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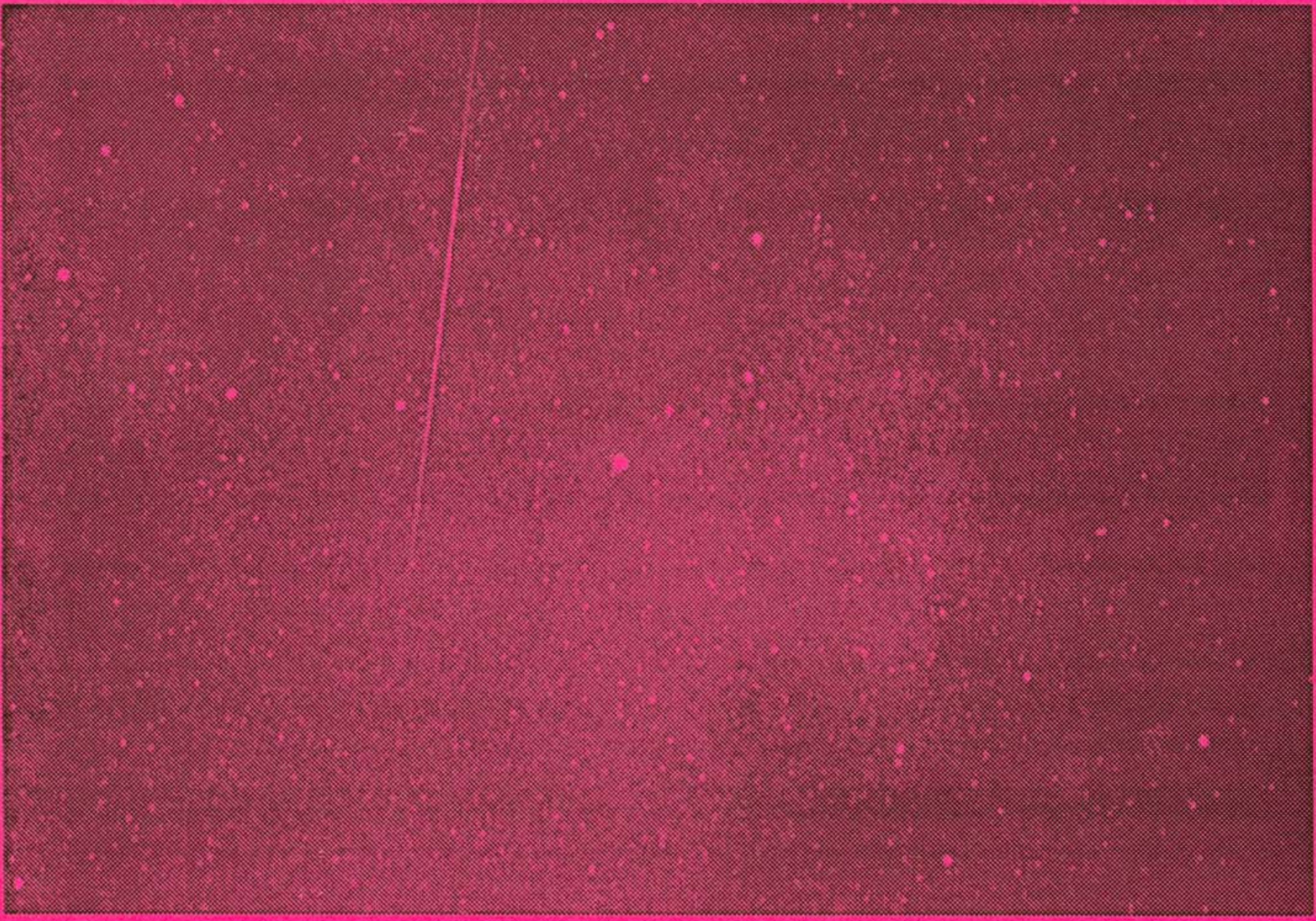

A meteor of magnitude +0.5 shot through Scutum in this exposure of the open cluster M11 on July 23, 2000, at $22^h12^m07^s$ UT. The exposure lasted from $22^h11^m40^s$ to $22^h13^m43^s$ UT and was taken by Davorin Zaloznik and Javor Kac with a 200-mm $f/4$ lens on Fuji 800.

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v.u.: Marc Gyssens, Heerbaan 74, B-2530 Boechout, Belgium

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Contents

Useful Information

The October issue *(WGN 28:5)*

The *October issue* will be mailed in the first half of October. Contributions are due on *September 25* at the latest. They should be sent to *Marc Gyssens*.

Subscriptions and ordering of publications

Volume 28 (2000) of *WGN* will contain at least 240 pages and costs 35 DEM or 17.90 EUR, including non-airmail delivery. Ordering other *IMO* publications is done in the same way as paying subscription/membership fees. Changes of address and complaints about not receiving *WGN* should be addressed to the Treasurer, Ina Rendtel.

All addresses can be found on the inside of the back cover.

From the Editor-in-Chief

Marc Gyssens

With this issue, we returned to our original schedule to have WGN *appear at the beginning of the month, and we intend to keep it this way, as we found out through inquiring with our readers that timeliness is the most important feature to them.*

At the same time, however, we must also face the fact that few articles have been submitted to WGN *in the first half of 2000, in stark contrast with 1999, when the large number of submissions resulted in a record volume, both with respect to number of pages as to content. Apart from working away the delay, the double April-June issue was partly a result of too few articles being available for the April issue.*

Most likely, this dip in number of submitted contributions has to be attributed to a certain "fatigue" after the 1999 Leonids which required a lot of effort and energy of everyone involved both in terms of preparation, observation, and data analysis, also on the part of the IMO *officers. It illustrates once more the vulnerability of our organization. Despite the fact that a lot of meteor workers contribute in one way, some key tasks, such as input of data in the* Visual Meteor Database (VMDB), *data analysis, and, of course, the editing and production, depend on frighteningly few persons. No doubt, many hard-working meteor enthusiasts in several different countries are too modest. Because they only see the* IMO*'s output and not the work that went into producing this output, they think they cannot significantly contribute. The opposite is the case. I once more encourage meteor workers who are prepared to make some commitment to contact an* IMO *officer to find out how they can participate in the effort required to run it. Every contribution that can be offered, even if it is minor, will be much appreciated, as it will ease the burden on the shoulders of the other* IMO *officers!*

Perhaps, the upcoming International Meteor Conference (IMC) *in Pucioasa, Rumania, an event that invariantly generates a lot of enthusiasm among all participating meteor workers, and for which we encourage you to register should you not already have done so, is a good occasion to discuss the matter I raised above with the* IMO *officers present.*

Unlike last year, the Moon will interfere greatly with two major showers ahead, the Perseids and the Leonids. Despite this, observers should not be discouraged. With regard to the Perseids, which are due by the time this issue is sent out, it is important to keep monitoring the evolution of the various peaks, now that we are farther and farther away of the parent comet. And for the Leonids, of course, the finding of this November will be crucial to validate Asher and McNaught's model which so nicely predicted last year's Leonid outburst. So, your observations of both these showers are very important!

In the October issue, we intend to report more definitive results on the 1999 Leonids and Perseids, which will make this issue a thick one! Also, we encourage you to reverse the trend of the past few months by submitting contributions! Meanwhile, enjoy this issue!

Meteor Shower Calendar: October–December 2000

compiled by Alastair McBeath and Rainer Arlt

1. Shower descriptions

Ecliptical minor shower activity reaches what might be regarded as a peak in early to mid November, with the Taurid streams in action. Unfortunately, both Northern and Southern Taurid maxima suffer from bright moonlight this year, but the interesting late October to early November period which sometimes produces more Taurid fireballs is excellently Moon-free. Taurid activity in late October 1998 reached levels comparable to the usual maximum rates, and checking what happens this year would be valuable, though nothing unusual has been predicted. Before then is a partly moonless Draconid epoch, together with badly Moon-affected ε-Geminid and Orionid maxima, all in October. The main Orionid peak is likely around 2^h–3^h UT on October 21.

Some predictions suggest a Leonid storm may occur in November, but moonlight will be a problem. Nevertheless, observations are very important to validate the model of Asher and McNaught which allowed to predict last year's storm which such accuracy.

The α-Monocerotid peak, however, is nearly Moon-free, together with the χ-Orionids in December. Shower maxima lost to moonlight in December include those of the Phoenicids (December 6 around 2^h UT), early December's best from the Puppid-Velids, the Monocerotids (December 8), σ-Hydrids (December 11), Geminids (December 13, 17^h UT to December 14, 2^h UT) and Coma Berenicids (December 19). The Ursids at least survive this lunar-light onslaught.

Draconids

Active: October 6–10; Maximum: October 8, 1^h30^m UT ($\lambda_\odot = 195\overset{\circ}{.}075$) or
around October 8, 9^h UT ($\lambda_\odot = 195\overset{\circ}{.}4$);
ZHR: periodic—up to storm levels;
Radiant: $\alpha = 262°$, $\delta = +54°$; radiant drift: negligible; $V_\infty = 20$ km/s; $r = 2.6$;
TFC: $\alpha = 290°$, $\delta = +65°$ and $\alpha = 288°$, $\delta = +39°$ ($\beta > 30°$ N).

Unfortunately for potential Draconid observers, although this periodic shower has produced spectacular, brief, meteor storms twice already this century, in 1933 and 1946, and lower rates in several other years (ZHRs ranging from 20 to 500+), so far, detectable activity has only been seen in years when the stream's parent comet, 21P/Giacobini-Zinner, has returned to perihelion. It did this last in November 1998, and in October 1998, a short-lived Draconid outburst yielding ZHRs around 700 was seen from Far Eastern sites, as well as being recorded by radio. This occurred at $\lambda_\odot = 195\overset{\circ}{.}075$, but a later time towards $\lambda_\odot = 195\overset{\circ}{.}4$ may be more generally applicable, based on the Earth's closest approach to the comet orbit's node. Activity in 2000 is unlikely, and conditions are far from ideal with a waxing gibbous Moon, but checking is important. The radiant is circumpolar from many locations, but is higher in the pre-midnight and near-dawn hours on October 8–10. With moonset only after local midnight, a repeat of the 1998 peak time would favor sites in central to eastern North America, while the later time would be better for European to West Asian observers. Note that Draconid meteors are exceptionally slow-moving, a characteristic which helps separate genuine shower meteors from sporadics accidentally lining up with the radiant.

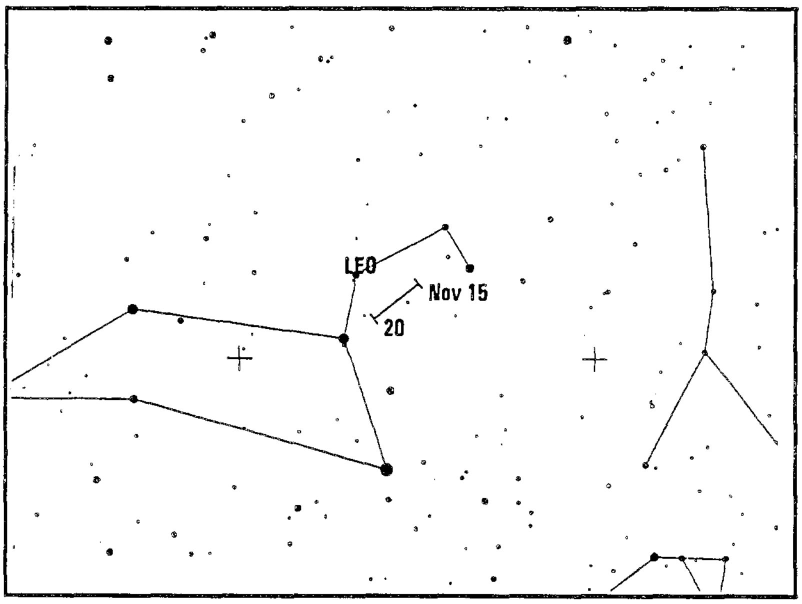

Figure 1 – Radiant position and drift of the Leonids.

Leonids

Active: November 14–21; Maximum: November 18, see text for exact times.
ZHR: more than 100, but may reach storm level in 2000;
Radiant: $\alpha = 153°$, $\delta = +22°$, radiant drift: see Table 2; $V_\infty = 71$ km/s; $r = 2.9$;
TFC: $\alpha = 140°$, $\delta = +35°$ and $\alpha = 129°$, $\delta = +06°$ ($\beta > 35°$ N);
$\alpha = 156°$, $\delta = -03°$ and $\alpha = 129°$, $\delta = +06°$ ($\beta < 35°$ N);
PFC: $\alpha = 120°$, $\delta = +40°$ before 0^h local time ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = +20°$ before 4^h local time;
$\alpha = 160°$, $\delta = 00°$ after 4^h local time ($\beta > 0°$ N);
$\alpha = 120°$, $\delta = +10°$ before 0^h local time;
$\alpha = 160°$, $\delta = -10°$ after 0^h local time ($\beta < 0°$ N).

The Leonids' parent comet, 55P/Tempel-Tuttle, reached perihelion last in February 1998, but recent stream evolution studies suggest high to storm-level Leonid activity may still occur in 2000 or even until 2002. There are, of course, no guarantees that this will happen, but all observers must realize that even discovering the absence of any unusual Leonid activity would still be very valuable information—albeit not all that interesting to witness!

Young material from the most recent, i.e., the 1965 and 1932 perihelion passages of the Comet, is likely to cause enhanced activity near closest approach to the Comet's node on November 17, 8^h UT ($\lambda_\odot = 235.^\circ27$), as also indicated by the stream model developed by Peter Brown, but the model finds an older trail from 1733 suggesting a peak as late as November 18, 8^h UT. David Asher and Robert McNaught predict two peaks, namely November 18, 3^h44^m for the 1733 trail and 7^h51^m for the 1866 trail. In 1999, Asher and McNaught's prediction of the maximum at 2^h08^m UT was confirmed by the observations (the actual peak occurred only about five minutes earlier). The predicted peak ZHR (1500) was surpassed by the observed ZHR (about 3700) by a factor 2. For both peaks in 2000, Asher and McNaught quote a ZHR between 100 and 5000. Observations of the 2000 Leonids are very important to confirm the validity of Asher and McNaught's model. They will also be very important to determine the level of activity, for example, to see whether recent more pessimistic predictions by Jenniskens et al. are founded.

The radiant rises only around local midnight (or indeed afterwards south of the equator), so the waning gibbous Moon will be a considerable nuisance for all observers. The two $\sim 8^h$ UT peak timings would favor locations across North America, while the 3^h44^m possible peak would be best seen from Europe and North Africa. Even minor variations from these timings would mean places east or west of these zones may see something of the shower's best too. All observing methods should be utilized, especially photography and video if a storm manifests.

α-Monocerotids

Active: November 15–25; Maximum: November 21, 8^h UT ($\lambda_\odot = 239.^\circ32$);
variable ZHR, usually around 5, but may produce outbursts to 400+;
Radiant: $\alpha = 117°$, $\delta = +01°$; radiant drift: see Table 2; $V_\infty = 65$ km/s; $r = 2.4$;
TFC: $\alpha = 115°$, $\delta = +23°$ and $\alpha = 129°$, $\delta = +20°$ ($\beta > 20°$ N);
$\alpha = 110°$, $\delta = -27°$ and $\alpha = 98°$, $\delta = +06°$ ($30° \leq \beta \leq 20°$ N).

Another late-year shower capable of producing surprises, the α-Monocerotids gave their most recent brief outburst in 1995 (the top ZHR, 420, lasted just five minutes; the entire outburst 30 minutes). Many observers across Europe witnessed it, and we have been able to completely update the known shower parameters as a result. Whether this indicates that the proposed ten-year periodicity in such returns is real or not, only the future will tell, however, so all observers should continue to monitor this source closely. We are currently at the mid-point of any decade-long cycle. The waning crescent Moon on November 21 makes this a good year for such scrutiny, with the radiant well on view in both hemispheres after about 23^h local time or so. The expected peak time falls especially well for North America.

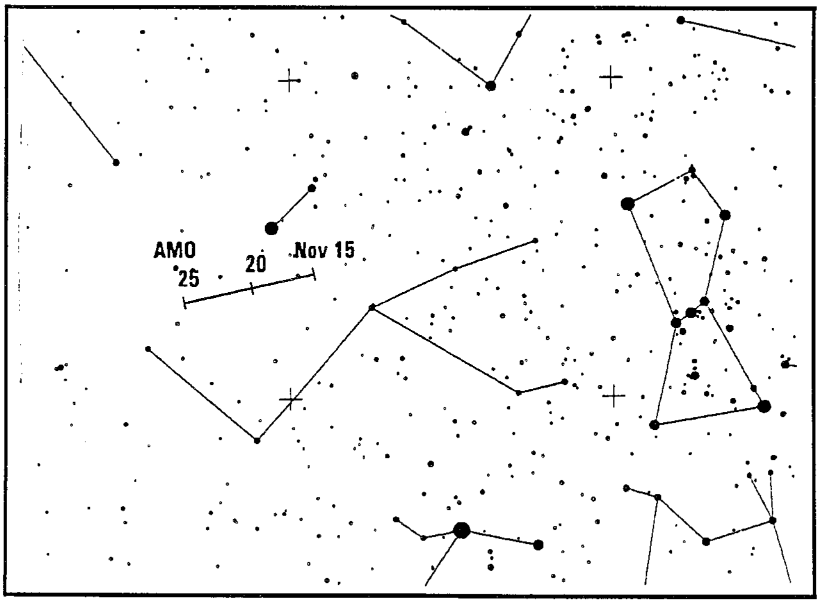

Figure 2 – Radiant position and drift of the α-Monocerotids.

χ-Orionids

Active: November 26–December 15; Maximum: December 1 ($\lambda_\odot = 250°$); ZHR = 3;
Radiant: $\alpha = 82°$, $\delta = +23°$; Radiant drift: see Table 2; $V_\infty = 28$ km/s; $r = 3.0$;
TFC: $\alpha = 83°$, $\delta = +09°$ and $\alpha = 80°$, $\delta = +24°$ ($\beta > 30°$ S).

This weak visual shower is moderately active telescopically, although a number of brighter meteors have been photographed, too. The shower has at least a double radiant, but the southern branch has been rarely detected. The χ-Orionids may be a continuation of the ecliptic complex after the Taurids cease to be active. The radiant used here is a combined one, suitable for visual work, although telescopic or video observations should be better able to determine the exact radiant structure. The waxing crescent Moon should give few problems, as the radiant is well on display for all watchers throughout the night.

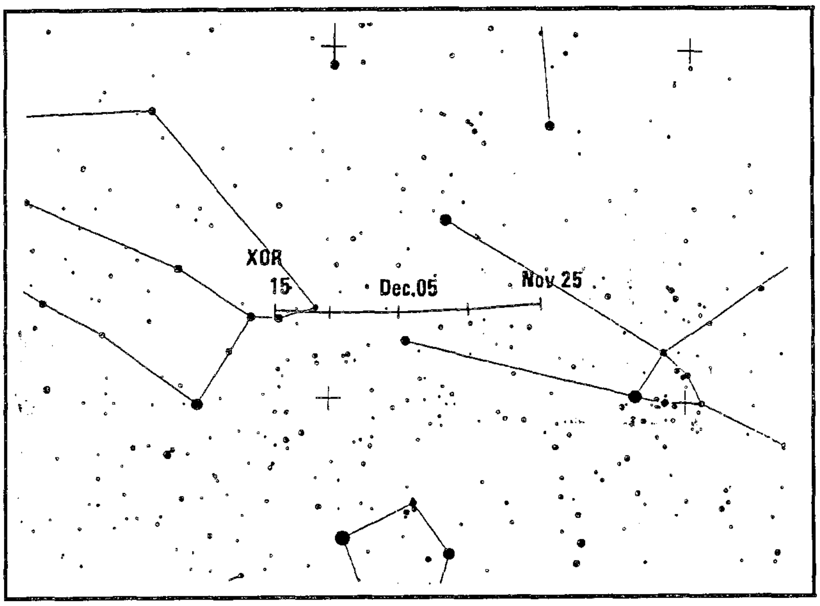

Figure 3 – Radiant position and drift of the χ-Orionids.

Ursids

Active: December 17–26; Maximum: December 22, 6^h UT ($\lambda_\odot = 270\overset{\circ}{.}7$);
ZHR = 10 (occasionally variable up to 50);
Radiant: $\alpha = 217°$, $\delta = +76°$; Radiant drift: see Table 2; $V_\infty = 33$ km/s; $r = 3.0$;
TFC: $\alpha = 348°$, $\delta = +75°$ and $\alpha = 131°$, $\delta = +66°$ ($\beta > 40°$ N);
$\alpha = 63°$, $\delta = +84°$ and $\alpha = 156°$, $\delta = +64°$ ($30° \leq \beta \leq 40°$ N).

A very poorly-observed northern hemisphere shower, but one which has produced at least two major outbursts in the past half-century or so, in 1945 and 1986. Several other rate enhancements, recently in 1988 and 1994, have been reported too. Other similar events could easily have been missed due to poor weather or too few observers active. All forms of observation can be used for the shower, since many of its meteors are faint, but with so little work carried out on the stream, it is impossible to be precise in making statements about it. The radio maximum in 1996 occurred around $\lambda_\odot = 270\overset{\circ}{.}8$, for instance, which might suggest a slightly later maximum time in 2000 of December 22, 8^h30^m UT. The Ursid radiant is circumpolar from most northern sites (thus fails to rise for most southern ones), though it culminates after daybreak, and is highest in the sky later in the night. The nearly-New Moon will give dark skies for observations almost all night on December 22.

2. Working list of meteor showers

Table 1 is the *IMO* Working List of meteor showers. The coordinates of the radiant refer to the reference date (in most cases, the date of maximum). When observing the shower on other dates, one must take into account the radiant drift. This can be deduced from Table 2, where the radiant coordinates are listed with steps of five days for other dates within the activity period.

Table 1 – Working list of meteor showers for the period October–December 2000. Showers marked with an asterisk are periodically or occasionally active, and therefore no ZHR is cited. The "maximum" date cited for the Puppid/Velids should be seen as a reference date only.

Shower	Activity	Maximum		Radiant		V_∞	r	ZHR
		Date	$\lambda_\odot$	α	δ	(km/s)		
δ-Aurigids (DAU)	Sep 05–Oct 10	Sep 08	166°	60°	+47°	64	3.0	6
Piscids (SPI)	Sep 01–Sep 30	Sep 19	177°	5°	−01°	26	3.0	3
Draconids* (GIA)	Oct 06–Oct 10	Oct 08	195°.4	262°	+54°	20	2.6	var
ε-Geminids (EGE)	Oct 14–Oct 27	Oct 18	205°	102°	+27°	70	3.0	2
Orionids (ORI)	Oct 02–Nov 07	Oct 21	208°	95°	+16°	66	2.9	20
Southern Taurids (STA)	Oct 01–Nov 25	Nov 05	223°	52°	+13°	27	2.3	5
Northern Taurids (NTA)	Oct 01–Nov 25	Nov 12	230°	58°	+22°	29	2.3	5
Leonids (LEO)	Nov 14–Nov 21	Nov 17	235°.27	153°	+22°	71	2.5	100+
α-Monocerotids (AMO)	Nov 15–Nov 25	Nov 21	239°.32	117°	+01°	65	2.4	var
χ-Orionids (XOR)	Nov 26–Dec 15	Dec 01	250°	82°	+23°	28	3.0	3
Dec Phoenicids (PHO)	Nov 28–Dec 09	Dec 06	254°.25	18°	−53°	22	2.8	var
Puppid/Velids (PUP)	Dec 01–Dec 15	Dec 06	255°	123°	−45°	40	2.9	10
Dec Monocerotids (MON)	Nov 27–Dec 17	Dec 08	257°	100°	+08°	42	3.0	3
σ-Hydrids (HYD)	Dec 03–Dec 15	Dec 11	260°	127°	+02°	58	3.0	2
Geminids (GEM)	Dec 07–Dec 17	Dec 13	262°.0	112°	+33°	35	2.6	120
Coma Berenicids (COM)	Dec 12–Jan 23	Dec 19	268°	175°	+25°	65	3.0	5
Ursids (URS)	Dec 17–Dec 26	Dec 22	270°.7	217°	+76°	33	3.0	10

Table 2 – Radiant positions in α and δ.

	NTA	STA	ORI	DAU				
Oct 5	25o +12°	27° +7°	85° +14°	89° +49°		GIA		
Oct 10	29° +14°	31° +8°	88° +15°	95° +49°		262° +54°		
Oct 15	34° +16°	35° +9°	91° +15°		EGE			
Oct 20	38° +17°	39° +11°	94° +16°		99° +27°			
Oct 25	43° +18°	43° +12°	98° +16°		104° +27°			
Oct 30	47° +20°	47° +13°	101° +16°		109° +27°			
Nov 5	53° +21°	52° +14°	105° +17°					
Nov 10	58° +22°	56° +15°		LEO	AMO			
Nov 15	62° +23°	60° +16°		150° +23°	112° +02°			
Nov 20	67° +24°	64° +16°	XOR	153° +21°	116° +01°			
Nov 25	72° +24°	69° +17°	75° +23°		120° 00°	MON	PUP	PHO
Nov 30			80° +23°	HYD		91° +8°	120° −45°	14° −52°
Dec 5	COM	GEM	85° +23°	122° +03°		96° +8°	122° −45°	18° −53°
Dec 10	169° +27°	108° +33°	90° +23°	126° +02°		100° +8°	125° −45°	22° −53°
Dec 15	173° +26°	113° +33°	94° +23°	130° +01°	URS	104° +8°	128° −45°	
Dec 20	177° +24°	118° +32°			217° +75°			

3. Lunar phases

Below are the lunar phases for the period October–December 2000.

Table 3 – Lunar phases for October–December 2000.

New Moon	Oct 27	Nov 25	Dec 25
First Quarter	Oct 05	Nov 04	Dec 04
Full Moon	Oct 13	Nov 11	Dec 11
Last Quarter	Oct 20	Nov 18	Dec 18

4. Radiant sizes and meteor plotting

If you are not observing during a major-shower maximum, it is much more essential to associate meteors with their radiants correctly, since the total numbers will be small. Meteor plotting allows the shower association by more objective criteria than the prolongation of paths under the sky.

As you plotted the meteors on gnomonic maps, you can trace the radiant by straight lines. If the radiant lies on another chart, you should find common stars on an adjacent chart in order to extend the backward prolongation there.

How large should the radiant be assumed for shower association? The physical radiant size is very small; visual plotting errors cause many true shower meteors to pass the radiant outside this area. We have to assume a larger radiant. The opposite behavior is caused by sporadic meteors—more and more sporadics line up accidentally upon enlarging the radiant. Hence, we have to apply an optimum radiant diameter compensating the loss due to plotting errors, and the sporadic meteor pollution.

Table 4 below gives the optimum radiant diameter as a function of the angular distance of the meteor from the radiant involved.

Table 4 – Optimum radiant diameters ("Diameter") to be assumed for shower association of minor-shower meteors as a function of the radiant distance ("*D*") of the meteor.

D	Diameter	*D*	Diameter
15°	14°	50°	20°
30°	17°	70°	23°

The direction of the path is not the only criterion for shower association. The angular velocity of the meteor should match the expected speed of the shower meteors according to the geocentric velocity of the meteoroids. Angular velocity estimates should be made in degrees per second (°/s). In your imagination, you make the meteors move for one second. The path length of this imaginary meteor is the angular velocity in °/s. Note that typical speeds are in the range 3°/s–25°/s.

Typical errors of such estimates are given in Table 5.

Table 5 – Error limits for the angular velocity.

Angular velocity (°/s)	5	10	15	20	30
Permitted error (°/s)	3	5	6	7	8

Table 6 gives the angular speeds for a few geocentric velocities, which can be looked up in Table 2 for each shower.

Table 6 – Angular velocities as a function of the radiant distance and the elevation of a meteor for three different geocentric velocities. All velocities are in °/s. The tables are symmetric: you can read radiant distance horizontally and elevation vertically, or vice-versa.

$h \backslash D$	$v_\infty = 25$ km/s					$v_\infty = 40$ km/s					$v_\infty = 60$ km/s				
	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°
10°	0.4	0.9	1.6	2.2	2.5	0.7	1.4	2.6	3.5	4.0	0.9	1.8	3.7	4.6	5.3
20°	0.9	1.7	3.2	4.3	4.9	1.4	2.7	5.0	6.8	7.9	1.8	3.5	6.7	9.0	10
40°	1.6	3.2	5.9	8.0	9.3	2.6	5.0	9.5	13	15	3.7	6.7	13	17	20
60°	2.2	4.3	8.0	11	13	3.5	6.8	13	17	20	4.6	9.0	17	23	26
90°	2.5	4.9	9.3	13	14	4.0	7.9	15	20	23	5.3	10	20	26	30

5. Daytime radio meter showers

Table 7 – Working list of daytime radio meteor showers. The "Best Observed" columns give the approximate local mean times between which a four-element antenna at an elevation of 45° receiving a signal from a 30-kW transmitter 1000 km away should record at least 85% of any suitably positioned radio-reflecting meteor trails for the appropriate latitudes. Note that this is often heavily dependent on the compass direction in which the antenna is pointing, however, and applies only to dates near the shower's maximum.

Shower	Activity	Max	$\lambda_\odot$	Radiant		Best Observed		Rate
		Date	2000.0	α	δ	50° N	35° S	
Sextantids	Sep 09–Oct 09	Sep 27	184°3	152°	00°	06^h–12^h	06^h–13^h	medium

Call for Observations of a Possible Minor Shower Around September 13, 2000

Pavol Habuda

During a visual observation on September 13-14, 1999, in Horná Maríková (Slovakia), I noticed enhanced activity of a shower with radiant near ε Aurigae. During one observing interval, I saw six meteors, but I saw only two during the rest of the night. The source was not active during other nights. This shower was observed by a TV system in Japan in 1994, too [1]. They detected six meteors during five hours, of which five appeared in the last hour of the observation. If this shower is real, ***I suppose it lasts very short, only for about one hour.*** The data show a time of maximum activity at $\lambda_\odot = 170.^\circ79 \pm 0.^\circ03$ (eq. 2000.0). The position of the radiant and other important characteristics are given in Table 1.

I would like to ask you for observing this shower in 2000. The best positions for observations of the possible maximum on September 13, 7^h UT will be in North America. If you will be successful with your observation, please send your observing log of this shower to me (in an as raw form as possible). My postal address is Horná Maríková 695, SK-018 03 Považská Bystrica, Slovakia, and my email address is `bzucino@yahoo.com`. Negative observations are important for me, too, they may indicate that the shower does not exist.

Table 1 – Characteristics of the possible ε-Aurigid meteor shower.

$\lambda_\odot$	α	δ	V_g	$\overline{m}$	ZHR
170°79	78°	+42°	65.6 km/s	+2.8	5–10

Reference

[1] Ueda, M., Nakamura, T., Sugimoto, M., Tsutsumi, M., "Detection of Three Meteor Streams by Double-Station TV Observation in 1994", *WGN* 25:4 (August 1997), pp. 165–181.

The 2000 International Meteor Conference

Pucioasa, Romania, September 21–24, 2000

Valentin Grigore and Andrei Dorian Gheorghe

The 2000 *International Meteor Conference* will be held in Pucioasa, Romania, between September 21 and 24. More information about this event can be found at the Internet addresses `http://sarm.romwest.ro/imc2000` or `http://sarm.ccs.ro/imc2000` (mirror site). If you wish to participate and have not yet returned your registration form, you should no longer wait and complete and return the registration form you can find in the previous issue!

Ongoing Meteor Work

The Analysis of a Weak Meteor Shower: The June Bootids in 2000

Rainer Arlt

First observational records of the 2000 June Bootids as submitted by 29 observers from 12 countries are presented. Very weak activity of the shower was observed and a geocentric radiant position at $\alpha = 220° \pm 0\overset{\circ}{.}5$, $\delta = +51° \pm 1\overset{\circ}{.}0$ was obtained. The population index computed is only a suggestive value of $r \approx 3.0 \pm 0.8$. If higher ZHR values are attributed to a shower maximum, this would have a half-peak width of roughly 1° in solar longitude (about one day) and a peak value of ZHR ≈ 2. The problems of minor-shower radiant search and activity analysis are discussed. It is concluded that the activity of minor showers with ZHRs less then 1.0 cannot be reasonably determined by visual observations.

1. Introduction

Perfectly Moon-free conditions permitted a good number of observations of the 2000 June Bootids. High northern latitudes face short nights or even insufficient darkness at all, while lower latitudes of such as in southern Europe or the United States provide long-enough nights to gather substantial data sets. A lot of the material presented here is based on the observing camp in Avren, Bulgaria, from where several nights were logged with excellent plotting data, and which was joined by the author. These data were processed using the VISDAT software package [1]. Since the program exports POSDAT files, an immediate radiant investigation was possible.

We are very grateful to the following observers from 12 countries who submitted their reports quickly and in many cases provided plotting data of their meteors to investigate the radiant position of the June Bootids:

> Karl Anthier (France), Rainer Arlt (Germany), Jure Atanačkov (Slovenia), Wienik Beirinckx (Belgium), Eva Bojurova (Bulgaria), Andreas Buchmann (Switzerland), Mary Cook (UK), Goedele Deconink (Belgium), Galin Genchev (Bulgaria), Riu Goncalves (Portugal), Robin Gray (USA), Cathy Hall (Canada), Roberto Haver (Italy), Svilen Ivanov (Bulgaria), Carl Johannink (the Netherlands), Javor Kac (Slovenia), Jakub Koukal (Czech Republic), Maria Krumova (Bulgaria), Mike Linnolt (USA), Robert Lunsford (USA), Pierre Martin (Canada), Mihail Mihov (Bulgaria), Lina Rashkova (Bulgaria), Elena Sârbinska (Bulgaria), Leo Stachowicz (UK), Valentin Velkov (Bulgaria), Jan Verbert (Belgium), Zornica Yancheva (Bulgaria), Yordan Yordanov (Bulgaria).

After an activity outburst of the June Bootids was observed in 1998, for at least the third time in this century, it became a challenge to detect the shower also in non-outburst years. The present article does not only address the analysis of the June Bootids, but also the general problems of minor-shower investigations.

2. Radiant analysis

The RADIANT program as described in [2] will be used here for the radiant search. Simple backward prolongations bear the disadvantage that points on either side of the prolongation are also likely to be the actual radiant of the meteor, since the orientation of the path may be altered due to plotting errors. The most elaborate mode of single-station radiant computations associates every meteor with a certain area behind it in which each point has a certain probability to be the radiant of the meteor. All these probability areas are added giving a final probability distribution possibly indicating the most likely radiant of an entire set of meteors.

The RADIANT program considers zenithal attraction and diurnal aberration. Zenithal attraction is the physical effect of the gravity of the Earth which bends the actual trajectory of the meteoroid in space towards its center. The radiant of each meteor shower is, therefore, shifted towards the zenith. Slow meteoroids are more easily affected than fast meteoroids. As the June Bootids enter the atmosphere with extremely low velocity, they are subject to shifts of several degrees. The shift depends on velocity and radiant elevation. When we search for a radiant, we do not know its position yet. As the radiant changes its elevation through the night, various values of zenithal attraction have to be applied for the meteors. The RADIANT program applies a special method to account for the zenithal attraction, even of unknown radiants, as follows. Given the path and the angular speed, each meteor has a most probable radiant lying somewhere in the backward prolongation of its path. We assume that this most probable point is the apparent radiant. Together with the geocentric velocity, the zenith attraction for this particular point can be computed. The meteor is now displaced in a way that this most probable radiant point fulfills the true radiant which lies somewhere closer to the horizon.

The diurnal aberration is a purely geometrical effect. It refers to the vector addition of the meteoroid's pre-atmospheric velocity and the surface velocity of the Earth due to its rotation. Diurnal aberration is maximum at locations at the equator and zero at the poles. It shifts the true radiant of a meteor to an apparent position towards the east. The RADIANT program accounts for this effect, which amounts up to 1° for the June Bootids, in the same way as for the zenithal attraction: Each meteor is corrected individually according to its most probable radiant point.

A total of 424 meteors recorded during the nights of June Bootid activity were used for the radiant analysis of the shower. No pre-selection of meteors was made in order to evaluate the June Bootid radiant against the background activity. Due to the peculiar geocentric velocity, the radiant is relatively easy to detect. Figure 1 shows the probability distribution at a given pre-atmospheric velocity $V_\infty = 18$ km/s.

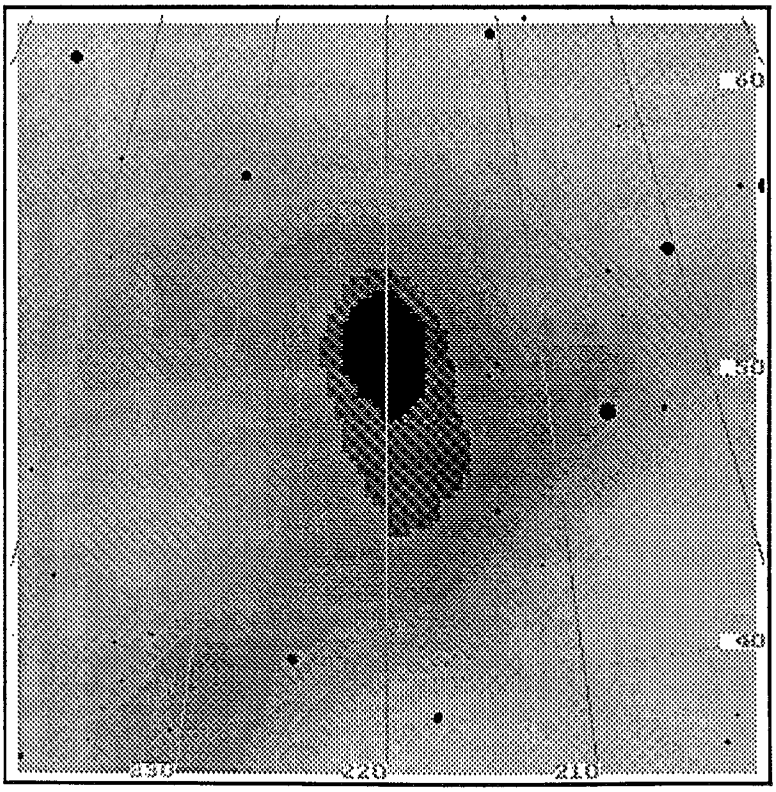

Figure 1 – The radiant of the June Bootids assuming a pre-atmospheric velocity $V_\infty = 18$ km/s. A total of 30 meteors contribute to this distribution, but not all of them are actually composing the radiant.

All meteors are shifted to a base solar longitude of $\lambda_\odot = 95^\circ\!.7$ by $+1^\circ\!.0$ per day parallel to the ecliptic (which results in very small actual shifts because of the high ecliptical latitude of the radiant). Meteors farther than 40° from the center of the distribution were excluded from the computations. The resolution in the center is $0^\circ\!.3$ per matrix element; the value is smaller for distribution elements near the edges because of the gnomonic projection. The distribution reaches a maximum at $\alpha = 220^\circ\!.0 \pm 0^\circ\!.5$ and $\delta = +52^\circ\!.7 \pm 0^\circ\!.3$ (J2000.0).

The distribution should be sensitive to the assumed entry velocity of the meteoroids. Upon increasing the value of V_∞ to 30 km/s, the prominence of the June Bootid radiant amplifies, too (Figure 2). Only for velocities greater than 30 km/s, a decrease of prominence is observed. It may be concluded that this effect is a result of systematic overestimation of angular velocities by the observers. The June Bootids put the observer in fact into a peculiar situation, since such low angular speeds are rarely observed during the activity periods of other showers, unless one stares exactly at the radiant. The radiant position derived from the 30-km/s plot is $\alpha = 219^\circ\!.7 \pm 0^\circ\!.5$ and $\delta = +50^\circ\!.9 \pm 0^\circ\!.3$. The position derived from K. Osada's observation of 1998 as described in [3] is $\alpha = 221°$ and $\delta = +51°$ and looks similar, but it must be noted that this position is the apparent one and will shift towards lower right ascension and higher declination by a total distance of about 5° when corrected for zenith attraction and diurnal aberration (moving it at significant distance from the photographic position given in [5] and [7].

If the assumption is correct that systematic speed overestimation is indeed a problem, we must give the 30-km/s plot more weight than the 18-km/s one. Moreover, the structure of Figure 1 extends towards lower declinations, whence a lower final position may be justified rather than the actual maximum. As the right ascension of the radiant did not alter much, we can give this figure with higher accuracy. *We will therefore conclude on a 1998 June Bootid radiant position at* $\alpha = 220° \pm 0^\circ\!.5$ *and* $\delta = +51° \pm 1^\circ\!.0$.

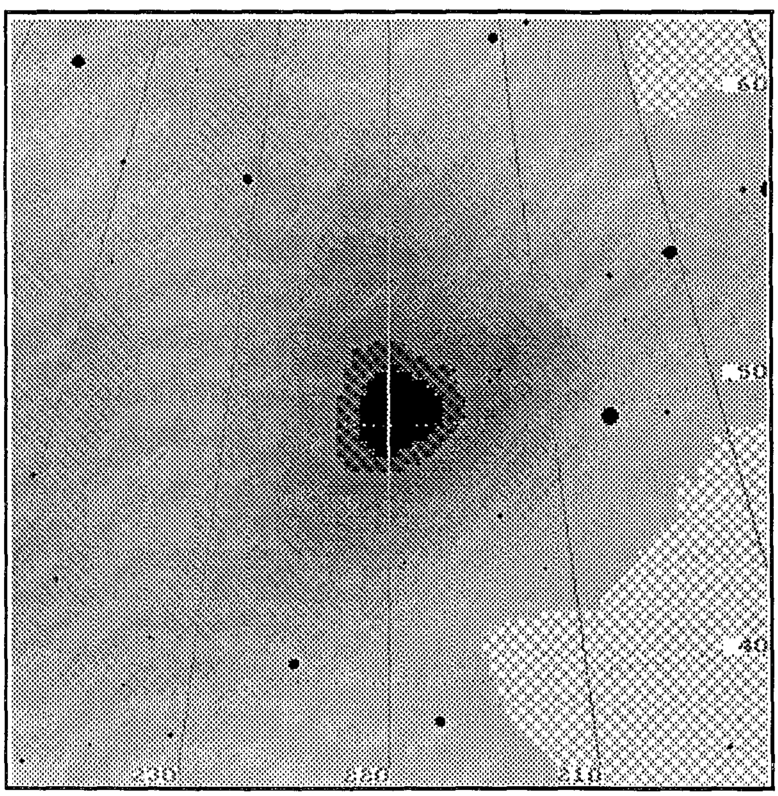

Figure 2 – The radiant of the June Bootids assuming a pre-atmospheric velocity $V_\infty = 30$ km/s instead of the correct $V_\infty = 18$ km/s. A total of 44 meteors contribute to this distribution.

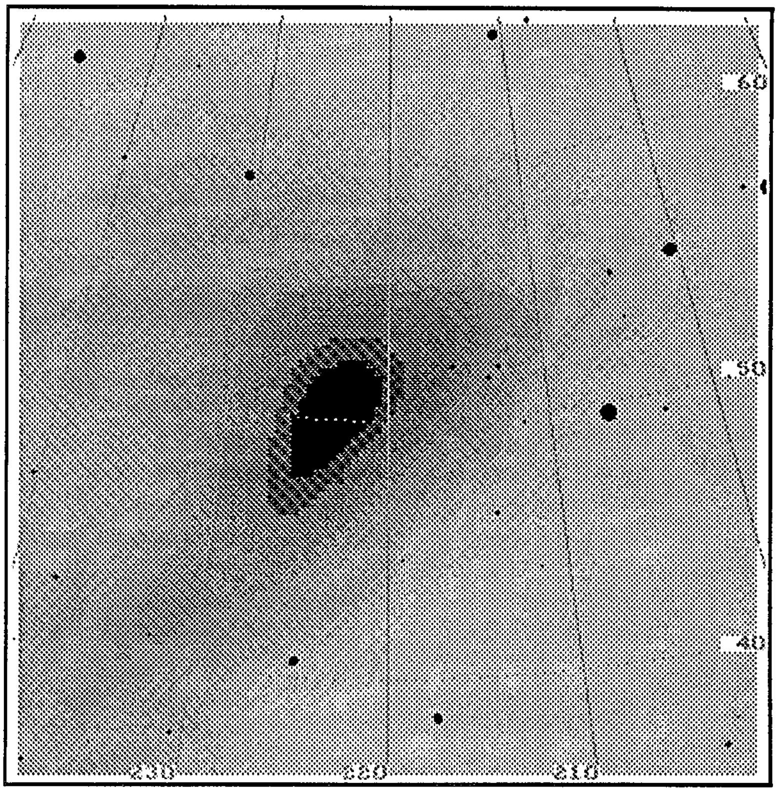

Figure 3 – The radiant of the June Bootids without correcting for zenithal attraction and diurnal aberration, assuming a pre-atmospheric velocity V_∞ = 18 km/s. A total of 36 meteors contribute to this distribution.

Figure 3 shows the same plot as Figure 1, but without any corrections for zenithal attraction and diurnal aberration. The radiant is shifted towards the zenith, given the fact that the majority of meteors was recorded from Avren, Bulgaria, at a geographical latitude of 43° N. The diurnal aberration always shifts the radiant to the east, and thus acts in about the same direction as the zenithal attraction for a radiant which has passed the meridian and moves down to the west.

Although the radiant looks very prominent in these large-scale graphs, it is a weak structure given the surrounding convergence areas. The small-scale graph in Figure 4 shows a large area of the sky in which the actual June Bootid radiant is only a slight enhancement at the edge of a large area of high-probability values. *The full structure extends only to the east, in fact towards the zenith.* The extension is roughly tracking the position of the local zenith—the point of highest probability to appear as a spurious radiant for a random meteor distribution. Whether or not more of the ring-like structure surrounding $\alpha \approx 230°$ belongs to the June Bootid shower is not known. Yet it seems unlikely that the actual June Bootid position coincides with the strongest peak near $\alpha = 250°$. Since the 1916 outburst of the shower, the radiant jumped within an area of at least 20° diameter even if zenithal and aberration correction are properly taken into account.

The question what the stronger sources in Figure 4 mean cannot be answered from the graph, since radiants situated east of the June Bootids will exhibit larger geocentric velocities (closer to the apex), and the plot must be repeated for higher values of V_∞. This is not the subject of the present analysis.

The large scatter of radiant points is a typical feature of meteor showers whose radiants are situated relatively close to the antapex of the Earth's motion. If a meteoroid enters the atmosphere from the exact rear direction o f the Earth's motion, it has a radiant in the antapex (forgetting about diurnal aberration). If it has a slight tilt against this direction, the vectorial sum with the motion vector of the Earth shifts the geocentric radiant to large distances from the antapex.

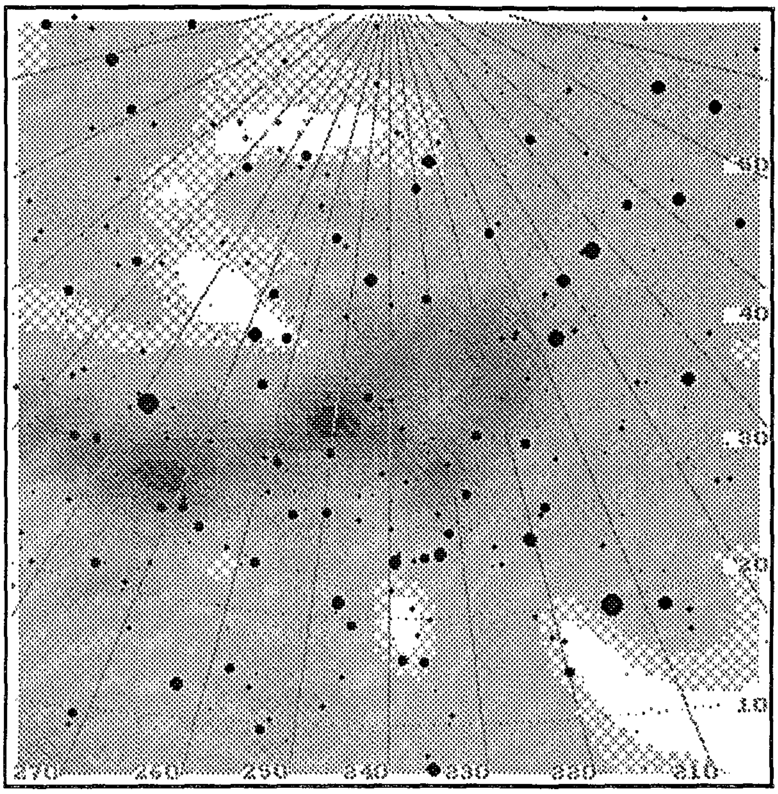

Figure 4 – The distribution of probabilities of a large area of the sky. The June Bootid radiant appears as the most northwestern part of the entire radiant structure. A pre-atmospheric velocity $V_\infty = 18$ km/s was assumed. A total of 127 meteors contribute to this distribution.

This is shown in the left panel of Figure 5. The right panel of the Figure illustrates the case of a retrograde stream hitting the Earth on the front side. The dependence of the actual geocentric radiant position on the meteoroid's direction is much smaller than for prograde orbits.

Mathematically, we can compute the apex distance α' of the geocentric radiant from the heliocentric velocity of the meteoroid stream $V_{\rm H}$ and the apex distance α of the heliocentric radiant, i.e., the actual angle between the two orbits—of the Earth and the meteoroid—in space, which we henceforth call the heliocentric influx angle. It is given by

$$\alpha' = \alpha - \arcsin \frac{V_{\rm E} \sin\alpha}{\sqrt{V_{\rm E}^2 + V_{\rm H}^2 + 2V_{\rm E}V_{\rm H}\cos\alpha}},$$

where $V_{\rm E}$ is the orbital velocity of the Earth (about 30 km/s). If we want to know how sensitive the geocentric radiant is to changes of the influx angle, we have to evaluate the derivative $\mathrm{d}\alpha'/\mathrm{d}\alpha$. The result is an awfully long expression which we will not give here; instead, we show the corresponding function in Figure 6 showing that radiants of meteoroids catching up with Earth from behind are most sensitive to orbital variations.

Let us quickly estimate the position of the June Bootids in this diagram: The solar longitude of the maximum in 1998 was $\lambda_\odot = 95\overset{\circ}{.}7$, the apex will therefore be located near $\lambda_\odot = 5.7$. This position is roughly at $\alpha_{\rm apex} \approx 5\overset{\circ}{.}7$ and $\delta_{\rm apex} \approx 0°$. From $\cos\alpha' = \sin\delta_{\rm apex}\sin\delta_{\rm JBO} + \cos\delta_{\rm apex}\cos\delta_{\rm JBO}\cos(\alpha_{\rm apex} - \alpha_{\rm JBO})$, we find a distance $\alpha' = 122°$. At this distance, we obtain as the heliocentric velocity of the stream

$$V_{\rm H} = \sqrt{V_{\rm G}^2 + V_{\rm E}^2 - 2V_{\rm G}V_{\rm E}\cos\alpha'} = 38.5 \text{ km/s},$$

when using a geocentric velocity $V_G = 13$ km/s. The influx angle follows by the sine law as $\alpha = \alpha' + \arcsin[(V_E/V_H)\sin\alpha'] = 163°$. In radians, this is $\alpha = 2.85$, which can be looked up in Figure 6, where we find an amplification of the influx angle of about 2.3.

This means that the structure of meteoroid streams may become visible in an amplified way in terms of the radiants of the meteor shower, if the stream encounter is from behind. Radiants like those of the Leonids will exhibit a behavior compressing the actual stream structure.

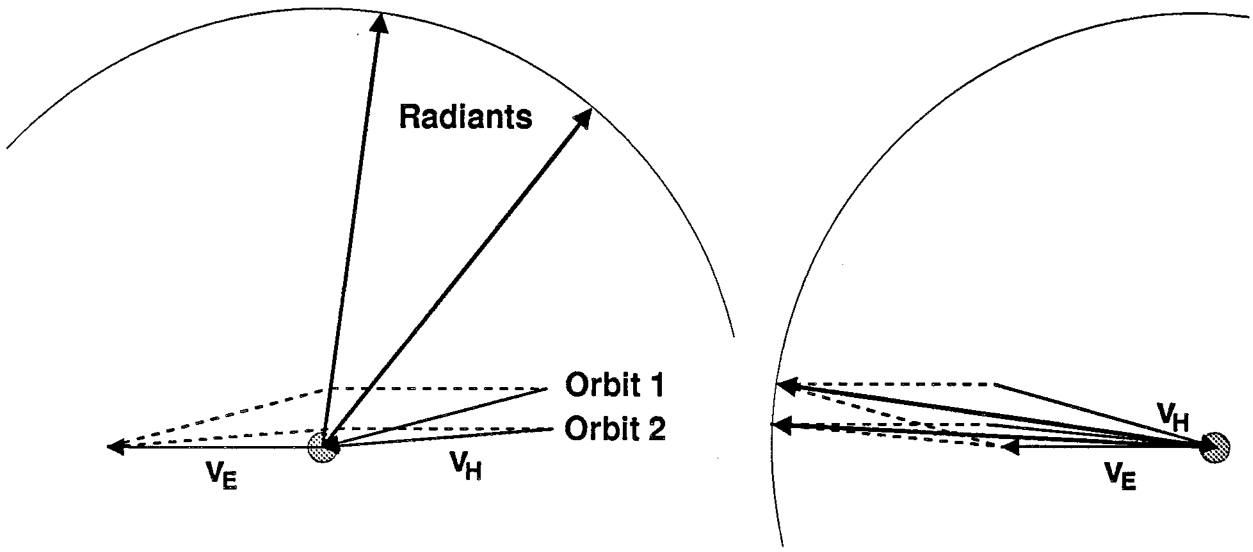

Figure 5 – Sketch showing the sensitivity of a radiant position to changes in the heliocentric influx angle. The *left panel* shows a shower moving in about the same direction as the Earth, whence approaching it from behind. The radiant position changes considerably if the influx angle is varied. The *right panel* shows a shower coming from ahead. The radiant position is much less sensitive to influx angle variations. In both panels, the influx angle was varied by 10°.

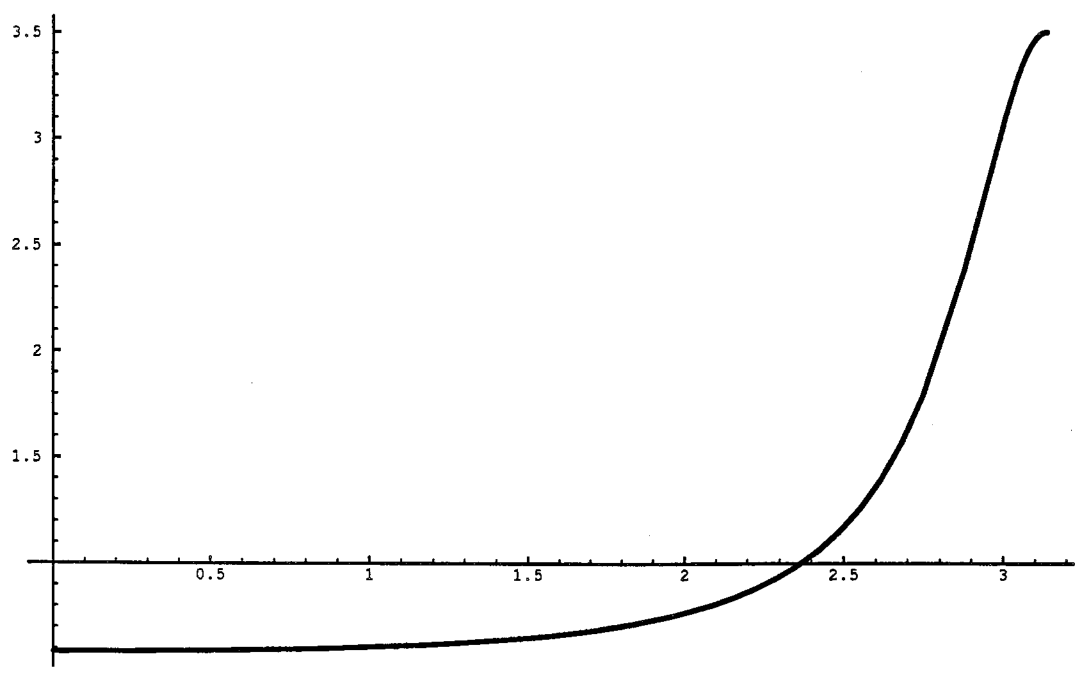

Figure 6 – Sensitivity of radiant position to heliocentric influx angle changes as expressed by the derivative $d\alpha'/d\alpha$.

3. The June Bootid activity in 2000

Small-number statistics

When analyzing the activity of a meteor shower, the Zenithal Hourly Rate (ZHR) gives a standard measure for visual meteor activity according to a formula of the form

$$\mathrm{ZHR} = \frac{n r^{(6.5-\mathrm{lm})} F}{T_{\mathrm{eff}} \sin h_{\mathrm{R}}},$$

where n is the number of shower meteors, r is the population index of the shower at a given time, "lm" is the stellar limiting magnitude, F corrects for possible field-of-view obstructions, T_{eff} is the duration of the observing period, and h_{R} is the radiant elevation at that time. Additional corrections are possible, but this is the basic form of ZHR computation.

The ZHR computed in this way, is by no means a true value. Apart from improper corrections and observers' peculiarities, we face an uncertainty in the number of meteors itself. Indeed, the statistics of random, uncorrelated events tells us that an observed number of events can be caused by various true ZHRs. Given an observed number of meteors, we can calculate the probabilities of all ZHRs to produce this number. The average weighed by these probabilities is the *expectation value* of the rate; it is the best value of a ZHR we may obtain for our meteor number seen. Let us now compute this value.

When actual meteor numbers are very small, we will often encounter zero-meteor periods. The true ZHR behind this observation could be ZHR $= 1$, and we just saw an hour with no meteor, such as there will be hours when 2 meteors are visible. Even ZHR $= 2$ cannot be excluded as, on rare occasions, no meteor may be seen either.

Let us first ask how to convert the meteor number seen into the expectation value of the visible rate, i.e., without considering all corrections yet. Put in another way, we ask for the rate or frequency of the "random-event generator" behind our observation n. If R is the uncorrected visual rate of the meteor shower involved, the meteor numbers follow a Poissonian distribution of probabilities given by

$$p(n) = \frac{R^n}{n!} \mathrm{e}^{-R}.$$

In our case, n is fixed, and R is the variable, so we must write

$$p(R) = \frac{R^n}{n!} \mathrm{e}^{-R}.$$

The expectation value of the visible rate R is obtained by averaging R over all possible values, using the continuous weight function $p(R)$:

$$\begin{aligned}\overline{R} &= \frac{1}{n!} \int_0^\infty R \times R^n \mathrm{e}^{-R} \mathrm{d}R \\ &= \frac{1}{n!} (n+1)! \\ &= n+1.\end{aligned}$$

In particular, if we saw no meteors in one hour, we expect the rate to be one! Notice that, indeed, for $R = 1$, we find $p(n=0) = p(n=1) = 1/\mathrm{e}$: both numbers of meteors have the same probability of occurrence. This means that is very likely that we see no meteors at a rate $R = 1$.

Following the same considerations as with the scatter of a Poissonian distribution, the error on the obtained expectation value $\overline{R}$ is

$$\Delta R = \sqrt{n+1}.$$

(Because of the skewness of the distributions, purists will not give the expectation value, but will say "the rate R lies with a 65% probability in the interval $[\overline{R} - \Delta R, \overline{R} + \Delta R]$.")

Now, the corrections come into play. A long $T_{\rm eff}$ decreases the expectation value of the ZHR below the expectation value of the visible rate, as do very excellent conditions. The zenith correction always increases the expectation value. The expectation values of both the visible rate and the ZHR are never exactly equal to zero, since this would mean we have to prove that no meteors are seen during an infinitely long time period.

Every contributing observer adds his amount of data, i.e., meteor numbers (n_i), effective observing times $T_{\rm eff}$, and (combined) correction factors (C_i). It should be noted now that expectation values cannot be averaged; instead, the expectation value has to be derived from the total. For example, it makes no difference, statistically, if there were two observers watching at $h_{\rm R} = 30°$ ($\sin h_{\rm R} = 0.5$) or one observer watching at $h_{\rm R} = 90°$ ($\sin h_{\rm R} = 1$). Again, we emphasize that do not deal with physical problems or observers' peculiarities here; we derive a suitable ZHR from statistical considerations affecting even the most accurate observation. Hence,

$$\overline{\rm ZHR} = \left(1 + \sum_i n_i\right) \Big/ \sum_i \frac{T_{{\rm eff},i}}{C_i}$$

We can see how tiny the effect of the "1+" is when meteor numbers are large, since $\sum_i n_i$ is typically between 100 and 1000. However, a very weak shower like the 2000 June Bootids is a good target to take the small-number statistics into account.

Where is the radiant?

Another peculiarity makes the analysis of the June Bootids more difficult than that of, say, the Perseids.

When the observer associates meteors with the radiant, he assumes a certain position to which the numbers refer. The radiant may be displaced by zenithal attraction and diurnal aberration by several degrees, and it is obviously not very fixed over the years. Unless there is an outburst making the actual radiant position obvious, shower association can be affected by an incorrectly assumed radiant position.

The above radiant study gave us two likely positions. As mentioned above, we will assume a probable geocentric radiant position at $\alpha = 220°$ and $\delta = +51°$ for the activity analysis. All observations for which meteor path positions were available were reprocessed by the VISDAT program using the new radiant position (again taking zenithal attraction into account). The VISDAT software associates the meteors with the showers consistently among all observers. Some observers may show peculiarities in plotting or speed estimation which cannot be considered by VISDAT. We should not, in general, regard this as a disadvantage; it is in fact an advantage since the program provides information of shower association failure—the program helps diminishing systematic observing errors gradually.

The population index

The meteors now classified as June Bootids were used for an attempt to derive the population index. The method of determining the average magnitude distance from the limiting magnitude was used [4]. It may be worth reminding the reader here that the average meteor magnitude becomes a unique function of the population index only after it has been shifted to a certain standard limiting magnitude, say, +6.5. We use the distance between meteor magnitude and "lm" in order to consistently add all meteors of various observers into one average $\overline{\Delta m}$.

The total of 31 meteors used gives $\overline{\Delta m} = 2.85$ converting into a population index of $r = 2.95 \pm 0.82$ according to the function provided by Richter [4]. The conversion depends on the perception probability of meteors which is also a function of Δm (*not* a function of m). The error is obtained by simulating a large number of magnitude distributions all having 31 meteors, based on a discrete exponential distribution with $r = 2.95$. The actual population indices derived by the mean-magnitude-distance method from these distributions vary due to the very limited number of meteors. The scatter in the r-values is the above error.

The population index is very similar to that of a distribution of sporadic meteors. It is higher than the values obtained for the 1998 June Bootid outburst [5], but the error margins are so wide that the value given here is not more than a suggestive figure in the sense of "significantly larger than $r = 2$," contrasting this shower with most of the major showers.

We will use a rounded $r = 3$ in the following calculations of the ZHR. It must be noted that a considerable number of observations had lm < +6.0; a change of 0.8 in the population index will thus easily change the ZHRs by 50%, while high-lm observations near +6.5 remain almost unchanged.

The ZHR graph

Using the above ZHR and error computation, we obtained a number of averages given in Table 1 and shown graphically in Figure 7. All solar longitudes refer to equinox J2000.0. ZHRs are computed using the radiant elevation of the apparent radiant. The column with ZHR-ranges is simply a more suitable representation of small-number ZHRs. The actual result is that the true ZHR lies with a 65% confidence within this interval. ZHR values for the 1995 and 1997 June Bootids as computed by Seifert in [6] are given in this way.

Table 1 – ZHR values of the 2000 June Bootids. Times are rounded to the nearest quarter of an hour, "Obs" is the number of individual observing periods contributing to the average. The ZHR-range column can be compared with values in [6].

Date	Time (UT)	$\lambda_\odot$ (J2000.0)	n_{JBO}	Obs.	ZHR	ZHR-range
Jun 26	06^h15^m	94°95	1	6	1.0 ± 0.7	0.3–1.8
Jun 26	22^h15^m	95°58	1	5	0.5 ± 0.4	0.2–0.9
Jun 27	00^h45^m	95°68	5	9	1.8 ± 0.7	1.0–2.5
Jun 27	07^h30^m	95°95	9	7	3.8 ± 1.2	2.6–5.1
Jun 27	21^h30^m	96°51	9	9	1.8 ± 0.6	1.2-2.3
Jun 27	23^h30^m	96°58	1	15	0.3 ± 0.2	0.1–0.5
Jun 28	06^h15^m	96°85	7	7	1.6 ± 0.6	1.0-2.2
Jun 28	22^h50^m	97°51	3	15	0.5 ± 0.2	0.2–0.7
Jun 29	22^h00^m	98°44	1	4	1.0 ± 0.7	0.3–1.8
Jul 3	23^h00^m	102°29	1	2	0.9 ± 0.6	0.3–1.6

It should be noted that the ZHR values at $\lambda_\odot = 96°51$, $\lambda_\odot = 96°58$, $\lambda_\odot = 97°51$, and $\lambda_\odot = 98°44$ were obtained almost entirely from those observations which were analyzed by the VISDAT program. Shower association depends sensitively on the error limits set for the path orientation and angular speed estimate. The high values at $\lambda_\odot = 95°95$ and $\lambda_\odot = 96°85$ may thus be caused by different sloppiness of shower radiant velocity matching applied by other observers. The plot in Figure 7 gives therefore two ZHRs for $\lambda_\odot = 95°95$, the lower omitting one observer with the highest June Bootid numbers.

We may give the average ZHRs more significance by choosing larger bins. Since we have no data from Asia, the choice of the bins is easy. Between American/Hawaiian and European observations is a gap of at least 10 hours; thus we obtain daily averages for the periods starting with European dusk and ending with American morning. The result is given in Table 2. The maximum is not significant in the sense of the error margins. A general activity level ZHR ≈ 1 may be the typical background level as obtained by visual observations, even if the meteors were plotted and the shower association was carried out *after the observation according to well-defined criteria.*

The values listed in Table 2 are actually lower than the ZHR-ranges obtained in [6], where the existence of visually detectable June Bootid activity remained questionable, too.

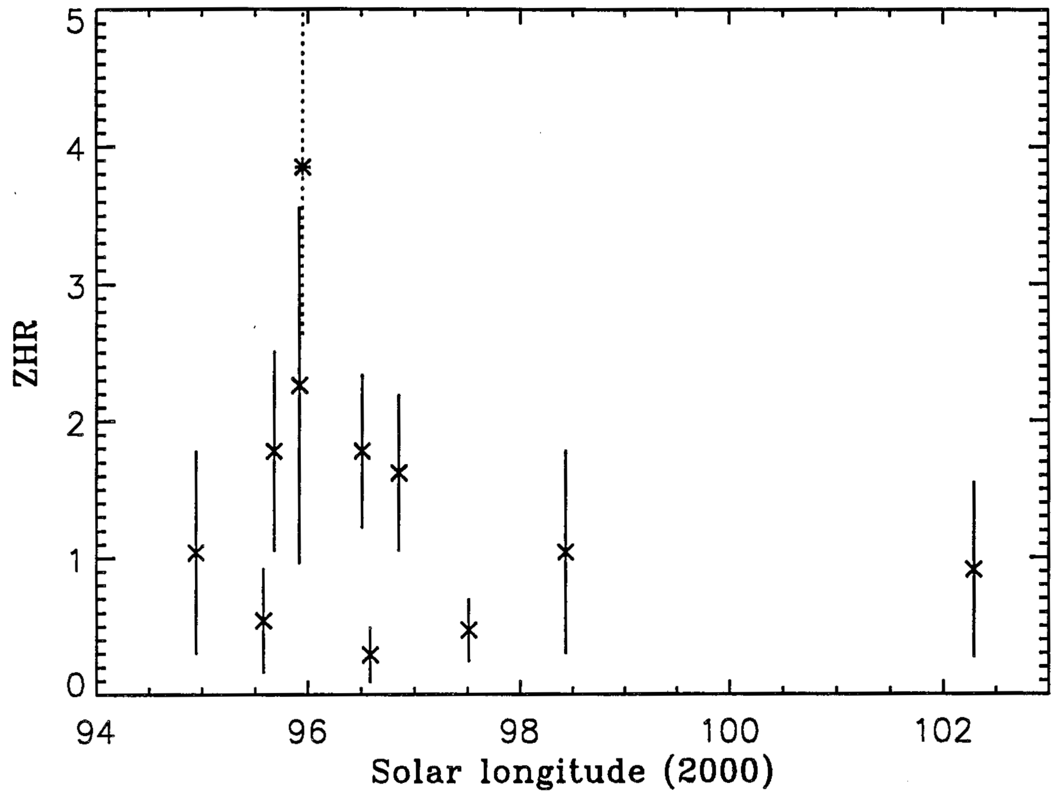

Figure 7 – ZHR profile of the 2000 June Bootids. The dotted ZHR-range is the one given in Table 1, the solid range omits one observer possibly including a couple of sporadics.

Table 2 – ZHR values of the 2000 June Bootids in one-day bins. Again, "Obs" is the number of individual observing periods contributing to the average. Times are rounded to the next hour here.

Date	Time (UT)	$\lambda_\odot$ (J2000.0)	$n_{\rm JBO}$	Obs.	ZHR	ZHR-range
Jun 25-26	6^h	94.°9	6	1	1.0 ± 0.7	0.3–1.8
Jun 26-27	4^h	95.°8	21	15	1.7 ± 0.4	1.3–2.1
Jun 27-28	3^h	96.°7	31	17	1.0 ± 0.2	0.7–1.2
Jun 28-29	23^h	97.°5	3	15	0.5 ± 0.2	0.2–0.7
Jun 29-30	22^h	98.°4	1	4	1.0 ± 0.7	0.3–1.8
Jul 3-4	23^h	102.°3	1	2	0.9 ± 0.6	0.3–1.6

4. Conclusions

Despite the difficulties in determining a meaningful activity profile, the radiant was reproduced quite prominently. Experienced observers' plotting data can obviously provide a variety of radiants corresponding to an existing meteoroid stream. Unfortunately, the knowledge of these radiants is not useful for the investigation of meteoroid stream structure, since the meteor numbers this streams yield are far too small.

It is very logical that the Solar System will be filled with both major and minor meteoroid streams, that a lot of weak sources will exist, that even weaker, almost extinct streams may provide one encounter event per year. The question about a possible new shower found as a convergence point somewhere in the sky is not "Is this shower real?", but "Is this shower helpful?". Does such a shower contribute to our understanding the structure and dynamics of meteoroid streams? The answer may be "no" for the June Bootids in non-outburst years (although, of course, annual monitoring is necessary to witness the outbursts).

To end on a more positive note, this study indicates a promising alternative way to use visual data to validate meteoroid stream models. Meteoroid stream models do not only yield activity profile predictions, but also radiant point predictions. Even in cases where visual observations do not yield a meaningful activity profile, they may yield meaningful radiant points which can be compared with predictions.

Acknowledgments

The present study would not have been possible without the enthusiasm of all the observers who contributed quickly their reports, in particular the efforts of the *Astroclub Canopus* from Varna, Bulgaria. I am therefore grateful to their leading members Valentin Velkov and Eva Bojurova for their help as well as their hospitality.

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Observations of the Cassiopeid Meteor Shower

Audrius Dubietis

Visual observations of the Cassiopeid meteor shower are presented. The processing of data obtained in 1990–1996 shows that the Cassiopeids are a minor shower active almost for one month with a maximum at $\lambda_\odot = 126.^\circ6$ and a typical ZHR value close to 10.

1. Introduction

The Perseid meteor shower always attracts a great deal of interest. The Perseid watch is the main summer event for northern hemisphere observers. During this watch many of minor meteor showers are active, thus the picture of the summer sky in terms of meteor observing is rather complex. Most of the minor showers are well known and have been covered by observations for decades. Nevertheless, several minor showers are still lacking considerable attention. A good example is the Cassiopeid meteor shower, which in fact can easily be monitored during the Perseid watch.

Some evidence of the existence of the Cassiopeid meteor shower dates back to the nineteenth century, pointing to α-Cassiopeids with $\alpha = 11^\circ$ and $\delta = +50^\circ$, active from July 20-21 to August 13 [1,2], and δ-Cassiopeids with $\alpha = 24^\circ$ and $\delta = +52^\circ$ [2]. Znojil [3] processed the data from the years 1957–1968 and listed three radiants located in Cassiopeia as shown in Table 1.

Table 1 – Characteristics of the three branches of the Cassiopeid meteor shower given by Znojil [3].

Shower	α	δ	$\Delta\alpha$	$\Delta\delta$	$\lambda_{\odot}^{max}$
β-Cassiopeids	$5\overset{\circ}{.}1$	$+60\overset{\circ}{.}7$	$+1\overset{\circ}{.}04$	$+0\overset{\circ}{.}20$	$134\overset{\circ}{.}45$
α-Cassiopeids	$5\overset{\circ}{.}6$	$+57\overset{\circ}{.}6$	$+1\overset{\circ}{.}20$	$+0\overset{\circ}{.}19$	$127\overset{\circ}{.}93$
κ-Cassiopeids	$11\overset{\circ}{.}8$	$+65\overset{\circ}{.}8$	$+1\overset{\circ}{.}16$	$+0\overset{\circ}{.}13$	$130\overset{\circ}{.}24$

The β-Cassiopeids are also attributed to a possible fireball stream [4], while the other two radiants were observed telescopically. The Cassiopeid activity has also been noticed by a Crimean group of observers during the Perseid campaign in 1980 when 225 shower meteors have been counted [5]. The maximum was not observed due to a Full Moon; the Cassiopeid activity period from July 7–August 19 has been established, however.

2. Observations

In this contribution, I present visual observations of the Cassiopeid meteor shower during the years of 1990 to 1996. I have collected my observations since 1986 and found that the shower really exists with a maximum ZHR of about 10 at $\lambda_{\odot} = 126\overset{\circ}{.}6$ (eq. J2000.0, July 29-30). The observations were carried out in Salakas, Lithuania, at $\lambda = 26°16'$ E and $\varphi = 55°58'$ N. During the period 1990–1996, a total of 5631 meteors was observed between July 21 and August 17, and 497 of them were attributed to the Cassiopeid shower.

It must be noted that there are no observations until July 21, as the sky conditions are quite bad due to bright skies for observers located in the north (the typical limiting magnitude for this period is +5.5 to +5.7 and the short nights allow only a few hours of observation).

Table 2 – Observing periods covered by the author in 1990–1996.

Year	Observing period	Observing Time	N
1990	Jul 21–Aug 25	$46^{h}20^{m}$	106
1991	Jul 22–Aug 21	$46^{h}51^{m}$	121
1992	Jul 24–Aug 08	$27^{h}48^{m}$	94
1994	Jul 29–Aug 18	$29^{h}30^{m}$	55
1995	Jul 21–Aug 21	$24^{h}33^{m}$	66
1996	Aug 03–Aug 13	$25^{h}51^{m}$	55

The Cassiopeids are swift, white meteors, and up to 40% of them leave persistent trains. The mean radiant of the shower is located at $\alpha = 14°$ and $\delta = +62°$ (July 28). It is an approximate radiant position as listed in [6], and, in several years, another two centers of radiation in Cassiopeia are active. My own observations reveal rather three active radiants of Cassiopeids: $\alpha = 0°$ and $\delta = +59°$; $\alpha = 10°$ and $\delta = +62°$; $\alpha = 22°$ and $\delta = +61°$. The shower is rich in faint and short meteors. The activity of the Cassiopeids spreads for almost one month, until about August 17. Another typical feature of the Cassiopeid activity behavior is the irregular activity even approaching the maximum. Large fluctuations in meteor hourly rates (from 2 to 10) around the maximum make the definition of the true maximum quite complicated. Moreover, in some years, the maximum seemed to be shifted to $\lambda_{\odot} = 130°$ (August 2), as it happened in 1994.

3. Magnitude distribution

The detection probability coefficients were computed using data set of sporadic meteors observed under ideal conditions (no moonlight, no clouds, and Lm = +6.5) in 1992–1996 as given in Table 3.

Table 3 – Magnitude distribution of sporadic meteors from 1992–1996 for detection probability determination.

Magnitude (m)	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot
Sporadics ($N(m)$)	2	6.5	21.5	52.5	88	139	152	90.5	18	571

In order to obtain the detection probabilities, I assumed that, for the true number of meteors, $n(0) = N(0)$, i.e., all meteors of magnitude 0 in the field of view were counted ($P(0) = 1.0$). The function $P(m)$ was found as $P(m) = N(m)/(N(0)r^m)$, using $r = 3.4$ for sporadic meteors.

The calculation yielded the following values: $P(0) = 1.00$, $P(+1) = 0.72$, $P(+2) = 0.36$, $P(+3) = 0.17$, $P(+4) = 0.053$, and $P(+5) = 0.01$. Then the true number of sporadic meteors $n(m) = N(m)/P(m)$ is a linear function of the magnitude in a logarithmic plot with slope $\log r$, as shown in Figure 1, (a).

The magnitude distribution of Cassiopeid meteors was found after the following procedure. Observations under unfavorable conditions were omitted, and the data set of Cassiopeids was thus reduced to 440 meteors which distribute over the magnitude classes as given in Table 4.

Table 4 – Magnitude distribution of the Cassiopeids.

Magnitude (m)	−1	0	+1	+2	+3	+4	+5	+6	Tot
Cassiopieids ($N(m)$)	6	16	36	44	100	124	94	20	440

The observed numbers of Cassiopeids $N(m)$ were corrected by the detection probabilities $P(m)$ and plotted as shown in Figure 1, (b). A linear fit yielded $r = 3.43$, which was used in the calculations of the ZHR.

It must be noted that two different values of r according to the plot in Figure 1, (b) can be obtained. For the magnitude range $m = -1$ to $m = +2$, the linear fit gives $r = 2.77$, whereas for faint meteors ($m = +3$ to $m = +5$), $r = 4.00$ as shown by the dashed lines.

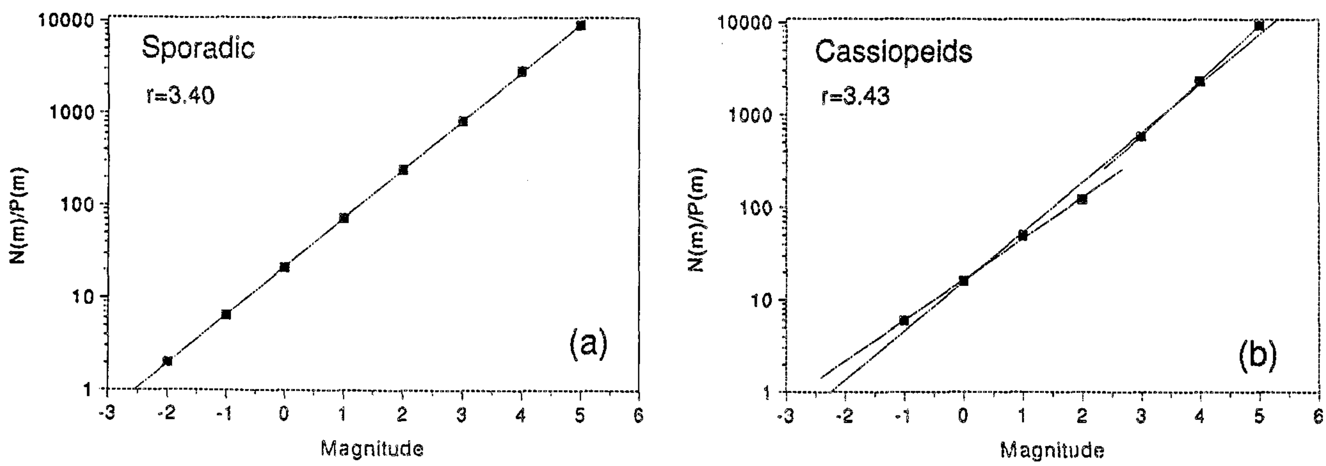

Figure 1 – Numbers of meteors corrected by the detection probability $n(m) = N(m)/P(m)$ as a function of the magnitude. Graph (a) is for the sporadic meteors, used for the derivation of $P(m)$; graph (b) for the Cassiopeids.

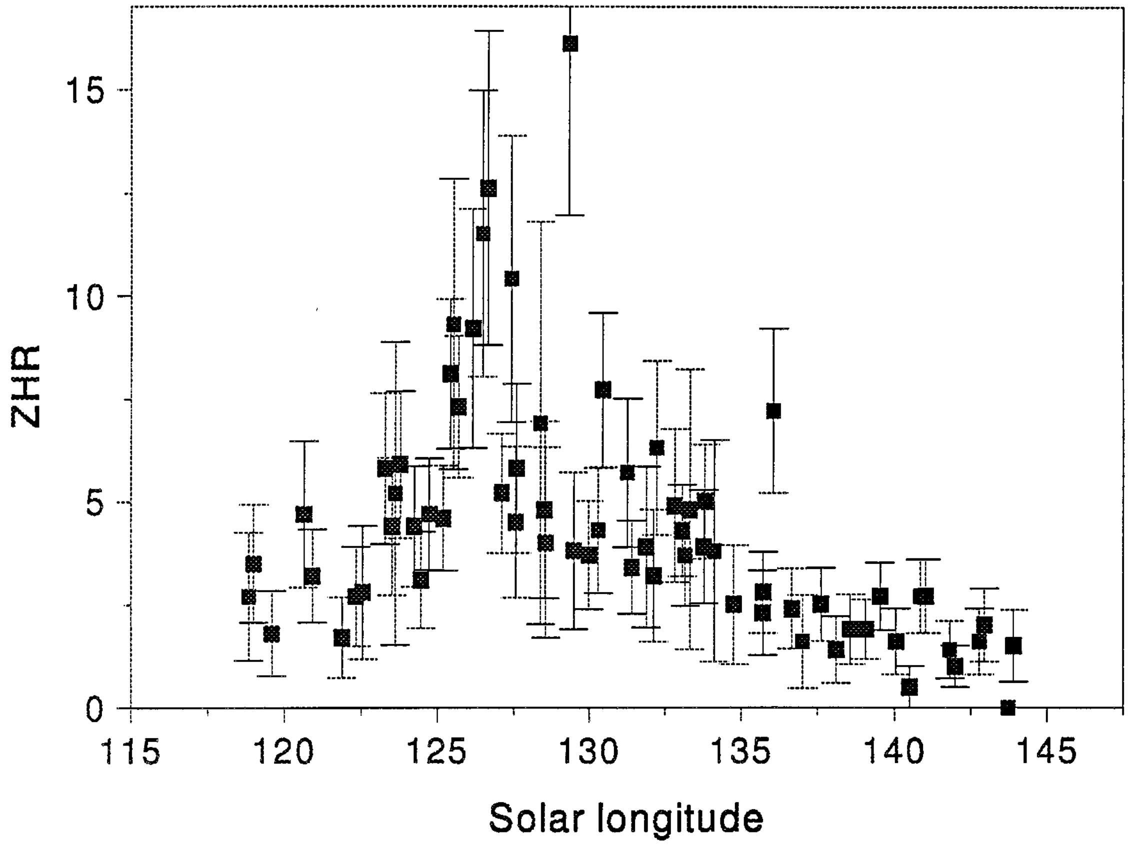

Figure 2 – The activity profile of the Cassiopeid meteor shower.

4. Hourly rates

The Zenithal Hourly Rates (ZHRs) were calculated using the standard formula [7]:

$$\mathrm{ZHR} = \frac{N}{T_{\mathrm{eff}}} \frac{r^{6.5-\mathrm{lm}}}{c_{\mathrm{p}} \sin^{\gamma} h_{\mathrm{R}}}.$$

The radiant elevation h_{R} was calculated for the mean radiant position, i.e., $\alpha = 10°$ and $\delta = +62°$, as the radiant motion was not defined. The perception correction c_{p} was derived using the data set of sporadic meteors, observed in the period July 26–August 5. The period of observations was highly disposed towards the definition of c_{p}. The sporadic rates are HR = 10 meteors per hour at 0^{h} local time for the beginning of August, and this period was well covered by the observations. The coefficient c_{p} was defined as the ratio of the observed, corrected sporadic hourly rate (corrected for limiting magnitude) and a standard value of HR = 10 [7]:

$$c_{\mathrm{p}} = \frac{N_{\mathrm{Spor}} r^{6.5-\mathrm{lm}}}{T_{\mathrm{eff}} \times \mathrm{HR}}.$$

The mean value of c_{p} was obtained by averaging 28 estimates yielding $c_{\mathrm{p}} = 1.17$. As for the zenithal exponent γ, a value of $\gamma = 1.0$ was applied. Figure 2 represents the Cassiopeid activity constructed from observations of 1990–1996.

The ZHR was calculated for each hour (or period) of observations and then averaged through the night. Each point represents the mean value of at least two successive periods per night. Error bars represent the standard deviation of the mean ZHR value: $\sigma\mathrm{ZHR} = \mathrm{ZHR}/\sqrt{N}$. The maximum observed ZHR values are listed in Table 5.

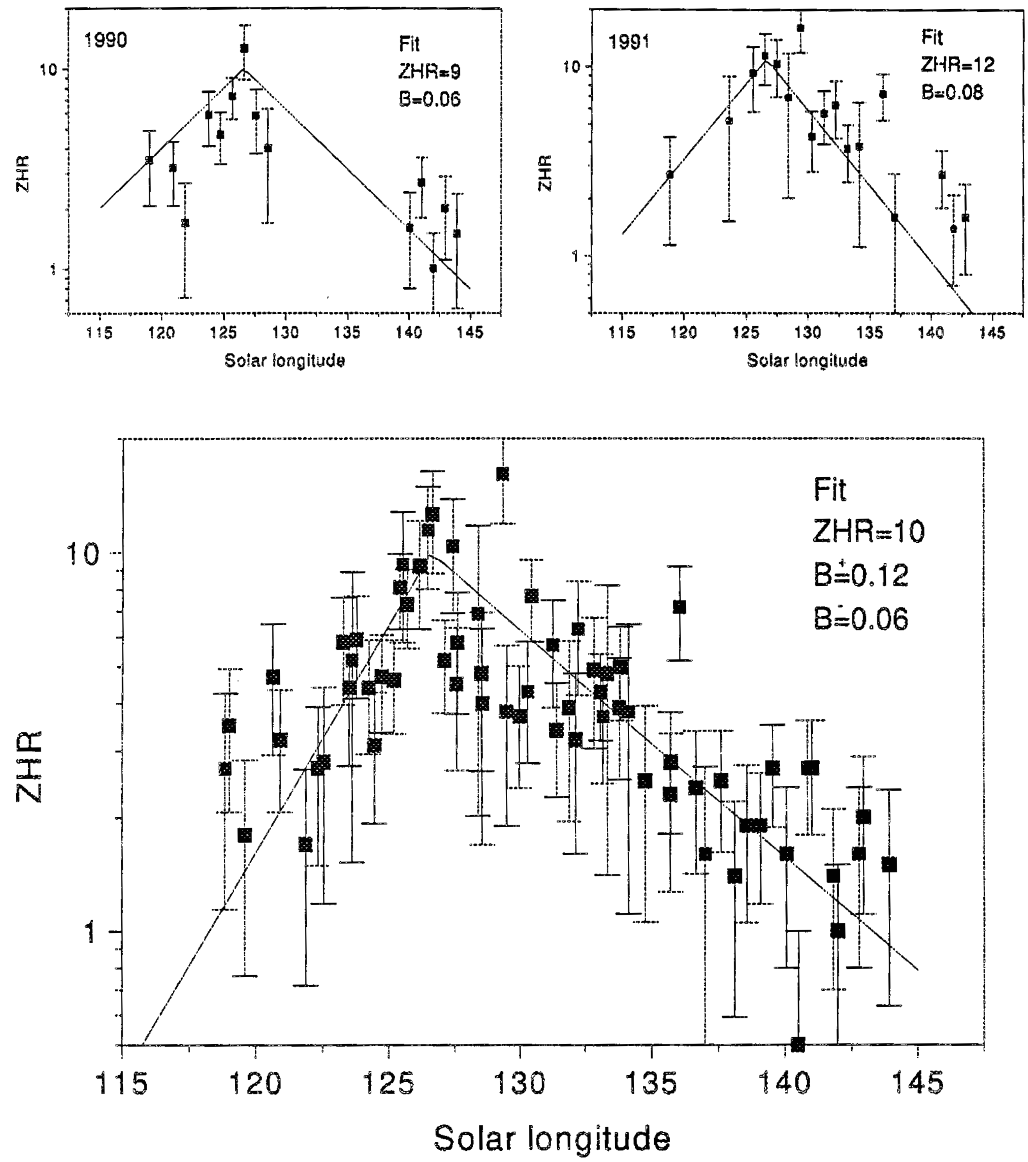

Figure 3 – Logarithmic plots of Cassiopeid activity profiles.

Table 5 – Maximum ZHR of the Cassiopeids as observed in 1990–1995. The 1991 ZHR may be overestimated due to changing observing conditions in a short period. Also note that dates (i.e., solar longitudes, $\lambda_{\odot}^{max}$) and ZHR values might not fix exactly the maximum.

Year	$\lambda_{\odot}^{max}$	ZHR	Year	$\lambda_{\odot}^{max}$	ZHR
1990	$126\overset{\circ}{.}6$	12.6 ± 3.8	1992	$126\overset{\circ}{.}2$	9.2 ± 2.9
1991	$126\overset{\circ}{.}5$	11.5 ± 3.5	1994	$130\overset{\circ}{.}4$	7.7 ± 1.9
1991	$129\overset{\circ}{.}3$	16.1 ± 4.1	1995	$125\overset{\circ}{.}4$	8.1 ± 1.8

Due to the scatter of the data points (Figure 3), a fit of the shower's activity profile by the equation $\mathrm{ZHR} = \mathrm{ZHR}_{max} 10^{-B|\lambda_{\odot} - \lambda_{\odot}^{max}|}$ is rather difficult. The activity profile of 1990 was fitted with the parameter set $\mathrm{ZHR}_{max} = 9$ and $B = 0.06$, whereas the best fit for observations in 1991 yielded $\mathrm{ZHR}_{max} = 10$ and $B = 0.08$.

The fit of the total activity profile constructed from the data of 1990–1996 exhibits a somewhat asymmetric character with $B^{(+)} = 0.12$ for the ascending branch and $B^{(-)} = 0.06$ for the descending one, accounting for ZHR = 10 and $\lambda_{\odot}^{max} = 126.^{\circ}6$. The asymmetry may be caused by the absence of data for solar longitudes earlier than $\lambda_{\odot} = 118°$, as my own observations in 1989 (not included in this study) reveal some activity of Cassiopeids even in the first decade of July.

Acknowledgment

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1999 Leonids

SPA Meteor Section: 1999 Leonids—Personal Recollections

Alastair McBeath

Personal recollections and comments extracted from communications sent to the *SPA Meteor Section* from the 1999 Leonid epoch are given. A brief obituary is presented following the death of one of northeast England's great astronomical characters, Joe McKie, on November 16. Meteoric items noted here include cautionary tales of some pitfalls of storm observing and unusual observations of possible meteor "jets."

1. Introduction

This article concludes a series of three on the *SPA Meteor Section*'s view of the 1999 Leonids. An interesting element of meteor watching is how humans react on viewing exciting events like a meteor storm, or indeed how they react when they miss one for whatever reason. As meteor observing is primarily an unpaid, voluntary pursuit, personal enjoyment is as valuable and valid a means of expression as any other, and can provide insight or even new topics for discussion along the way. Consequently, this paper consists of such personal recollections and comments extracted from various communications received by the *Section* from the 1999 Leonid epoch, to give a flavor of what people saw and how they reacted.

As all the *SPAMS* observers have been previously named in the two earlier *Section* articles [1,2], those lists are not repeated again here. Names and locations are given for all those whose comments are used here, however.

For those who may wish to investigate, or simply read and enjoy, further recollections, Jim Richardson of the *American Meteor Society* set up a dedicated website during the 1999 Leonids to collect comments from those with Internet access. Those narrative reports are available at `http://www.amsmeteors.org/leo99update.html`. A printed version is scheduled to appear in the *AMS* magazine *Meteor Trails* in due course.

We begin on a rather somber note with a short obituary, given here because of the impact it had on perceptions of the Leonid storm in northeast England.

2. Joe McKie, 1930–1999

Joe McKie was for many years one of the leading lights of amateur astronomy in northeast England, and remained one of *Newcastle Astronomical Society*'s four Vice-Presidents up to his death on November 16, 1999. He was a natural and gifted teacher, author, and communicator, who bubbled over with enthusiasm for the topics he dealt with and the people he met and knew. He gave lectures and classes on a wide variety of matters apparently effortlessly, and possessed an encyclopedic knowledge of his favorite subjects. Though increasingly seriously ill in his later years, he continued to teach evening classes in astronomy, mythology, metaphysics, and parapsychology until only a few years ago, entertaining and enthusing all involved along the way. He was a great believer in keeping an open mind, and to examining the evidence for phenomena, rather than merely complying with currently fashionable dogmas and beliefs. I am happy and proud to have known Joe, and to have worked alongside him briefly in the mid 1980s, when we helped set up and run an astronomy course for local school teachers. Although not a meteor observer, he could make even an ordinary starry sky come alive with interest, let alone a sky full of meteors. Among his many passions, Joe had made a particular study of beliefs in spiritualism and life-after-death. Some who knew him in northeast England, and who were out to catch the 1999 Leonid storm under a partly clear sky, later wondered if our good fortune was not a final farewell from Joe. If anybody could make something like that happen on his way out, it would be Joe!

3. Personal recollections of the 1999 Leonid storm night

As we saw earlier [2], it was chiefly northern England and the southern half of Scotland that enjoyed the best, though still cloud-affected, view of the Leonid storm night in the UK. This meant that one of our longest-established observers, George Spalding, who observed the 1966 Leonids from Scotland (as described in [3]), but who now lives in Oxfordshire in southern England, missed the event completely. He summarized his 1999 Leonid observations as follows:

> *"November 16-17 was largely good, though a cloudy gap of at least two hours occurred, reducing the amount I was able to do. I was very disappointed with the rates for this night and thought (erroneously) that it boded badly for the critical night.*
>
> *I was quite hopeful on November 17 that there would be a clear spine down the middle of the UK, encouraged by pretty favorable weather forecasts, and a beautiful day. However, the clouds from the west came in so rapidly around tea-time that I knew we were doomed. There was then drizzle by midnight. So it was a grave disappointment, especially when I found out on the Web by* 6^{h} *a.m. of the great events elsewhere.*
>
> *On November 18-19, I perhaps erred in waiting till moonset before starting to observe, as it clouded up fatally after only half an hour. However, it was evident that activity was pretty low. November 19-20 was again partly clear after moonset, but by then I had lost interest.*

George was not alone in missing out in the UK or beyond, either because of cloudy skies or the storm's timing. Jay Brausch in North Dakota, USA, who had clear skies on November 17-18, summed up the feelings of a surprising number of North American observers thusly: *"the greatest disappointment of this year's shower was the storm long-awaited that never came."*

Having traveled from Britain to Bali in Indonesia, Michael Maunder was also unimpressed by nonexistent Leonid rates in clear skies on November 16-17. He went on to record no Leonids at all on November 17-18 (in a very cloudy sky generally) or November 18-19, while Leonid rates were busily showing a surge to ZHRs of perhaps 150+ above the overcast he endured then.

Back in western Scotland near Ayr, Tom McEwan found that even partly clear skies were no guarantee of seeing anything, when he fell asleep from exhaustion shortly before 2^{h} a.m. on November 17-18. It had been overcast up to then, but he was dismayed to find on waking around 6^{h} a.m. that skies had broken shortly after he slept, and the excitement on the Internet and among his friends and colleagues at *Ayr Astronomical Society* began to demonstrate what he had missed.

From the Ayr group, Nick Martin and three other observers spent a frustrating first half of November 17-18 watching clouds either live outdoors or on a monitor showing Meteosat images, as the edge of the cloud-sheet crept nearer to them. Around 2^{h} UT, the clouds at last started to fragment, and in even quite small gaps, it was obvious the sky was full of meteors, including a magnitude −6 fireball and another unseen fireball that lit up the sky. Nick commented on seeing a strange effect with a couple of his moderately bright Leonid meteors, where a spark-like object seemed to angle away from the line of flight. Another of the Ayr observers also saw this, and the phenomenon may be similar to apparent jets from several meteors recorded on video by Bob Hawkes during the 1998 Leonid fireball night. Indeed, Nick's reports have been included in a recent paper by Bob Hawkes discussing this subject.

Nick also remarked that many of the Leonid trails he saw were green in color, something echoed by other people, including a new *SPAMS* observer Pamela Foster in Pitlochry, Scotland. Pamela was lucky in managing some watching on both November 16-17 and 17-18, and on the latter night recorded a healthy number of meteors in spite of often very poor skies. She was even able to estimate a peak time of between $2^{h}00^{m}$ and $2^{h}05^{m}$ UT from her own observations alone, close to the time many other lucky British watchers found their highest Leonid counts, too.

At Livingston, about 20 km west of Edinburgh, Tom Patton had gone to bed under cloudy skies, but happily woke later and described his view of the events on November 17-18 in almost real-time via e-mail:

> $2^{h}52^{m}$ *UT: Standing in the freezing cold in my dressing gown. Just got up for a cup of tea! Skies clear just now over Livingston. Leonids every few minutes. I'm going to get pneumonia. Great sight!!*
>
> $3^{h}29^{m}$ *UT: Saw lots of shooting stars over the last 30 minutes moving across the east/south high up and low down. Moving singly or in pairs in different directions and of varying intensity. It's bitterly cold here in Scotland, so off to bed with a very large single malt to celebrate!*

In Edinburgh itself, Mike Holmes was out watching with a few friends:

> *We went up Blackford Glen in Edinburgh and set up a small fire to ward off the cold. It was 100% cloud cover when we went out there at* $12^{h}30^{m}$ *a.m., but we thought we'd try to be optimistic. By* 1^{h} *a.m., we could see Jupiter and the brighter stars through thin cloud and began to see the occasional meteor. By* $1^{h}25^{m}$ *a.m., the haze was thin enough that we could see magnitude +3 stars through it, and we'd started counting meteors. The valley is deep enough that we could only see half the sky, and only the east and above us had cloud thin enough to see through. Half of Leo had risen above the angle of the hill. We could see the Plough above one hillside and Orion above the other. We saw about one meteor per minute up to around* 2^{h} *a.m., when they ramped up to about five per minute. We saw quite a few doubles and a couple of times saw four at once. When trails were visible these were always quite bright green. By* $2^{h}45^{m}$ *a.m. ,fairly thick cloud had covered the sky again. We'd seen over 330 meteors by our count at that point, which is probably more than I've seen in total from 30 years of trying to watch meteor showers. Quite a night!*

Such count numbers were very typical from the cloud-influenced UK data. At South Shields by the mouth of the River Tyne east of Newcastle, Eva Hans stood watching outside the door of her home for an hour or so from about 2^h UT, turning in when the cold grew too much, but not before she had counted 100 Leonids in a mostly cloudy sky. My own count at Morpeth, some 20 km northwest of Eva's site, was 187 Leonids in $1\overset{h}{.}27$, between 1^h55^m and 4^h25^m UT, as a further instance (limiting magnitude around +6.1, average cloud cover 55%!).

At Derwent Reservoir, on the Durham-Northumberland border about 40 km southwest of Morpeth, Dave Newton remarked that the problems there were more mist which had lifted into low cloud, but that a clearer area seemed to have formed above the reservoir itself, as if warmer air was rising from the surface of the water, and punching a hole through the clouds specially for him and his colleagues from *Sunderland Astronomical Society*. Dave mentioned that Leonid rates started to shoot up rather like turning on a tap after 1^h40^m UT, but had tailed off before 3^h UT. Typically, sky conditions were at their best between roughly 3^h30^m and 4^h30^m UT! Even so, *there were plenty of bright meteors though, making it a good display despite the weather, although not the storm of fireballs I had hoped for.*

In Mechelen, Belgium, one of the original prime movers who set up the *IMO*, and its first Secretary-General, Paul Roggemans, was delighted with what was visible there of the Leonid storm, despite again unhelpful skies, with a poor limiting magnitude and a lot of clouds. Paul still managed to spot 99 Leonids between 2^h02^m and 2^h19^m UT, and noted that overall these were *the best rates I have ever seen under such poor sky conditions!*

On Malta in the central Mediterranean Sea, normally noted for its fine, dry weather, Martin Galea de Giovanni reported that two teams of watchers, one at the northernmost point of Malta, the other at the southernmost, spent an almost fruitless night watching clouds. The two groups maintained contact by radio, *but the only use of this was that the team from the north managed to warn the south of more showers (rain)!* The northern group did eventually manage to spot five meteors when the clouds thinned momentarily, but the southern team spotted just a single meteor all night.

The western and eastern ends of the Mediterranean were favored with better skies. Spain and Portugal provided some of the best views from Europe, and many people had headed there, often at short notice, to take advantage of the predicted clearer weather. Steve Evans and his colleague Andrew Elliott were in the Algarve region of southern Portugal, having struggled with careful handling and customs bureaucracy to get all their photographic and video equipment safely from Britain to Portugal intact. Sky conditions for the Leonid storm were indeed excellent, and a mass of valuable data was collected, but Steve said afterwards, *my only regret is that I was so intent on making sure the equipment was working correctly that I did not have time just to look at the sky and enjoy the show, but even so the display was truly impressive.*

In southern Spain, not far from Alicante, Marco Langbroek and several other observers from the *Dutch Meteor Society* had set up their observing camp on November 17-18. Marco described the night as being quite surreal during the storm, with four visual observers all chanting *"yes, yes, yes"* simultaneously into their tape recorders as each fresh Leonid appeared. He commented too that all four were mentally and physically exhausted afterwards, a psychological impact that nobody had expected beforehand. He also found he overreacted to quite ordinary demands during the storm's height, panicking when having to change his tape and not being able to think clearly enough to do it with normal efficiency. This phenomenon may well play a part in tales of people reacting with terror on witnessing such an event.

Across the Strait of Gibraltar, in Morocco, our man in Marrakesh, Stan Armstrong, had a similar experience of people calling out in unison on seeing every new meteor. Stan and part of a group of Australian visitors decided to use the sixth floor roof of their hotel as their observing platform for the storm, a stable location for his regrettably unsuccessful photography, but with excellently clear skies for more than three hours from local midnight till after 3^h a.m. The limiting magnitude was affected by streetlights, and was only about +4.5 at best, but with rates of around 15 Leonids a minute at times, nobody was complaining. Stan remarked that he hoped no one had overheard them, as a line of ten young Australian women lying on the rooftop crying out *"yes, yes, yes"* to the Leonids made it sound more like an orgy was in progress, not a meteor storm!

Further south off the Northwest-African coast, a number of European observers had made for the Canary Islands as a suitable site. Later reports suggested those on La Palma had mostly been stuck beneath clouds, but those on neighboring Tenerife had seen the storm well. Maggie Daly and Robin Scagell had traveled with a group of Britons to Tenerife, and there met up with some of the German *AKM* observers (including Petra Rendtel and Hartwig Lüthen) as well as a couple from the USA, the lady of whom was called "Leonid," having been born near the time of the storm in 1966! Both Maggie and Robin carried out photographic observations, but took plenty of time to visually enjoy the spectacle as well, though Robin later commented of his photos, *it is a bit unfair that a 7-minute exposure made as the meteors were at their maximum did not record any at all!* Maggie said that they somehow managed to transport a lizard from their lava field observing location back to the hotel inside one of the equipment cases after the storm ended too!

Of course, no round-up of recollections like this would be complete without some comments from the Near East, where the Leonid radiant was at its highest before dawn twilight at the storm's maximum. Robert McNaught had headed off to Jordan with his colleague David Asher to witness the storm, and there observed alongside members of the *Jordanian Astronomical Society* (*JAS*) led by Mohammed Odeh. It was most appropriate Robert should choose to observe with a *JAS* group, as he was a former Director of the *JAS* (though, here, the acronym stands for *Junior Astronomical Society*) Meteor Section, now the *SPA* Meteor Section, back in the late 1970s. The view from Jordan was superb, as expected, but Robert commented there were a great many journalists present as well as meteor observers, and this sometimes created problems. He drew particular attention to a German journalist, who decided he could wait no longer to send his story back to his newspaper, and so he drove off with his car headlights blazing just as the storm was reaching its peak around 2^h UT, amid the loud complaints of the dark-adapted meteor watchers!

Robert was also able to clear up one small mystery. Many UK evening newspapers on November 18 and the morning papers next day carried a photograph supposedly showing Leonid meteors raining down over the Jordanian desert, but as *Section* correspondent David Frydman in London and other astronomers in the following days said, the photos were simply of star trails in a quite bright sky, with no meteors visible at all. The answer was simple. Robert had noticed a number of the journalists with the *JAS* group taking time-exposure photos of the night sky soon after dark, but before moonset. These had been taken up by the various press agencies and passed on as supposedly showing the Leonid storm, which had really happened only hours later!

Acknowledgments

Once more, I extend my thanks to all observers who contributed information to the *SPAMS* from the 1999 Leonids. Let us hope even better storm rates are still to come from the shower in the next few years!

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Leonid Multi-Aircraft Campaign Workshop—An Amateur's View

Tel Aviv, Israel, April 16–19, 2000

Robert J.M. Barron

Let me introduce myself: I am 22 and am an officer in the Israel Defense Force. Since January 9, 1987, I have considered myself an amateur astronomer (I remember the date because that was the first day I cut out a newspaper clipping and pasted into the first of many astronomy scrapbooks).

A few months ago, I attended the Annual General Meeting of the *Israeli Astronomical Association.* It was a rather regular meeting: a few lectures, the annual budget, and, of course, a summary of what the Association had done during the Leonid meteor storm. One item of the agenda, however, stood out—Mr. I. Manulis informed us that, in the coming April, there would be an international conference on the Leonid meteors on the campus of the Tel Aviv University. My interest was immediately piqued, and I decided to visit the web site of which Mr. Manulis had said that it advertised the coming conference (`http://leonid.arc.nasa.gov/workshops/`).

I soon discovered that the Leonid *Multi-Aircraft Campaign* (*MAC*) was the scientific program which took two planes, equipped with high-tech cameras (and low-tech astronomers to look at the screens) to observe the 1999 Leonid meteor shower. Since the shower's peak had been over Israel, and Tel Aviv had been the starting point for the planes on the night of the storm, the Tel Aviv University was chosen as the site for the summary workshop.

I was quite impressed with the site, although one thing bothered me. I could not find where amateurs were supposed to sign up—the whole thing appeared to be aimed completely at professional astronomers. I was thoroughly intimidated by the registration procedure—it seemed to assume that I had a degree and was planning to present my findings to my peers. Needless to say, I did not. So, summoning my courage (and making sure through Mr. Manulis that amateurs *were* invited), I simply ignored all the registration items which were irrelevant (or incomprehensible) to me, i.e., the presentations and the various flight and lodging arrangements—unnecessary to me since I live in Israel less than an hour from the University.

The big day arrived. I breathed a sigh of relief as I walked up to the gathering of strangers; I was not late and I had arrived at the right place. Standing in line at the registration booth, I looked along the corridor and saw people sticking and stapling all sorts of interesting looking posters and pictures to cork stands. My apprehension quickly left, everyone seemed to be in such a good mood—I quickly realized that most of these people knew each other and this was not only a scientific conference, but also a reunion of sorts.

I registered and got an official "Leonid MAC Workshop" bag full of goodies. Goodie number one was a nametag. To my great amusement, I had been granted a degree or two, because the name was "Dr. Robert Barron" and not the "Mr." my high-school education deserves. My amusement lasted about one second when I saw people who had "Dr." and deserved them. I solved my problem by simply covering the erroneous prefix with a small piece of paper. I was especially relieved I had done this, when one of the first lecturers to stand also apologized for masquerading as a "Dr.," for he was still working on his thesis! At least a degree or so below average, I wandered along to the posters. I was pleased to see how lucid they were—really a delight to the eye and the mind.

I found my seat in the auditorium and unpacked the bag I got. Hmmm, a pen, tons of Tel Aviv University propaganda, and the conference's Agenda and Abstracts notebook. I gleefully leafed through it as I waited for others to take their seats. I went into the workshop not really knowing what to expect; not only had I never been to a scientific meeting of this caliber, but what *was* there to talk for three days about the Leonid meteors? I was expecting, say, a day about the historical aspects of the meteor shower, a few hours of statistics from innumerable sites around the world, future predictions which had a 50% margin of error, and, of course, how the Internet had revolutionized meteor watching, i.e., highbrow CNN... In three words? I was wrong. Just by glancing though the abstracts, I could see I was in for an astronomical treat! True, the abstracts of the first day did show signs of statistics and high-tech gizmos, but there was no sign of hyperbole what so ever. After the brief introductions by the hosts and representatives of the Israeli Space Agency, the Workshop began in earnest.

In the following few paragraphs, I will endeavor to give some "highlights" of the Leonid MAC Workshop; emphasizing more my feelings, as a layman, than being a proper synopsis of the workshop.

The first thing I noticed was how different the atmosphere here was to that of a TV interview or Internet website, the speakers simply "spoke normally," there was no "talking down" or simplifying for the layman. These people were in their element—and swimming fast. Dr. David Asher (Armagh Observatory) was the first to speak. He was one of the people who created the meteor stream model and one of the "celebrities" (if one may use that word) of the Workshop. I was impressed with his quiet certainty when he described the various particle streams and where Earth would be positioned in each of the future passes. One got the feeling he was reading from a history book rather than predicting the future.

Skipping forward to Dr. Hajime Yano (Institute of Space and Astronomical Sciences, Japan), who spoke often during the Workshop, we got a glimpse both of the latest imaging systems which created some amazing images during the meteor storm but also of some future-tech: a mini-satellite being developed in his university in Japan which will be sent up just before the 2001/2 shower and analyze the Leonids from above. Among other things, the images it might show would be of meteors cascading into the radiant!

Another very interesting lecture was that of Dr. Colin Price (Tel Aviv University), who spoke of measuring the Leonid meteors in the Very and Extremely Low Frequency (VLF/ELF). The interesting thing about these frequencies is that it could very well be responsible for meteor "noises" as they shoot through the sky.

I was impressed both by the *Dutch Meteor Society* (represented by Dr. Pavel Spurný), who set up two observation stations in Spain (these are amateurs?!) and by the "Lunar Leonids" spoken of by Dr. Luis Bellot (Instituto de Astrofisica, Spain). I had read of them on the Internet, of course, but I had not realized to what depth they had been analyzed and what scientific results could be gained from observing them.

Speaking of science, I came to the workshop holding the assumption that I assume most people hold; namely that meteoroids were "just" small rocks or grains of sand burning up in the atmosphere. The seminars were a real eye-opener—lecture after lecture described the physical characteristics of meteoroids, not as simple objects, but as complex conglomerates of silicates and ices with strange producing complex spectra at various heights in the atmosphere. I have just gone through about ten lectures with one sentence, but I think that was the best way to express how the seminars each complemented each other, each giving another aspect of the meteors and together building a complex model of what just three days earlier had seemed to be an extremely simple object. Another thing about the lectures was the audience. After the lectures, the audience often bombarded the speaker with questions, seemingly not wanting him (or her) to leave the stage and change the subject. Many of them were interested in all aspects of the meteors and not just in whatever they had come to talk about. The hosts (Dr. Peter Jenniskens and Dr. Noah Brosch) were especially adroit at milking an extra five or ten minutes out of a lecture. Dr. Jenniskens's enthusiasm was especially marked. He seemed bubbling over with it whenever someone around him was talking about meteors!

Towards the end there was a bittersweet lecture by Capt. S. Butow (U.S.A.F.) about the U.S. government's view of the project. After the favorable introduction, I was dismayed to learn that, if anything, the Leonid MAC project was too much of a success. There was no reason to repeat it during the next storms in 2001/2! This naturally raised a storm from the floor and a short debate began on how best to convince the U.S. government that a repeat of the mission was needed.

From my point of view, one of the highlights of the week was not a specific lecture but a short encounter with Dr. Yano during one of the breaks. An article from the daily newspaper *Ha'aretz* ("The Country") had been posted there. After translating the short piece for Dr. Yano, we spoke for a few minutes. He asked me where I had been during the night of November 17. (He had of course been on one of the NASA planes flying over the Mediterranean and Atlantic). I sheepishly admitted that, far from aiding science and taking part in one of the many official counts around the Israeli countryside, I had wandered over to a nearby strawberry field and had simply wandered around getting a crick in my neck from starting up at the sky. He laughed and admitted than he would have liked to have done that too. I suddenly felt a feeling of kinship with the other members of the Workshop and felt more than ever that my future place was with them. Not quite an epiphany, but a great feeling of belonging.

There is much more to tell of the period between April 16 and 19, 2000. I must at least name the Starfire Optical Range experiments and the Romanian Leonid-inspired poetry as things I have not referred to but was very impressed by. Nor have I mentioned the many other participants with whom I spoke or whom I heard during the conference. Worth a mention were my non-astronomy activities during those few days, for example, meeting some old friends I met on campus during the Workshop. Rather than a comprehensive review of the conference, this has been a short trip down memory lane, reminding myself of the mood I had been in during the conference. How much I learned there and, especially, how much I enjoyed simply being in the company of "professional" astronomers, a group which I hope to join someday.

I would like to re-read this account at some future time as a professional astronomer, and be reminded of my first venture into the world of professional astronomy.

Observational Results

Two 1999 Perseid Orbits from Spain

Josep M<u>a</u> Trigo-Rodriguez, Juli Castellano-Roig, Antonio de Ugarte, Julián Ruiz-Garrido, Juan Fabregat, and Jordi Llorca

During the night of August 12-13, 1999, two bright meteors (SPMN 990801 and 990802) were photographed from two stations of the *Spanish Photographic Meteor Network (SPMN)*. We have been able to obtain orbital and radiant data. Some bright meteors which appeared in 1999 are still connected to the new Perseid filament associated to the return at perihelion of Comet 109P/Swift-Tuttle.

During the night of August 12-13, 1999, bright meteors appeared coming principally from a compact radiant centered at $\alpha = 46°$ and $\delta = +58°$, such as reported below. Some of them were photographed from a single station at Castelló, without possibility to determine atmospheric and heliocentric data (see, e.g., Figure 1). In Andalucia, a clear sky permitted photographing two fireballs from stations at El Arenosillo ($\lambda = 6°43'58''$ W, $\varphi = 37°06'16''$ N, $h = 30$ m) and Carmona (Sevilla, $\lambda = 5°42'43''$, $\varphi = 27°26'55''$ N, $h = 5$ m) between $\lambda_{\odot} = 139\overset{\circ}{.}93$ and $\lambda_{\odot} = 193\overset{\circ}{.}94$. In this solar longitude interval, according to *IMO* observations [1], Perseid activity had decreased to a ZHR of 90, coming principally from the new Perseids peak. The intrinsic interest to analyze and compare the orbits of these meteoroids with other of the annual stream was reflected in an excellent review [2]. Unfortunately, in our campaign, weather conditions did not allow to obtain a significant number of orbits, and detailed radiant and orbital data could be calculated for only two 1999 Perseids.

The first and the fifth author are affiliated with the Dept. Astronomia i Astrofísica, Univ. València; the first author is also affiliated with the Dept. Ciències Experimentals, Univ. Jaume I; the second and fourth author are affiliated SOMYCE; the third author is affiliated with the Univ. Complutense de Madrid; and the last author is affiliated with the Dept. Química Inorgànica, Univ. Barcelona, and the Institut d'Estudis Espacials de Catalunya.

Figure 1 – A selected magnitude −5 fireball photographed by Felipe Peña, participant in our network and also member of the *Societat Astronòmica de Castelló*. Using a 50 mm lens, he registered this fireball from Mosqueruela (Castelló) during an exposure on August 12 between 23^h44^m and 23^h59^m UT.

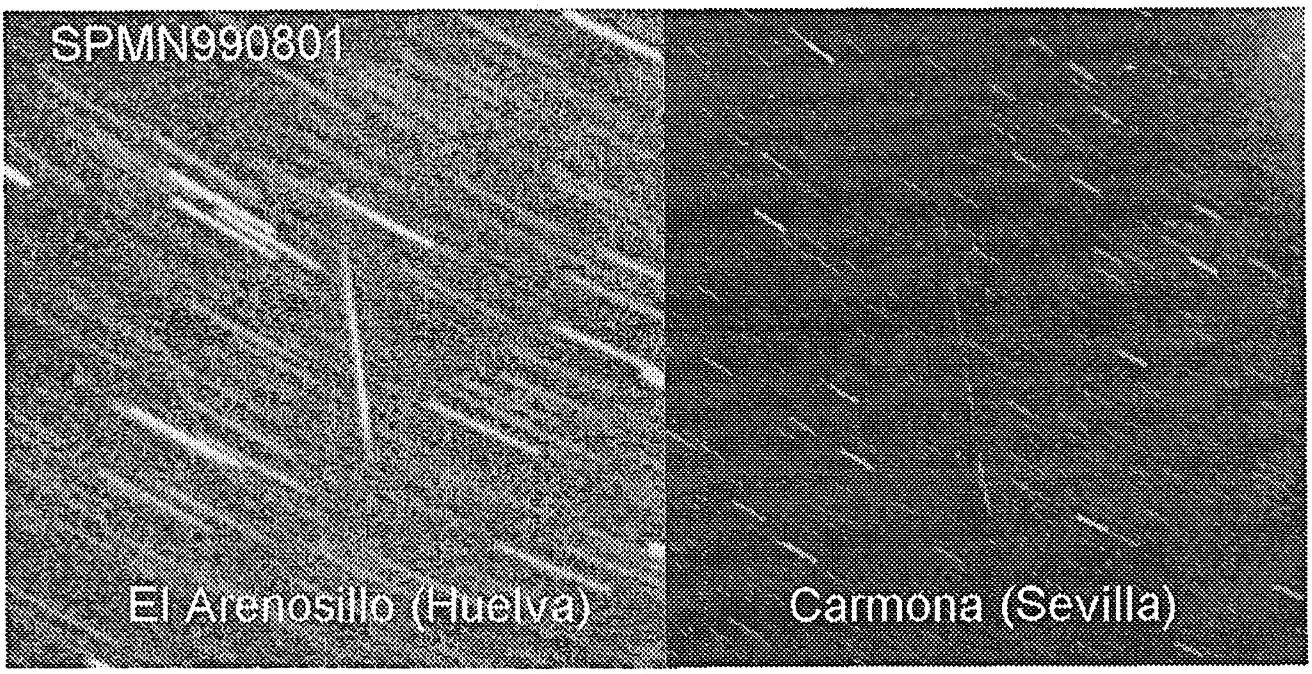

Figure 2 – The magnitude −3 Perseid SPMN 990801 photographed from both stations.

The fireball data are shown in Tables 1–6. Regarding data accuracy, we note that the first meteor (SPMN 990801) was visually seen by camera operators from two stations and, as a consequence, the quality of radiant position and related orbital elements is good. However, camera operators did not see the other meteor and, as a consequence, the uncertainty in its data is larger. In spite of this, using the known common exposure times of both photographs, we reduce the time uncertainty to 61 seconds. Moreover this second meteor was captured only in the last part of its trajectory, whence its geocentric velocity could be slightly larger. We note also that only two cameras were working from these two stations and the common field covered was minimal: approximately 4500 km^2. The objectives used were an $f/2.8$ $f = 28$ mm lens and an $f/2.8$ $f = 50$ mm lens with Kodak TMAX3200 film and Fuji P800. Meteor velocity data were obtained from a rotating shutter operative in the Carmona station, breaking 12.3 times per second.

Table 1 – Trajectory data of SPMN 990801 (August 13, $2^h23^m00^s \pm 1^s$ UT).

Trajectory data	Beginning point	End point
Geocentric velocity (km/s)	58.5 ± 0.2	
Heliocentric velocity (km/s)	40.8 ± 0.2	
Trajectory Length (km)	28.2 ± 0.2	
Height (km)	118.87 ± 0.07	97.41 ± 0.06
Longitude	6°02′46″ W	6°12′00″ W
Latitude	37°31′23″ N	37°22′41″ N
Absolute magnitude (Maximum −3)	+2	+1
Photometric mass (g) (0.7 g at max.)	0.002	None

Table 2 – Observed and geocentric radiant positions of SPMN 990801.

Radiant (J2000.0)	Observed	Corrected
Right ascension	44°.9 ± 0°.3	45°.88 ± 0°.02
Declination	+58°.74 ± 0°.02	+58°.32 ± 0°.02

Table 3 – Orbital data (J2000.0) of SPMN 990801.

Element	Data
a (AU)	10.4 ± 1.4
e	0.91 ± 0.01
q (AU)	0.9607 ± 0.0005
i	112°.1 ± 0°.1
Ω	139°.94546 ± 0°.00002
ω	153°.0 ± 0°.2
T	2451384.22 (July 23, 1999)

Table 4 – Trajectory data of SPMN 990802 (August 13, $2^h41^m00^s \pm 1^m01^s$ UT).

Trajectory data	Beginning point	End point
Geocentric velocity (km/s)	58.9 ± 0.3	
Heliocentric velocity (km/s)	40.6 ± 0.3	
Trajectory Length (km)	41.3 ± 0.2	
Height (km)	122.8 ± 0.1	90.49 ± 0.08
Longitude	5°38′13″ W	5°49′55″ W
Latitude	37°42′29″ N	37°32′17″ N
Absolute magnitude (Maximum −4)	+1	+2
Photometric mass (g) (1.7 g at max.)	0.02	None

Table 5 – Observed and geocentric radiant positions of SPMN 990802.

Radiant (J2000.0)	Observed	Corrected
Right ascension	46°.4 ± 0°.3	47°.3 ± 0°.2
Declination	+57°.49 ± 0°.02	+57°.07 ± 0°.02

Table 6 – Orbital data (J2000.0) of SPMN 990802.

Element	Data
a (AU)	8.4 ± 1.8
e	0.89 ± 0.02
q (AU)	0.945 ± 0.003
i	114°.1 ± 0°.2
Ω	139°.957 ± 0°.008
ω	150°.9 ± 0°.6
T	2451381.52 (July 22, 1999)

Measuring the Cartesian coordinates of the stars and the meteor, we obtained the conversion to equatorial coordinates using new astrometry software developed by our team. Taking into account the accuracy of the lenses and the distance between stations, the velocity error was within 1%, and the astrometric positional error is smaller than 1′ in the two photographs.

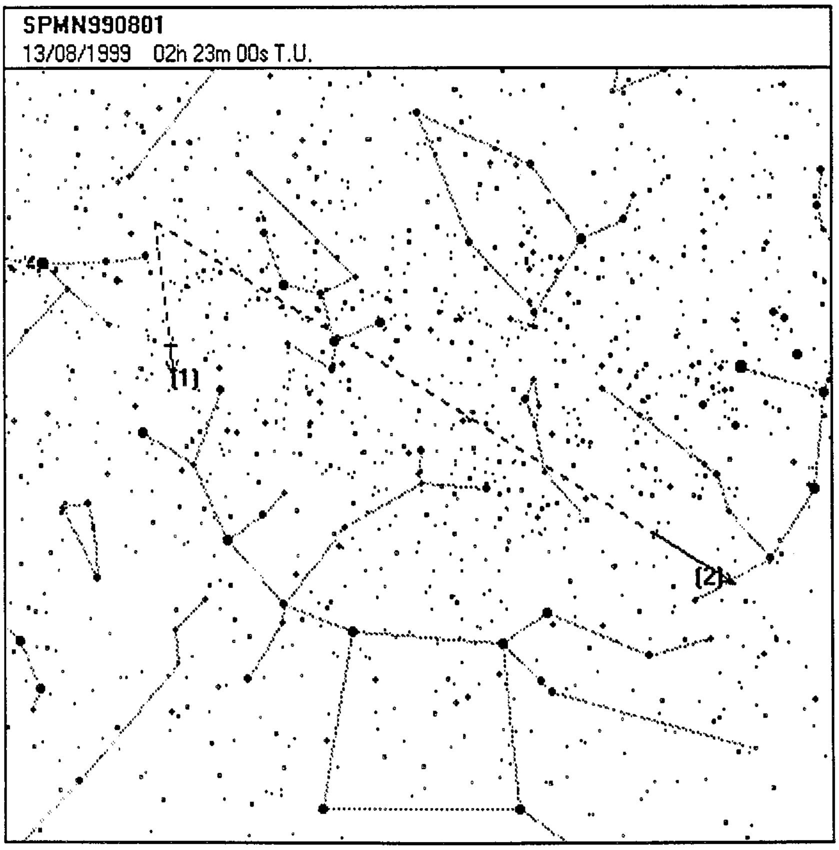

Figure 3 – Apparent trajectory between the stars of SPMN 990801 from El Arenosillo (1) and from Carmona (2).

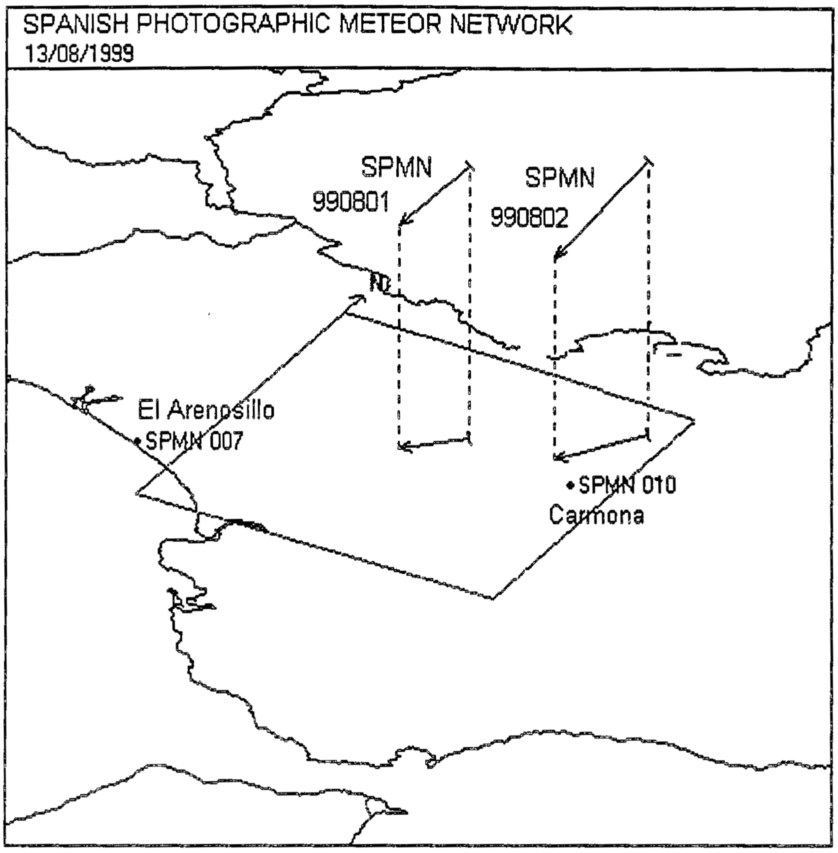

Figure 4 – Meteor trails projected in a map showing the position of the two SPMN stations in Andalucia.

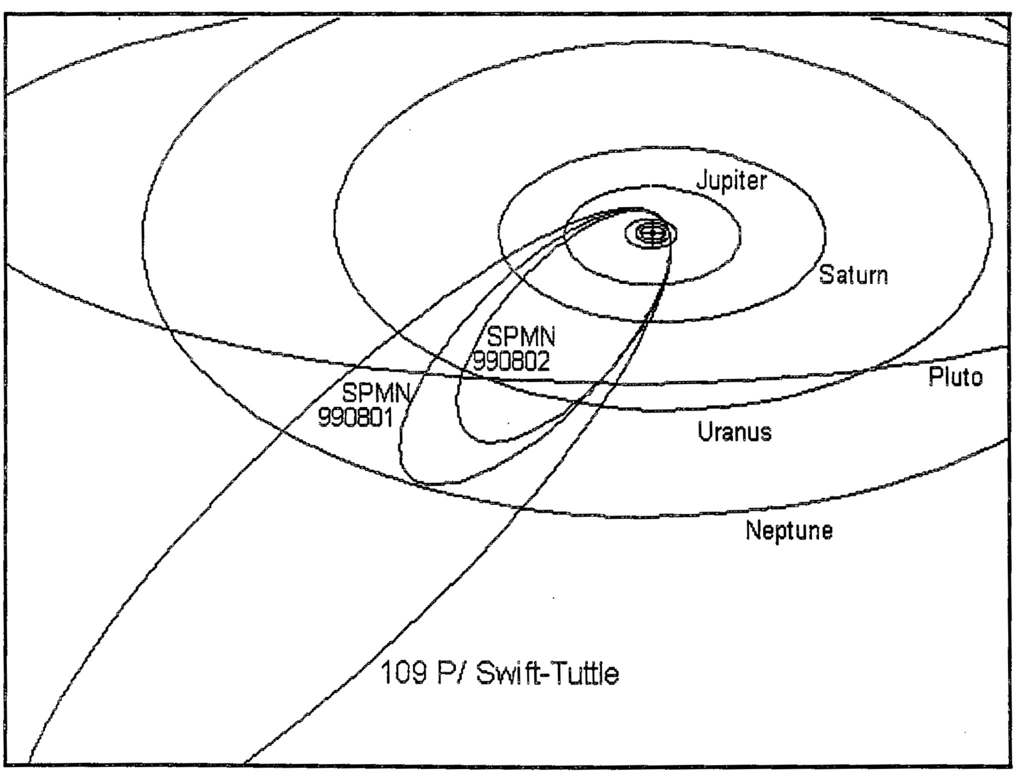

Figure 5 – The two orbits obtained in this work, showing the similarity with the orbit of Comet 109P/Swift-Tuttle.

The fireball astrometry was done using digitalized images of the negatives. We created a model of the trajectory using the method of planes [4]. From the photometric analysis of the negatives, we obtained the absolute magnitude at maximum light. From these data, we calculated the approximate meteoroid mass using Hughes's formula [5]. From the radiant position and the heliocentric orbit (see Figure 5), it is evident that these meteoroids belonged to the Perseid stream.

Acknowledgments

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SPA Meteor Section Results: September–October 1999

Alastair McBeath

Summaries of news and results presented to the *SPA Meteor Section* from September and October 1999 are given. The δ-Aurigids were moderately well observed in mid-September, but no clear maximum was apparent in either the visual or radio data. A possible new minor radio echo-count spike was found in European data around (eq. J2000.0) $\lambda_\odot = 174°$ (September 17), which may be related to one found at (eq. 1950.0) $\lambda_\odot = 172\overset{\circ}{.}91$ in 1989 [1]. The most notable feature of September was a strong radio meteor maximum around $\lambda_\odot = 186°$ (September 30), most probably due to a good Sextantid return. October 9, 9^h–12^h UT ($\lambda_\odot = 195\overset{\circ}{.}631$–$195\overset{\circ}{.}755$) produced an unexpected visual-radio Draconid outburst over Japan, with ZHRs around 10–20. Some European radio observations provided confirmation, but visual reports of weak Draconid activity over Japan and Europe on October 8-9 were inconclusive. The lead-up to the Orionid maximum was quite well-seen visually and by radio, with a maximum on October 21-22 in the radio profile much as expected. No pre-peak enhancement was seen on October 17-18 this year. Radio results showed minor enhancements in late October around $\lambda_\odot \approx 215°$ and $\lambda_\odot \approx 217°$, but these were not as marked as in 1998, during the increased Taurid activity then.

1. Introduction

Both September and October received some useful coverage at times in 1999, though the bright Moon near the Orionid maximum was rather a deterrent. Even UK weather conditions were reasonably helpful for once, especially in October! The observing totals are given in Table 1.

The photographic and video details came exclusively from cameras in Germany run by *Arbeitskreis Meteore* (*AKM*) observers, which, together with the other *AKM* data used here, were extracted from their journal *Meteoros* 2:10 and 2:11 (1999), and 3:2 (2000), kindly submitted by Ina Rendtel. The all-sky fireball cameras were operated by Ina Rendtel, Jürgen Rendtel and Jörg Strunk. One fireball on September 16-17 was recorded by three of the German *EFN* stations. The video observers were Michael Gerding, Sirko Molau, Jürgen Rendtel, and Ulrich Sperberg. Among the identified trails 387 were Orionids and 73 Piscids.

Radio observations were extracted from *Radio Meteor Observation Bulletins* (*RMOBs*) 74–76 (October–December 1999 inclusive), thoughtfully provided by Chris Steyaert. Observers included

> Enric Fraile Algeciras (Spain), Mike Boschat (Canada), Eisse Pieter Bus (the Netherlands), Maurice de Meyere (Belgium), Ghent University (Belgium), Werfried Kuneth (Austria), Sadao Okamoto (Japan), R.B. Minton (New Mexico, USA), Garfield Tsao (Taiwan), Ilkka Yrjölä (Finland), and Wim T. Zanstra (the Netherlands).

The normal procedures for examining raw forward-scatter data were followed, and Figure 1 is presented here as representative of the data available. Visual data came from

> *AKM* members (all in Germany) Rainer Arlt, Frank Enzlein, Christoph Gerber, Matthias Growe, Isabel Händel, Bernd Heinrich, Irina Heide, Hartwig Lüthen, Sven Näther, Ina Rendtel, Jürgen Rendtel, Janko Richter, Marion Rudolph, Ulrich Sperberg, Manuela Trenn, Nikolai Wünsche and Oliver Wusk; Jay Brausch (North Dakota, USA), Mary Cook (England), Shelagh Godwin (England), Chris Hall (England), Marco Langbroek (Netherlands), Alastair McBeath (England), and George Spalding (England).

In addition, details were extracted from various messages and reports forwarded to the *Section* in letters and e-mails, especially concerning the Japanese Draconid observations, and those made from Europe.

Table 1 – Visual, photographic, radio and video hours' totals, visual meteor, photographic and video trail numbers, recorded in each month, including a partial breakdown of visual meteor types.

Month	Visual	DAU	SPI	ORI	TAU	Meteors	Photo	Trails	Radio	Video	Trails
September	181^h	184	96	–	–	133	276^h	7	3134^h	196^h	527
October	121^h	12	–	272	159	1325	129^h	2	3324^h	227^h	1515

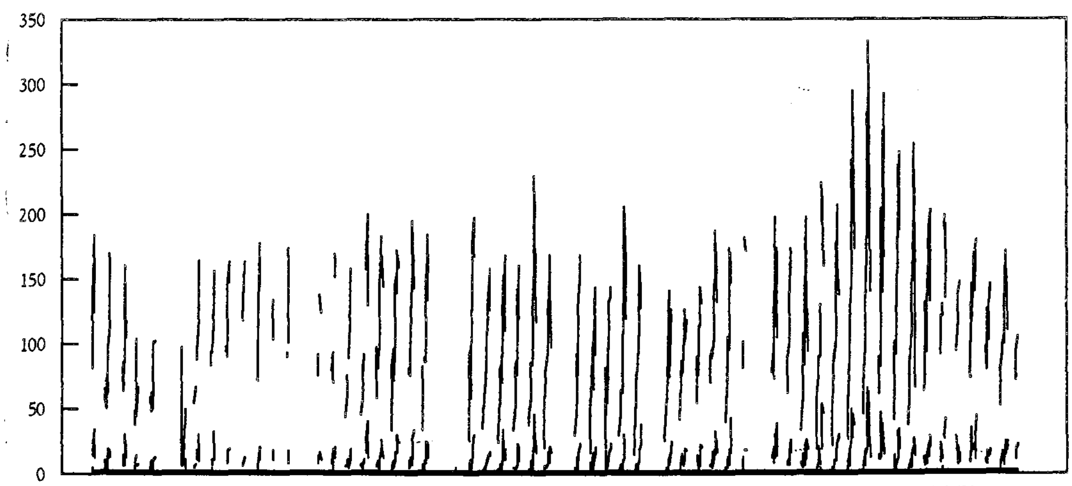

Figure 1 – Raw hourly radio meteor echo counts from September and October 1999, recorded by Maurice de Meyere. Maurice's set-up was active for around 11 hours daily, between 20^h and 6^h UT until the end of Summer Time on October 31, then from 21^h to 7^h UT. The other breaks mostly resulted from either interference (including Sporadic-E) or thunderstorms on September 23–25. The upper line illustrates all echoes detected, while the lower one gives only echoes with a duration of more than 1 s. The one-day Sextantid peak in late September and the week-long Orionids in October produced the more obvious echo-count signatures.

2. September

Much as expected, the late August Full Moon prevented detailed visual observations during the most active phase of the α-Aurigids, though a minor radio peak at $\lambda_\odot = 158^\circ$–$159^\circ$ (September 1–2; first noticed at this time in 1998 [2]) was coincident with the shower's expected maximum. Lunar conditions were better for the expected δ-Aurigid peak on September 9, but there was no clear sign of any particular spike from them in data between September 8-9 and 16-17. A suspected visual "peak" ZHR of 4 ± 1 was reported by Rendtel [3] for the interval $\lambda_\odot = 165\overset{\circ}{.}5$–$166\overset{\circ}{.}2$ (September 8–9), but this was scarcely above the general ZHR level of 2–4 found from September 5–20. The radio reports supported a general echo-rate enhancement for the interval $\lambda_\odot = 166^\circ$–$169^\circ$ (September 9–12), which has been seen before ([4]; the extended $\lambda_\odot = 169^\circ$ peak), with three-quarters of the available data sets finding two more obvious maxima around $\lambda_\odot = 167^\circ$ and $\lambda_\odot = 169^\circ$ (September 10 and 12, respectively). Neither of these peaks was dominant, however. A series of e-mails posted to *IMO-News* at various times from mid-September to early December 1999 suggested a very limited enhancement of visual δ-Aurigid rates may have been detected by a few individual observers on any of the following nights: September 7-8 (or 6-7?), 8-9, 9-10, or 13-14. The lack of consensus in these, and the fact that basic information such as the date, time, location, or sky conditions for these observations was frequently omitted, means these claims cannot be treated especially seriously. Combined with the radio data and the more accurate visual reports, there is the suggestion that the δ-Aurigids may not have produced a single, clear maximum in 1999 at least.

Low Piscid rates were reported throughout the month. Their most likely maximum on September 20 passed almost unnoticed thanks to the waxing Moon. Observed rates were never above 1–2 meteors per hour at other times. After this, visual checking was impractical for our watchers thanks to moonlight or poor weather, as well as attendance at the excellent Italian *IMC*.

Most of the other minor radio maxima recorded previously during September [4] were rediscovered in 1999, though the $\lambda_\odot \approx 165^\circ$ (September 8) peak was found only weakly, and not in all data sets. The $\lambda_\odot \approx 170^\circ$ (September 13) peak was not found then, but a slight showing in half the reports was seen at $\lambda_\odot \approx 171^\circ$ instead.

The $\lambda_\odot = 172^\circ$–$173^\circ$ (September 15–16) rate increase was seen as usual, notably on the former date, but a new peak not reported in [4] occurred at $\lambda_\odot \approx 174^\circ$ (September 17) in the European data sets from Ghent University and Werfried Kuneth, though not in the Japanese results by Sadao Okamoto. This may be related to a suspected radiant in northeastern Orion or western Gemini found in radio results in 1989 as reported by Artoos [1]. Artoos gave a maximum time of $\lambda_\odot = 172\overset{\circ}{.}91$ (eq. 1950.0) for the 1989 event, which would equate with September 16, 1999, $22\overset{h}{.}3$ UT. Checking the radio reports from September 16, 1999, around 22^h UT, showed the following effects, compared to several dates to either side at the same time of day: Maurice de Meyere—a significant enhancement in echoes of durations over 1 s from 23^h to 0^h UT; Ghent University—an unusual if small increased count-rate from 22^h to 23^h UT; Werfried Kuneth—no significant rate increase near 22^h UT; R.B. Minton—possibly enhanced echo rates around 19^h–21^h UT (but lightning interference was also reported on this date at an unspecified time); Sadao Okamoto—a minor enhancement in all-echo counts from approximately 19^h to 23^h UT, especially from 20^h to 22^h UT, and in long duration echoes (more than 5 s) from 22^h to 23^h UT. Overall, there is an indication of a minor increase in echo-counts at about the expected time Artoos indicated. However, the more significant echo peaks reported here were found in Ghent University's data on September 17 around 5^h–8^h UT ($\lambda_\odot = 173\overset{\circ}{.}88$–$174\overset{\circ}{.}01$, eq. J2000.0) and Werfried Kuneth's reports for 11^h–13^h UT on the same date ($\lambda_\odot = 174\overset{\circ}{.}13$–$174\overset{\circ}{.}21$), between $6\overset{h}{.}5$ and $14\overset{h}{.}5$ later than the time suggested by Artoos. The Ghent data show small single-hour enhancements around 2^h–3^h UT, 9^h–10^h UT, and 13^h–14^h UT on September 17 as well, though such short-term fluctuations, notably during daylight between 8^h and 15^h UT, are not unprecedented in their September counts. It is worth noting that, in the unpublished September 1998 data, several radio operators showed the $\lambda_\odot = 172^\circ$–$173^\circ$ peak extended weakly to $\lambda_\odot =$

174°.

The rough radiant area around the Orion-Gemini border suggested by Artoos would be available between about 23^h and 14^h local time daily (with a margin of 1–2 hours to allow for its uncertain position and unknown size), for all our radio observers. This could explain why the September 17 enhancement seen from Europe was not detected in Japan, where 5^h–13^h UT equates to 14^h–22^h local time. Such a radiant would also be accessible to visual watchers during the second half of the night, though our available reports contain no plots featuring such a radiant in 1999. The location might suggest it to be an outlying part of the cluster of radiants in Aries-Triangulum-Perseus-Auriga active from late August through to October. Its approximate superposition on the anthelion sporadic source (cf. [5]) may create problems in identifying it for visual observers, plus it may well not be as noticeably active every year.

The $\lambda_\odot = 176°$–$177°$ radio peak (September 19–20) recurred as normal, but, in a few data sets, this seemed to blend into the $\lambda_\odot = 180°$–$181°$ enhancement (September 24–25), with peaks in long-duration echoes (over 1 s) at $\lambda_\odot \approx 78°$ and, especially, at $\lambda_\odot \approx 179°$, too (September 21 and 22, respectively). The vagueness of this peak has been typically reported since 1997. The $\lambda_\odot = 183°$ peak (September 27) extended from $\lambda_\odot \approx 182°$ again, as in 1998.

The final peak of the month at $\lambda_\odot = 185°$–$187°$ produced another surprise this year, with the strongest echo counts for September in virtually all the radio reports occurring at $\lambda_\odot = 186°$. There was no specific preferred timing for this, except commonly during the local morning daylight hours up to midday. As Figure 1 illustrates, this peak dominated the remainder of September in strength, which has not been seen before. It seems likely this spike in activity, which continued into the opening day or two of October as normal, was due to the Sextantids. Kronk [6] gives a helpful synopsis of what little is known about this shower, indicating that previous data have suggested a maximum at some stage between September 29 and October 4 ($\lambda_\odot = 185°$–$190°$), and that the activity may be periodic, perhaps with a 4–5 year cycle. Artoos [1] also drew attention to this source as potentially active strongly in 1988 and 1989 around September 26–30 ($\lambda_\odot = 182°$–$186°$). In 1993–1996 data [4], I identified three radio maxima possibly coincident with this shower's best, at $\lambda_\odot = 183°$, $\lambda_\odot = 185°$–$187°$, and $\lambda_\odot = 190°$–$192°$ (perhaps extending sometimes to $\lambda_\odot \approx 195°$; October 4–6/9), with the clearest peaks at $\lambda_\odot = 183°$ and $\lambda_\odot = 191°$. Since then, all these maxima have been recovered in each year.

Assuming that all these peaks are produced by a single source (Artoos indicated that his September 26–30 activity may have derived from radiants in Auriga or Sextans), the available results seem to indicate the Sextantids may have more than one maximum, and that the best rates occur only occasionally from the later September one. The interval to watch for future high peaks would seem to be $\lambda_\odot = 182°$–$187°$ (September 26 to October 1), though coverage beyond this time is advisable, too, if only to give ample comparison data. Any periodicity remains unknown.

3. October

Once across the October border, most radio observers recorded the routine early-month peaks, but Sadao Okamoto (our only active reporter from Japan) detected another strong maximum in his all-echo counts at $\lambda_\odot \approx 188°$, later than the $\lambda_\odot = 185°$–$187°$ spike usually extends to. This seemed especially noticeable around 21^h–23^h UT on October 1 (6^h–8^h local time for Japan on October 2), thus may again be due to the Sextantids. It did not show up in his long-duration echo counts (over 5 s) however, and nothing untoward was recorded by our other radio observers then.

The $\lambda_\odot = 190°$–$192°$ (October 4–6) radio-rate enhancement continued through to $\lambda_\odot \approx 195°$ (October 9) again in 1999, as has been seen before, with an early peak around $\lambda_\odot = 189°$ (October 3; also noted in 1998) in longer-duration counts (over 1 s), and more general increases around $\lambda_\odot \approx 192°$ and $\lambda_\odot \approx 195°$ in 75% of the data sets. The $\lambda_\odot = 195°$–$196°$ peak, which was earlier suggested as probably separate in [4], seemed to blend into the rate increases of earlier dates, but was found only at $\lambda_\odot \approx 195°$.

Useful visual reports from October 4 onward, revealed weak activity from the Taurids that persisted all month, δ-Aurigids (which were still possibly active as late as October 13 in one or two observations) and some early Orionids.

On October 8-9 ($\lambda_{\odot} = 195°$), several Japanese and European watchers commented on sighting some possible Draconid meteors. Drawing on data submitted to *IMO-News* as well as first-hand reports and additional comments from correspondents, it seems the numbers of positive and negative sightings were about equal for that night. The positive reports suggested ZHRs of the order of 5–8 at most, between $10^{h}30^{m}$ and 16^{h} UT (Japan) and between 20^{h} and 23^{h} UT (Europe), though only Marco Langbroek provided any plots for checking. In radio reports from *RMOB* 75 (November 1999), Eisse Pieter Bus and Wim T. Zanstra both presented computed values for October 8-9, suggesting marginally enhanced echo-counts perhaps due to the Draconids from about 16^{h} to 21^{h} UT (Bus), respectively, 18^{h} to 21^{h} UT (Zanstra), but in both cases the enhancement was marginal, and difficult to confirm because of a lack of comparison data from either observer. The more complete data sets from other European observers active simultaneously revealed nothing unusual at these times. In Japan, only a single report of possibly slightly increased radio counts was mentioned in the *IMO-News* messages, with the sole *RMOB* observer, Sadao Okamoto, detecting nothing unusual at all. Overall, the evidence for any detectable Draconid activity on October 8-9 is inconclusive, though the radio reports especially favor the negative side, and do not support the visual observations at all well. We should note though that, as mentioned above, the $\lambda_{\odot} = 195°$ radio echo enhancement was detected again in 1999, which could indicate a weak general level of Draconid rates. Although this radio peak was very weak and poorly confirmed in 1993–1996 data, it does seem to have been found in most years since 1993, except 1997.

However, radio and visual reports from Japan indicated an unexpected Draconid outburst did actually happen in 1999, but on October 9 during the European morning daylight hours around 9^{h}–12^{h} UT ($\lambda_{\odot} = 195.^{\circ}631$–$195.^{\circ}755$). Drawing again on data published on *IMO-News* and elsewhere, visual ZHRs were perhaps 10–20 at best (the highest rate claimed was 20–30, but no other details on this were given: it is not clear if this value was a recognized standard ZHR). In the radio data, Sadao Okamoto recorded his most significant raw counts from 10^{h} to 11^{h} UT, but the Draconid signature was invisible in his long-duration counts (over 5 s). His all-echo trace was somewhat above-normal again around 14^{h}–15^{h} UT on October 9. Of the active European radio observers, the only data set to show any comparably unusual activity was that from Ghent University, with elevated echo-counts from about 2^{h} to 8^{h} UT on October 9, which extended sporadically through until about 12^{h} UT as the Draconid radiant rose in the morning daytime sky. This most unusual event happened about 15 hours later than the equivalent time the more spectacular 1998 Draconid outburst occurred, and some 7–9 hours after the nodal crossing time around 3^{h} UT on October 9.

The $\lambda_{\odot} = 199°$ (October 13) radio peak was found again, but was strongest around $\lambda_{\odot} = 200°$, soon after which echo rates began to rise as expected towards the Orionid maximum on October 21-22. There was no trace of any enhanced radio or visual activity near October 17-18 this year though, the pre-maximum Orionid sub-peak most recently seen in 1998 [2].

As Figure 1 demonstrates, the Orionid maximum was well-seen by our radio observers, with the clearest peak signature at $\lambda_{\odot} = 208°$ (October 22) in most data sets, in-line with predictions. Visual ZHRs could be computed for every night from October 11-12 to 20-21 in our results, except October 13-14, but were little better than 5–8 for most of that time. Rates began to rise only on October 19-20 (ZHR $= 16 \pm 2$) and were good the following night at 23 ± 5, but moonlight prevented proper coverage of the maximum night itself. The radio profile suggests an unexceptional peak ZHR can probably be inferred. Too few good-condition visual reports contained magnitude and train details for a full Orionid analysis, but the corrected mean magnitudes for this shower and the October sporadics were +2.98 and +3.63, respectively, with 32% of Orionids leaving persistent trains.

Unlike in 1998, radio rates dropped as normal after the Orionid maximum, and, although peaks at $\lambda_\odot \approx 215°$ and $\lambda_\odot \approx 217°$ (October 29 and 31; first detected in 1998 as running in the interval $\lambda_\odot = 216°$–$217°$ [2]) were recorded, these were not as clearly marked as last year, so it seems unlikely a repeat of the heightened Taurid rates took place in late October this year. There are almost no visual observations on-hand to confirm this, but the few there are support the view that the Taurids produced nothing more than anticipated.

4. Acknowledgments

As always, my grateful thanks are extended to every contributor. October continues to be a month to watch in particular, and the Draconid epoch especially needs regular, careful monitoring. September too seems no longer quite the boring, anticlimactic, post-Perseid month it once did either. Clear skies!

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The Lacertids—A New Spring Shower?

Arkadiusz Olech

A discovery of a possible shower radiating from Lacerta in the beginning of June is reported. The equatorial coordinates of the radiant are $\alpha = 333°$ and $\delta = +43°$, and the most probable geocentric velocity is around 50 km/s. During the first three night of June the Zenithal Hourly Rates (ZHRs) of the shower were as high as around 8, which makes the Lacertids almost a major shower.

The New Moon and very good weather conditions strongly encouraged observations at the beginning of June. Despite of the short nights, I decided to go to Chelm (*IMO* code 34012) and try to observe. During three nights from June 1-2 to June 3-4, I collected 6 hours and 37 minutes of effective time with 71 meteors detected. The full log of my observations in shown in Table 1.

Table 1 – Log of observations.

Date	Period (UT)	$T_{\rm eff}$	$\overline{\rm lm}$	Meteors
June 1-2, 2000	20^h34^m–23^h47^m	$3\overset{h}{.}000$	+6.21	30
June 2-3, 2000	20^h20^m–23^h54^m	$3\overset{h}{.}250$	+6.18	38
June 3-4, 2000	20^h22^m–20^h45^m	$0\overset{h}{.}367$	+5.53	3

During the first night, I was surprised by such a large number of observed meteors.

There is only one shower active in the beginning of June—the Sagittarids, but, in Polish latitudes, during almost the whole night, the radiant of this shower is only about 10°–20° above the horizon. Additionally, the ecliptic has also a low elevation and thus the sporadic background reaches its minimum at this time of the year.

It was interesting that as many as about 10 mainly fast meteors (over 30% of the total number observed) seemed to radiate from the constellation of Cygnus. My rough estimate of the radiant's coordinates was $\alpha = 315°$ and $\delta = +40°$.

Surprisingly, the situation repeated during the night of June 2-3. About 11 fast meteors (almost 30% of the total number observed) seemed to radiate from the same radiant as during the previous night. In the third night, I had been watching only for 22 minutes, but one meteor from a total of three observed also radiated from the vicinity of Deneb.

I decided to enter all my meteors into the RADIANT software [1].

The results are presented in Figure 1.

Four pictures were obtained for geocentric velocities equal to 40, 50, 60, and 70 km/s, respectively. All pictures clearly show the double radiant with one component placed near Deneb and the second near the border between Cygnus and Lacerta. The most compact size of both radiants is obtained for a velocity equal to 50 km/s. For this velocity, the equatorial coordinates of both radiants are $\alpha = 312°$ and $\delta = +43°$ for the radiant in Cygnus and $\alpha = 333°$ and $\delta = +43°$ for the radiant in Lacerta.

Knowing the coordinates of the radiants and the geocentric velocity of the meteors, we are able to estimate the activity of the suspected shower. During all three nights, the number of meteors radiating from the radiant in Cygnus was 16 and the number of those radiating from Lacerta was 22.

The magnitude distributions of these events are shown in Table 2.

Table 2 – Magnitude distributions.

Shower	Date	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot
Cygnus	June 1-2	0	0	0.5	0.5	2	2	2	0.5	0.5	8
	June 2-3	0	0	0	1	1	1	0.5	3	0.5	7
	June 3-4	0	0	0	0.5	0.5	0	0	0	0	1
Lacerta	June 1-2	0	0	1.5	0.5	1.5	1.5	4	0.5	0.5	10
	June 2-3	1	0	0	1	1	2	1.5	3.5	1	11
	June 3-4	0	0	0	0.5	0.5	0	0	0	0	1

It is clear from both Figure 1 and Table 2 that the radiant in Lacerta is more active and it corresponds most probably to the true position of the radiant of the shower which we hereafter call the Lacertids.

However, the value of the population index obtained from our data shown in Table 2 is equal to 2.0 ± 0.3; in our ZHR calculations, we decided to use $r = 2.5$. For the radiant in Lacerta, the activity of the shower was ZHR $= 7.4 \pm 1.9$ during the night of June 1-2 and ZHR $= 8.2 \pm 0.6$ during the next night. The activity of the shower in Cygnus was lower, and ZHRs were 5.0 ± 1.2 and 4.5 ± 1.4, respectively. The night of June 3-4 was not used in the ZHR calculations due to the shortness of the observing run.

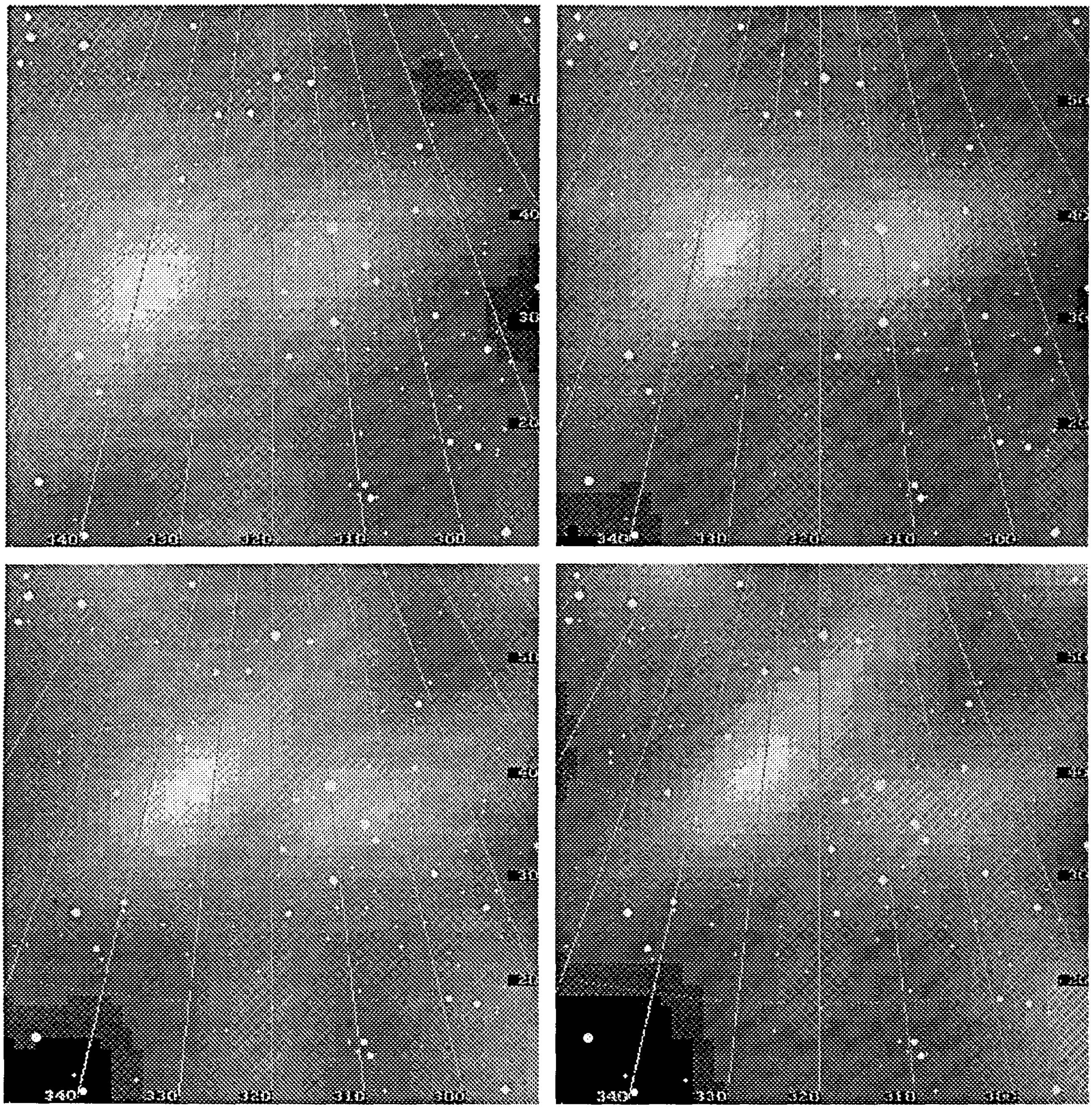

Figure 1 – The radiant of the Lacertids. The assumed parameters are: $\lambda_\odot = 71°$, a daily radiant drift of $\Delta\delta = 1.^\circ0$, angular speeds between 6°/s and 30°/s. The geocentric velocity is 40, 50, 60, and 70 km/s, respectively.

The obtained ZHRs of the Lacertids are high, making this shower almost a major one. The observations made by other members of the Polish *Comets and Meteors Workshop* are still under reduction, and our results will be presented as soon as possible. I also encourage *IMO* observers to check their late May and early June reports and look for possible Lacertids.

Acknowledgments

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