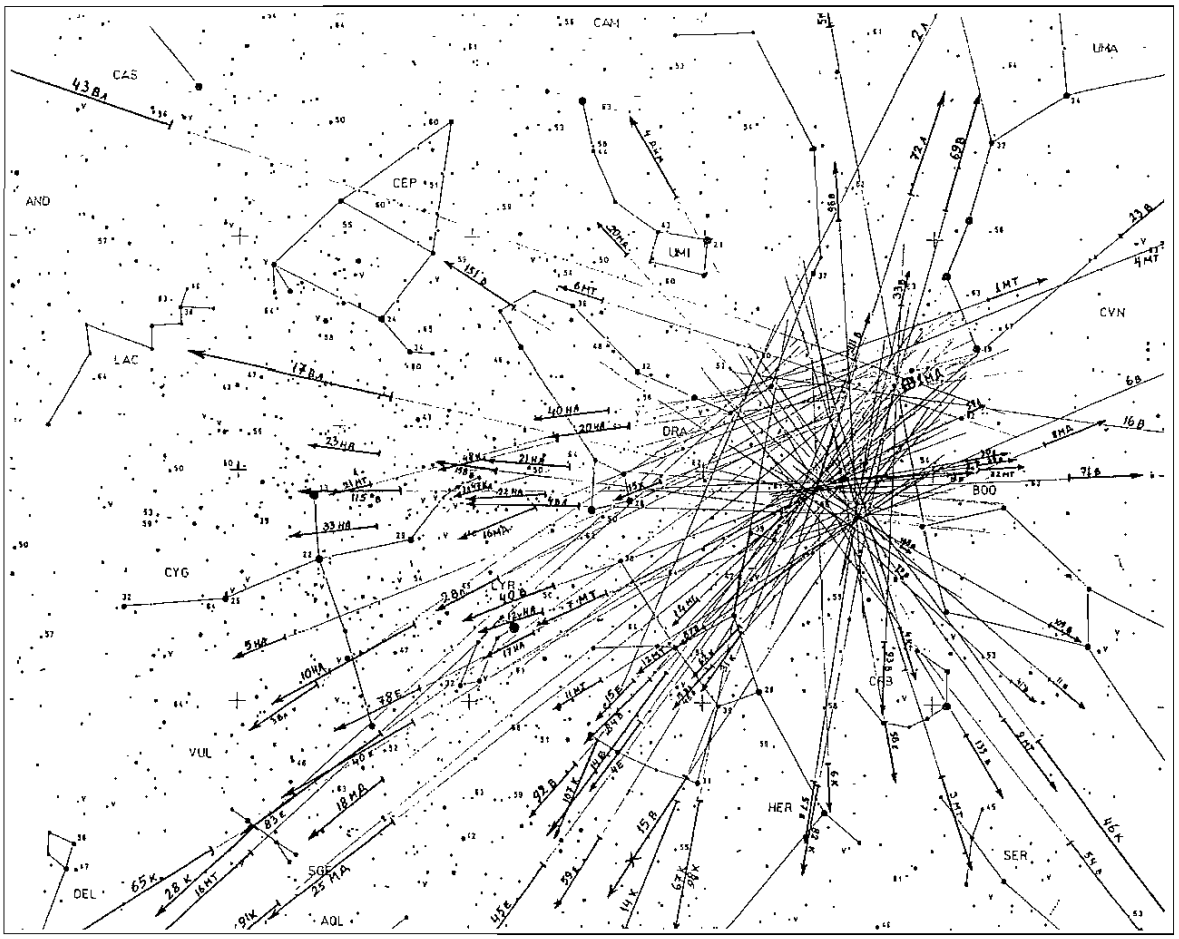


Figure 7: *Composite picture of all visually seen, plotted meteors.*

are scattered over an area of 20° diameter (Figure 7). The most active were the subradiants found by us already based on the data from the previous night (June 26-27). For June 27-28 their coordinates are:

(I) $\alpha = 233.^{\circ}9$, $\delta = 48°$; (II) $\alpha = 230.^{\circ}9$, $\delta = +44.^{\circ}0$.

Besides them another centre (IV) appeared near the star ι Draconis with $\alpha = 227.^{\circ}5$, $\delta = 60.^{\circ}4$, and one more (III) near θ Bootis with $\alpha 214.^{\circ}9$, $\delta = 52.^{\circ}5$.

3.2 Photographic data

For the night of June 27-28 we have at least 6 June Bootids caught on guided photographs. One of them is on a plate exposed by our colleague Veselka Radeva, using the Schmidt telescope in the National Astronomical Observatory, Rozhen. Most of these June Bootids were recorded visually by the observers too. Five of the photographed meteors form a pointlike radiant with coordinates $\alpha = 230.^{\circ}0$, $\delta = 48.^{\circ}5$ (Figure 8). Table 1 lists their characteristics determined by visual observations:

They are spread in a sector of about 180° around the radiant and appeared in an interval between $20^{h}35^{m}$ and $22^{h}10^{m}$ UT when the zenith attraction should have not been quite strong. For $V_{\infty} = 18$ km/s this corresponds to a geocentric position with $\alpha = 225.^{\circ}5$ and $\delta = +48.^{\circ}4$ (eq. 2000). It was obtained after correction or diurnal aberration of the meteor particles and zenith attraction. (The correction for diurnal aberration was made using the following formulae (Astapovich 1958; Zotkin 1972):

$$\alpha_{cor} = \alpha + \Delta\alpha \tag{1}$$

$$\delta_{cor} = \delta + \Delta\delta \tag{2}$$

$$\Delta\alpha = -1594.45 \frac{\cos\phi \cos t \sec\Delta}{V_{\infty}} \quad \text{[in arc minutes]} \tag{3}$$

$$\Delta\delta = -1594.45 \frac{\cos\phi \sin t \sin\Delta}{V_{\infty}} \quad \text{[in arc minutes]} \tag{4}$$

where α, δ and α_{cor}, δ_{cor} are the apparent and corrected radiant coordinates, t is hour angle of the radiant and ϕ is the geographic latitnde. The correction formulae for the zenith attraction are:

$$Z_{cor} = Z + \Delta Z \tag{5}$$

$$\tan\frac{\Delta Z}{2} = \frac{V_{\infty} - V_g}{V_{\infty} + V_g} \tan(Z/2) \tag{6}$$

where Z and Z_{cor} are the apparent and the corrected zenithal distances of the radiant, V_g and V_{∞} are the initial (geocentric) velocity of the stream particles and the velocity influenced by the Earth's gravity resp.

It has to be noticed that despite the low velocity of the meteor particles, among the photographed meteors there are quite many of significant brightness (with magnitudes of -0.5, -1).

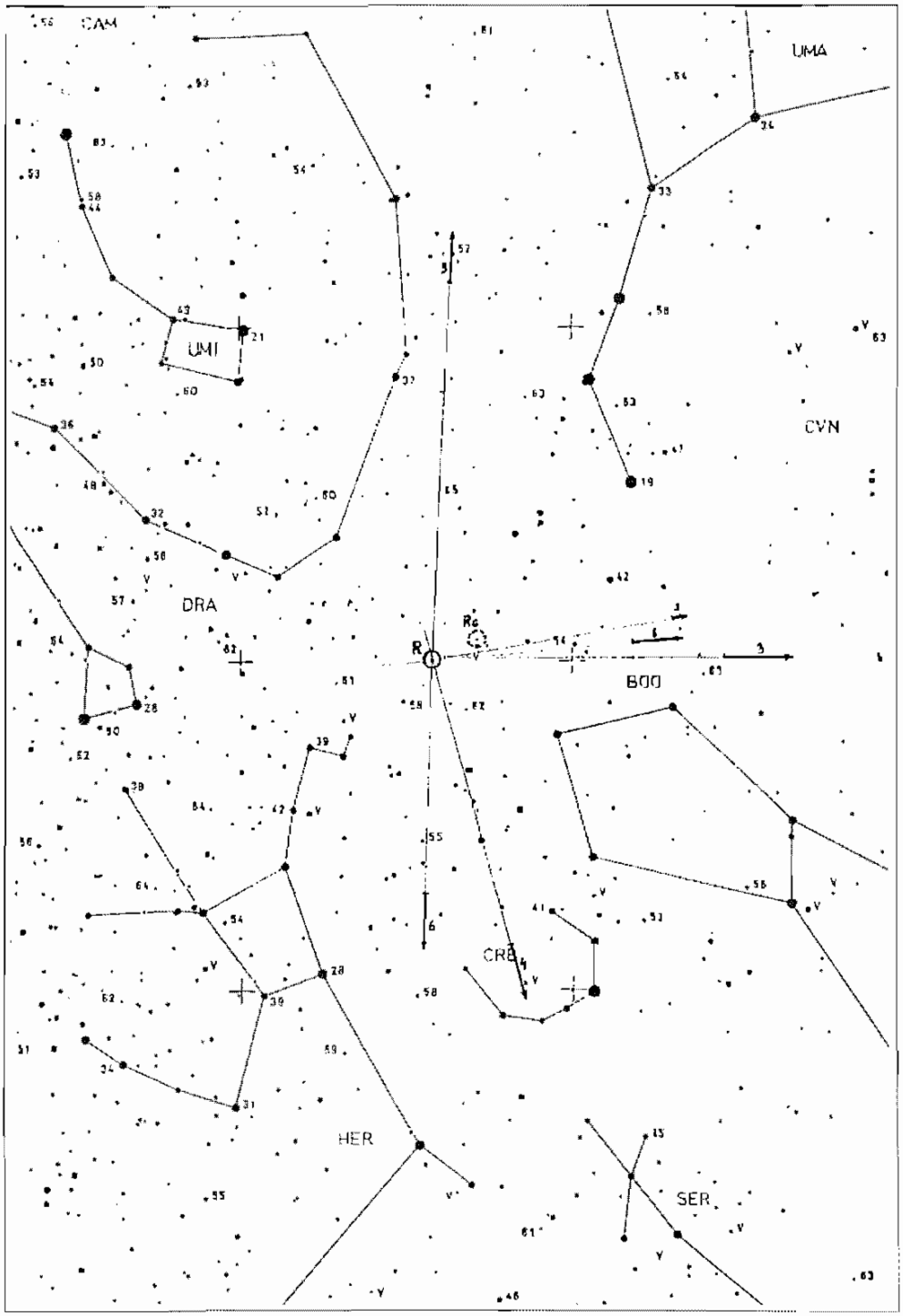


Figure 8: *Photographic radiant. R is the apparent radiant, R_G is the geocentric radiant.*

Some of the brighter June Bootids showed interesting flares captured also on the photographs. There are 3 more June Bootids, belonging to the main radiant, on unguided photographs made in the National Astronomical Observatory, Rozhen, by Ilian Iliev.

Besides the June Bootids originating from the main radiant (I), there are 2 June Bootids probably coming from the subradiant near ι Draconis, on guided photographs. One of them, short and faint, is shot on June 27-28 together with 3 more shower meteors of the main radiant present in the same frame. The other appeared on June 28-29 between 22^h50 and 23^h45^m UT.

During the last observing night of June 28-29 the June Bootid activity was lower than that of the sporadic meteors again. The ZHR values of the different observers vary between 0 and 4.3. The mean value is 1.2.

4 Conclusion

Quite strange is this outburst of the June Bootids 2.5 years after the perihelion passage of the parent comet (Astronomical Almanac 1996) especially if having in mind its period of only 6.37 years at present. We could suppose that it was a beautiful present from Jupiter. In our case it is good that we got June Bootids and not the comet Shoemaker-Levy for instance!

In the conclusion, we appeal to the meteor observers to watch this still poorly explored shower also in 1999. As it can be seen in the literature, the past June Bootid outbursts have been observed in several subsequent years sometimes, like in 1921–22 and 1927–28 (Abalakin 1981). Maybe we can expect another interesting appearance next year.

References

Abalakin, V.K., ed. (1981). Astronomical Calendar — Invariable Part. Nauka, Moscow (in Russian)

Astapovich, I.S. (1958). Meteor Phenomena in the Earth's Atmosphere. FIZMATGIZ, Moscow (in Russian).

Astronomical Almanac 1996. Naturella, Sofia (in Bulgarian).

Proceedings of the III Varna City Astronomical Conference organized by Astroclub *Canopus* in 1977 (in Bulgarian).

Proceedings of the VI Varna City Astronomical Conference organized by Astroclub *Canopus* in 1980 (in Bulgarian).

Roggemans, P., ed. (1987). Handbook for Visual Meteor Observations. Belgium.

Velkov, V. (1990), Proceedings of the XV National Astronomical Conference organized by Astroclub *Canopus* (in Bulgarian).

Zotkin, I.T. (1972). Meteor Observations. Nauka, Moscow (in Russian).