ISSN 1016-3115

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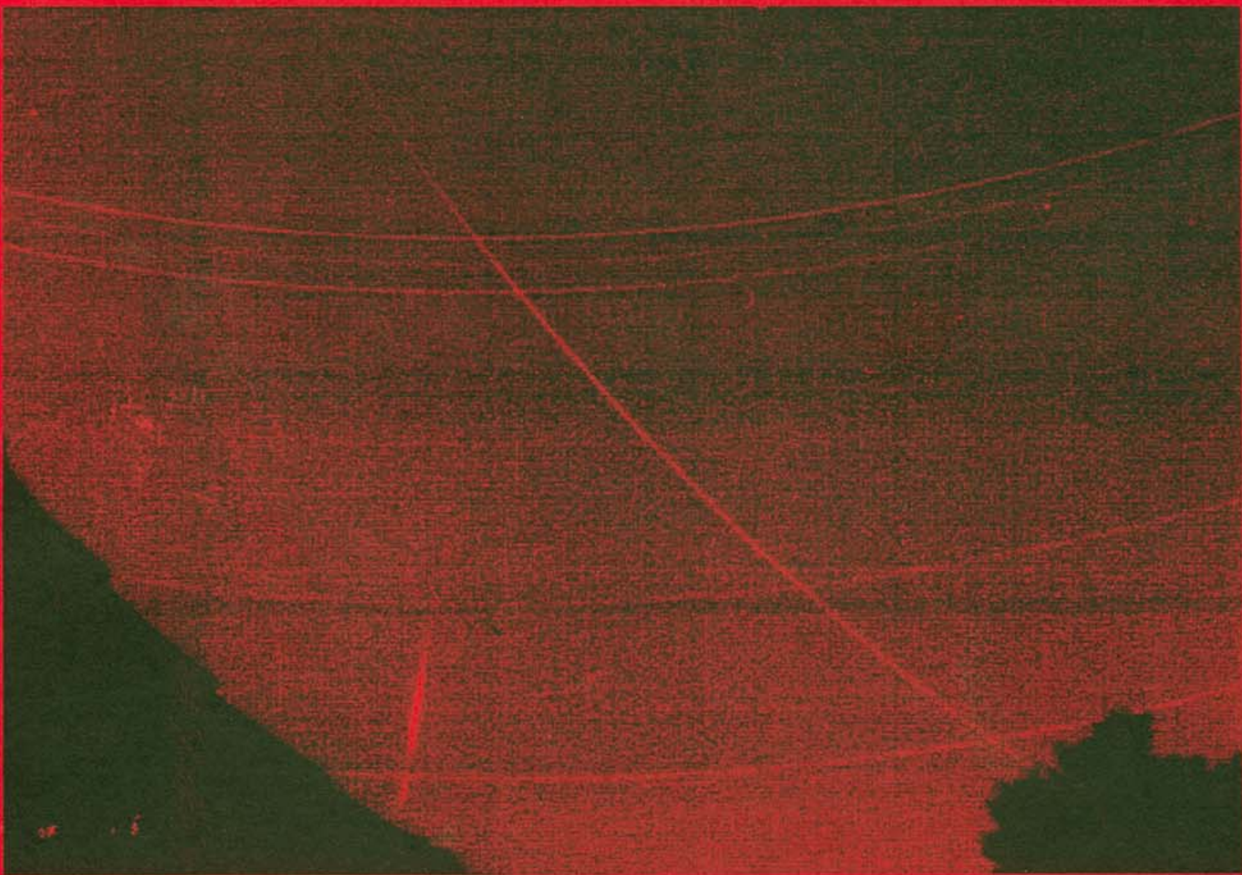
26 - 1
february 1998

bimonthly journal of the international meteor organization



Portion of the southern sky of a fish-eye photo of the fireball patrol camera no. 33 of the European Network located in Potsdam, Germany. The exposure of January 25, 1998, lasted from 17^h54^m to 22^h01^m UT. The fireball of magnitude about -6 occurred at $19^h13^m50^s$ UT. According to a preliminary analysis by Pavel Spurný and Jiří Borovička of the Ondřejov Observatory, the entry velocity was about 13 km/s, and the luminous end height was approximately 30 km. Possibly, a meteorite of at most 100 g may have fallen, but has not yet been recovered. The search area consists of forest and grassland.

In this issue:

In case of non-delivery, return postage guaranteed. Please return to:
v.u.: Marc Gyssens, Heerbaan 74, B-2530 Boechout, Belgium

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Contents

Useful Information

The April Issue *(WGN 26:2)*

The *April issue* will be mailed during the third week of April. Contributions are due on *March 24* at the latest. They should be sent to *Marc Gyssens*.

Administrative Correspondence

Ordering *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 *Ina Rendtel*.

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

From the President

Jürgen Rendtel

On January 1, 1998, a new term started for several Council members. I would like to thank those who worked within the Council over the last years for their continuous efforts. It cannot be said often enough that all tasks which are necessary to keep the IMO *running should be distributed over many shoulders. This is the only way to keep the workload acceptable for everyone. All volunteers are welcome—any task is worth it to share it with others. And there are various things to do. Could it not be interesting for you to take on some responsibility? All Council members are willing to cooperate with new enthusiasts, sharing their ideas, work, projects, and success.*

A special word of thanks is due to past Secretary-General Paul Roggemans, who decided not to seek a new term. In the new Council, he has been succeeded by Bob Lunsford.

1997 was another very interesting year for all observers: the Perseid peak re-occurred, and, having the new activity feature in mind, future campaigns may yield further unexpected events, too. Of course, the Leonids will gain most of the 1998 attention, although one should not forget the Draconids in October, which may also show some unusual rates. Besides all the known showers, there are various hints on short-term activity of minor showers. This is not too much of a surprise, and it shows the importance of regular meteor observations throughout the year as opposed to coverage of the major showers only.

The 1998 International Meteor Conference *will take place in conjunction with two professional meetings on meteoroids and comets at the same location in Slovakia. This will offer a good opportunity to discuss results and projects with a wide audience. A similar situation with the* International Meteor Conference *and the* Meteoroids Conference *in 1992 yielded a lot of useful contacts.*

With the establishment of the Video Commission during the 1997 International Meteor Conference, *we intend to promote this very important field of optical meteor work. This should lead to better contacts between the involved people, and to exciting new results in the field of meteor research.*

I wish all members and friends of the IMO *a healthy, peaceful year and, of course, good luck with all your plans.*

Frequently Asked Questions on Observing Methods

compiled by Rainer Arlt

We received the following letter from Godfrey Baldacchino.

Sixteen Maltese meteor observers enjoyed a lucky break in cloudy weather to observe the Quadrantid meteor shower from two sites on January 3-4, 1998. Some 400 meteor events were recorded in a 3-hour stretch between a decent elevation of the radiant and the break of dawn.

During these watches, a number of meteors were seen which were not within the field of view covered by the map being used. This occurred both in the case of Quadrantid and sporadic meteors. Although observers were concentrating their gaze within the area of sky covered by the map, they could not help glimpsing and recording relatively bright, "out-of-field," meteors which they saw anyway.

My difficulty arose when it came to analyzing the activity rates. Consistently, I realized that calculated standard sporadic rates were being inflated to an unacceptable level (such as a sporadic HR of 40). This statistic would achieve a more "acceptable" lower level if "out-of-field" sporadics were filtered out. However, one could not filter out sporadic meteors and leave the "out-of-field" shower meteors included in the analysis. So, these were also discarded.

Somehow, I do not think that this is a valid procedure. On the other hand, including "out-of-field" meteors increases the hourly rates in an artificial manner, and probably also biases the magnitude distribution in favor of brighter meteors. Can any expert on reducing visual meteor rates advise?

Godfrey Baldacchino, January 10, 1998

The regions of the sky covered by the respective maps of the *Atlas Brno* do not represent the typical field of view of an observer. Only the long axis is almost 100° long, corresponding well with the approximate diameter of the field of view. Additionally, the observer does not necessarily look always into the center of the chart. It is very natural that meteors outside the chart will be seen, and the only reasonable recommendation is to take several adjacent maps outside and plot the meteors on that chart, which allows the most accurate representation of the path. For example, if one considers Chart 4, to be the observer's main observing area, and the observer sees a meteor in Lynx, he should definitely plot the meteor onto Chart 2, although it might fit on Chart 4.

The striking bias of the rates due to meteors not plotted underlines the difficulties in associating meteors directly under the sky. Minor showers and showers whose rates are comparable to the sporadic activity should therefore always be analyzed from plots. Note that the Quadrantids have to be regarded as a minor shower when the radiant is low in the sky. If the shower activity exceeds the sporadic activity significantly, the errors of misclassified sporadics becomes smaller, because of their relatively smaller number. Hence, the shower rate is not that much affected anymore, but the sporadic rate still is.

A composite method allows the direct association of clear shower meteors under the sky and requires plots of all other meteors. This way, the observer saves time to follow the enhanced activity (say between 20 and 40 observable meteors per hour) and preserves path information for the association with the minor showers keeping the errors in their rates and in the sporadic rate small.

In the case Godfrey describes, the observers should use all the meteors they saw for the meteor report. If the majority of meteors were Quadrantids, the ZHRs are probably useful; the sporadic rates will have larger relative errors and will naturally suffer from not-plotted meteors just like a minor shower. The observers should definitely report all meteors seen.

Meteor Shower Calendar: April–September 1998

compiled by Alastair McBeath

1. April to June

Meteor activity picks up towards the April-May boundary, with showers like the Lyrids, π-Puppids and η-Aquarids, and only this latter source suffers from moonlight this year. During May and June, most of the activity is in the daytime sky, with six shower peaks expected during this time. Although a few shower members from the o-Cetids and Arietids have been reported from tropical and southern hemisphere sites visually in previous years, sensible activity calculations cannot be carried out from such observations. For radio observers, the expected UT maxima for these showers and the Moon-affected η- Aquarids are as shown in Table 1.

Table 1 – Expected maxima in UT for radio observations of meteor showers in April–June, 1998.

Shower	Maximum	Shower	Maximum	Shower	Maximum
April Piscids	Apr 20, 13^h	ε-Arietids	May 09, 12^h	Arietids	Jun 07, 15^h
δ-Piscids	Apr 24, 13^h	May Arietids	May 16, 13^h	ζ-Perseids	Jun 09, 14^h
η-Aquarids	May 06, 04^h	o-Cetids	May 20, 11^h	β-Taurids	Jun 28, 14^h

The ecliptical complexes continue with some late Virginids and the best from the minor Sagittarids in May-June.

Lyrids

Active: April 16–25; Maximum: April 22, 10^h UT ($\lambda_\odot = 32\overset{\circ}{.}1$); ZHR: variable—up to 90, usually 15;
Radiant: $\alpha = 271°$, $\delta = +34°$, Radiant drift: see Table 3; radius: 5°; $V_\infty = 49$ km/s; $r = 2.9$
TFC: $\alpha = 262°$, $\delta = +16°$ and $\alpha = 282°$, $\delta = +19°$ ($\beta > 10°$ S)

The Lyrids are best viewed from the northern hemisphere, but they are observable from most sites either north or south of the equator, and are suitable for all forms of observation. Maximum rates are usually attained for only about an hour or two at best, although in 1996, mean peak ZHRs of 15–20 persisted for around 8–12 hours. The ZHR can be rather erratic at times, a variability also seen in 1996, when rates ranged between 10 and 30 from hour to hour during the peak. The last high maximum occurred in 1982 over the USA, when a very short-lived peak ZHR of 90 was recorded. This unpredictability always makes the Lyrids a shower to watch, since we cannot say when the next unusual return may occur.

As the shower's radiant rises during the night, watches can be usefully carried out from about 22^h30^m local time onwards. This year, the Moon will be a waning crescent in Capricornus/Aquarius for the peak and will rise not long before dawn, so skies should remain dark for much of the night. The predicted maximum should favor sites across North America if correct, but variations in the stream could mean this is not the case in actuality.

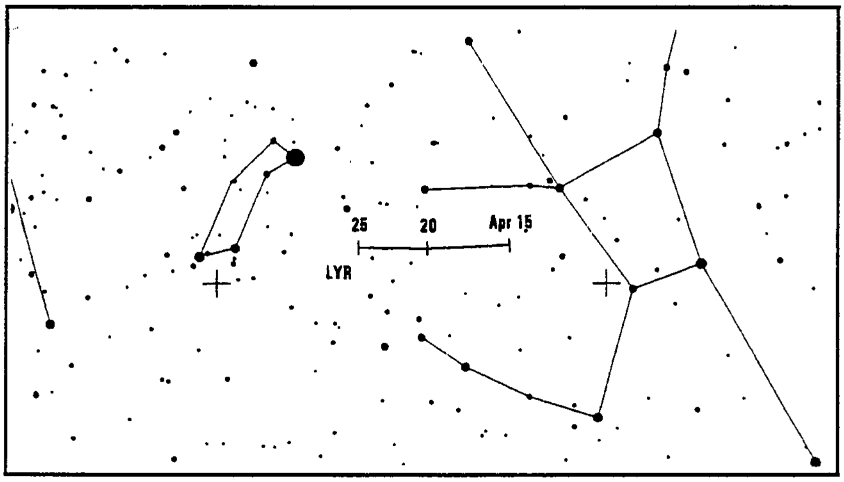


Figure 1 – Radiant positions and drift of the Lyrids.

π-Puppids

Active: April 15–28; Maximum: April 23, $20^{\rm h}$ UT ($\lambda_\odot = 33.°5$); ZHR: periodic—up to around 40;
Radiant: $\alpha = 110°$, $\delta = -45°$, Radiant drift: see Table 3; radius: 5°; $V_\infty = 18$ km/s; $r = 2.0$
TFC: $\alpha = 135°$, $\delta = -55°$ and $\alpha = 105°$, $\delta = -25°$ ($\beta < 20°$ N)

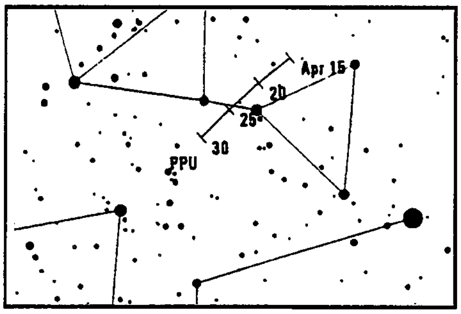


Figure 2 – Radiant positions and drift of the π-Puppids.

This is a young stream produced by Comet 26P/Grigg-Skjellerup, and shower activity has only been detected from it since 1972. Notable short-lived shower maxima of around 40 meteors per hour took place in 1977 and 1982, both years when the parent comet was at perihelion, but before 1982, little activity had been seen at other times. In 1983, a ZHR of well over 10 was reported, perhaps suggesting that material has begun to spread further along the comet's orbit, as theory predicts.

Comet Grigg-Skjellerup was due at perihelion on August 30, 1997, but in 1997 an almost Full Moon coincided with the shower's peak.

At the 1998 return, we reach the closest-approach point to the orbit almost eight months after the comet, so this will be a useful year to check for π-Puppid activity further from the comet, especially as the Moon is just three days from new for the maximum.

The shower is best seen from the southern hemisphere, with useful observations mainly possible before local midnight, as the radiant is very low or setting after $1^{\rm h}$ local time.

So far, visual and radio data have been collected on the shower, but the slow, bright nature of the meteors makes them ideal photographic subjects too. No telescopic or video data have been reported in any detail as yet either.

2. July to September

Minor shower activity continues apace from near-ecliptic sources throughout this quarter, first from the Sagittarids, then the Aquarid and Capricornid showers (discussed below with the Piscis Austrinids; the Southern ι-Aquarid and Northern δ-Aquarid maxima lose out to August's Full Moon), and finally the Piscids into September.

Other showers that vanish into bright moonlight this quarter include the Pegasids and Phoenicids in July; the Perseids in August (coverage is still important, but will be exceptionally difficult with a waning gibbous Moon; the maxima are predicted for August 12, $14^{\rm h}$ UT and August 12, $22^{\rm h}$ UT); and the α- and δ-Aurigids in September (α-Aurigid peak due around September 1, $5^{\rm h}$ UT). At least the minor κ-Cygnids still survive this moonlight onslaught!

For daylight radio observations, the interest of May–June has waned, but there remain the visually inaccessible γ-Leonids (peak due August 25, $14^{\rm h}$ UT), and a tricky visual shower, the Sextantids (maximum expected September 27, $14^{\rm h}$ UT). The latter has no problems from the waxing crescent Moon, but its radiant will rise less than an hour before dawn in either hemisphere.

Piscis Austrinids

Active: July 15–August 10; Maximum: July 28 ($\lambda_\odot = 125°$); ZHR = 5;
Radiant: $\alpha = 341°$, $\delta = -30°$; Radiant drift: see Table 3; radius: 5°; $V_\infty = 35$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to 360°, $\delta = 00°$ to $+15°$, choose pairs separated by about 30° in α ($\beta < 30°$ N).

Southern δ-Aquarids

Active: July 12–August 19; Maximum: July 28, 6^h UT ($\lambda_\odot = 125°$); ZHR = 20;
Radiant: $\alpha = 339°$, $\delta = -16°$; Radiant drift: see Table 3; radius: 5°; $V_\infty = 41$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to 360°, $\delta = 00°$ to $+15°$, choose pairs separated by about 30° in α ($\beta < 30°$ N).

α-Capricornids

Active: July 3–August 15; Maximum: July 30 ($\lambda_\odot = 127°$); ZHR = 4;
Radiant: $\alpha = 307°$, $\delta = -10°$; Radiant drift: see Table 3; radius: 8°;
$V_\infty = 23$ km/s; $r = 2.5$;
TFC: $\alpha = 255°$ to 360°, $\delta = 00°$ to $+15°$, choose pairs separated by about 30° in α ($\beta < 30°$ N).
PFC: $\alpha = 300°$, $\delta = +10°$ ($\beta > 45°$ N),
$\alpha = 320°$, $\delta = -05°$ ($\beta = 00°$ to 45° N), or
$\alpha = 300°$, $\delta = -25°$ ($\beta < 0°$ S.)

Northern ι-Aquarids

Active: August 11–31; Maximum: August 20 ($\lambda_\odot = 147°$); ZHR = 3;
Radiant: $\alpha = 327°$, $\delta = -06°$; Radiant drift: see Table 3; radius: 5°; $V_\infty = 31$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to 360°, $\delta = 00°$ to $+15°$, choose pairs separated by about 30° in α ($\beta < 40°$ N).

The Aquarids and Piscis Austrinids are all rich in faint meteors, making them well-suited to telescopic work, although enough brighter members exist to make visual and photographic observations worth the effort too, primarily from more southerly sites. Radio work can be used to pick up the Southern δ-Aquarids especially, as the most active of these showers. The α-Capricornids are noted for bright—sometimes fireball-class—events, which, combined with their low apparent velocity, can make some of these objects among the most impressive and attractive an observer could wish for. A minor enhancement of α-Capricornid ZHRs to about 10 was noted in 1995 by European *IMO* observers, although the Southern δ-Aquarids were the only one of these streams previously suspected of occasional variability.

Such a concentration of radiants in a small area of sky means that familiarity with where all the radiants are is essential for accurate shower association for all observing nights. Visual watchers in particular should plot all potential stream members seen in this region of sky rather than trying to make shower associations in the field. The only exception is when the Southern δ-Aquarids are near their peak, when, from southern hemisphere sites in particular, rates may become too high for accurate plotting.

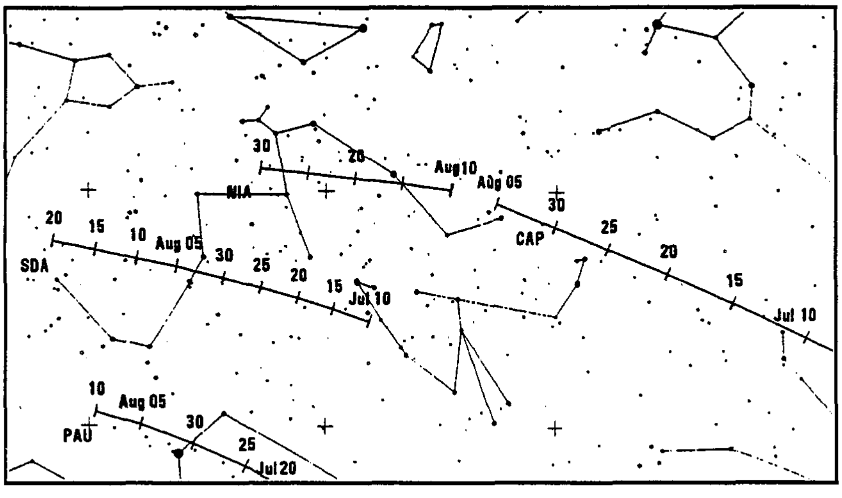


Figure 3 – Radiant positions and drift of the Piscis Austrinids (PAU), Southern δ-Aquarids (SDA), α-Capricornids (CAP), and Northern ι-Aquarids (NIA).

All the above listed shower maxima are almost free from lunar interference in 1998. The Piscis Austrinid, Southern δ-Aquarid, and α-Capricornid maxima have only a waxing crescent Moon to contend with, while August's New Moon falls favorably for the Northern ι-Aquarid peak. All these radiants are above the horizon for much of the night.

κ-Cygnids

Active: August 3–25; Maximum: August 18 ($\lambda_\odot = 145°$); ZHR = 3;
Radiant: $\alpha = 286°$, $\delta = +59°$; Radiant drift: see Table 3; radius: 5° $V_\infty = 25$ km/s; $r = 3.0$;
PFC: $\alpha = 330°$, $\delta = +60°$ and $\alpha = 300°$, $\delta = +30°$ ($\beta > 20°$ N)

The waning crescent Moon will rise during the local early morning hours at the κ-Cygnid peak this year, a very minor nuisance only for watchers north of the equator, where the shower is chiefly accessible from. Its r-value suggests telescopic and video observers may benefit from its presence, but visual and photographic workers should note that occasional slow fireballs from this source have been reported too.

Its almost stationary radiant results from its close proximity to the ecliptic north pole in Draco. There has been some suggestion of a variation in its activity at times, perhaps coupled with a periodicity in fireball sightings, but more data are urgently needed on a shower that often is ignored in favor of the Perseids during August.

Piscids

Active: September 1–30; Maximum: September 20 ($\lambda_\odot = 177°$); ZHR = 3;
Radiant: $\alpha = 5°$, $\delta = -01°$; Radiant drift: see Table 3; radius: 5° $V_\infty = 26$ km/s; $r = 3.0$;
TFC: $\alpha = 340°$ to 020°, $\delta = -15°$ to $+15°$, choose pairs separated by about 30° in α

The Piscids are a poorly studied minor shower, with a radiant very close to the March equinox point in the sky. Consequently, they can be studied equally well from either hemisphere throughout the night near the September equinox, close to their probable maximum time.

This year, New Moon falls exactly on September 20, but there is some doubt as to exactly when the Piscid peak may occur—or, indeed, if there is only the one. Telescopic and video methods can be usefully employed to study it, along with careful visual plotting.

3. Working list of meteor showers

Table 2 – Working list of meteor showers for the period April–September 1998. Streams marked with an asterisk are periodically or occasionally active, and therefore no ZHR is cited. The "maximum" dates cited for the Virginids and the Puppid/Velids should be seen as reference dates rather than true maxima.

Shower	Activity	Maximum		Radiant			V_∞	r	ZHR
		Date	$\lambda_\odot$	α	δ	Radius	(km/s)		
Virginids (VIR)	Jan 25–Apr 15	Mar 24	4°	195°	−04°	15°/10°	30	3.0	5
Lyrids (LYR)	Apr 16–Apr 25	Apr 22	32°1	271°	+34°	5°	49	2.9	15
π-Puppids* (PPU)	Apr 15–Apr 28	Apr 23	33°5	110°	−45°	5°	18	2.0	
η-Aquarids	Apr 19–May 28	May 06	45°5	338°	−01°	4°	66	2.7	60
Sagittarids (SAG)	Apr 15–Jul 15	May 20	59°	247°	−22°	15°/10°	30	2.5	5
Pegasids (JPE)	Jul 07–Jul 13	Jul 10	108°	340°	+15°	5°	70	3.0	3
Jul Phoenicids* (PHE)	Jul 10–Jul 16	Jul 13	111°	32°	−48°	7°	47	3.0	
Piscis Austrinids	Jul 15–Aug 10	Jul 28	125°	341°	−16°	5°	35	3.2	5
Southern δ-Aquarids (SDA)	Jul 12–Aug 19	Jul 28	125°	339°	−30°	5°	41	3.2	20
α-Capricornids (CAP)	Jul 03–Aug 15	Jul 30	127°	307°	−10°	8°	23	2.5	4
Southern ι-Aquarids (SIA)	Jul 25–Aug 25	Aug 04	132°	334°	−15°	5°	34	2.9	2
Northern δ-Aquarids (NDA)	Jul 15–Aug 25	Aug 08	136°	335°	−05°	5°	42	3.4	4
Perseids (PER)	Jul 17–Aug 24	Aug 12	140°0	46°	+58°	5°	59	2.6	90
κ-Cygnids (KCG)	Aug 03–Aug 25	Aug 18	145°	286°	+59°	5°	25	3.0	3
Northern ι-Aquarids (NIA)	Aug 11–Aug 31	Aug 20	147°	327°	−06°	5°	31	3.2	3
α-Aurigids (AUR)	Aug 25–Sep 05	Sep 01	158°6	84°	+42°	5°	66	2.5	10
δ-Aurigids (DAU)	Sep 05–Oct 10	Sep 08	166°	60°	+47°	5°	64	3.0	6
Piscids (SPI)	Sep 01–Sep 30	Sep 20	177°	5°	−01°	5°	26	3.0	3

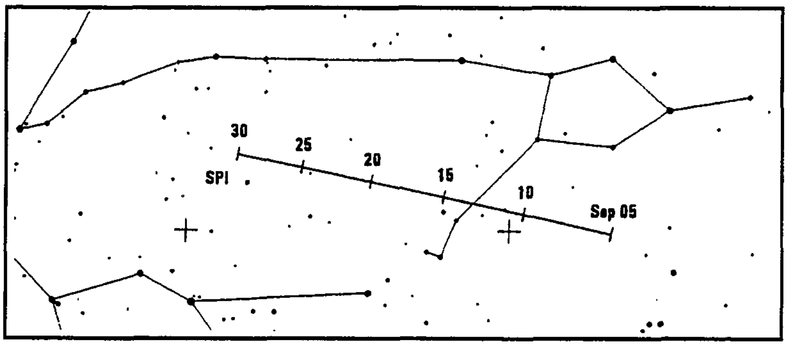


Figure 4 – Radiant positions and drift of the Piscids.

Table 3 – Radiant positions during 1998 in α and δ.

					VIR			
Apr 10	**SAG**	**LYR**	**PPU**		203° −7°			
Apr 15	224° −17°	263° +34°	106° −44°	**ETA**	205° −8°			
Apr 20	227° −18°	269° +34°	109° −45°	323° −7°				
Apr 25	230° −19°	274° +34°	111° −45°	328° −5°				
Apr 30	233° −19°			332° −4°				
May 5	236° −20°			337° −2°				
May10	240° −21°			341° 0°				
May20	247° −22°			350° +5°				
May30	256° −23°							
Jun 10	265° −23°							
Jun 15	270° −23°							
Jun 20	275° −23°							
Jun 25	280° −23°							
Jun 30	284° −23°		**CAP**			**JPE**		
Jul 5	289° −22°		285° −16°	**SDA**		338° +14°		
Jul 10	293° −22°	**PHE**	289° −15°	325° −19°	**NDA**	341° +15°	**PER**	**PAU**
Jul 15	298° −21°	32° −8°	294° −14°	329° −19°	316° −10°		12° +51°	330° −34°
Jul 20			299° −12°	333° −18°	319° −9°	**SIA**	18° +52°	334° −33°
Jul 25			303° −11°	337° −17°	323° −9°	322° −17°	23° +54°	338° −31°
Jul 30	**KCG**		308° −10°	340° −16°	327° −8°	328° −16°	29° +55°	343° −29°
Aug 5	283° +58°	**NIA**	313° −8°	345° −14°	332° −6°	334° −15°	37° +57°	348° −27°
Aug10	284° +58°	317° −7°	318° −6°	349° −13°	335° −5°	339° −14°	43° +58°	352° −26°
Aug15	285° +59°	322° −7°		352° −12°	339° −4°	345° −13°	50° +59°	
Aug20	286° +59°	327° −6°	**AUR**	356° −11°	343° −3°		57° +59°	
Aug25	288° +60°	332° −5°	76° +42°		347° −2°		65° +60°	
Aug30	289° +60°	337° −5°	82° +42°	**DAU**				
Sep 5			88° +42°	55° +46°	**SPI**			
Sep 10				60° +47°	357° −5°			
Sep 15				66° +48°	1° −3°			
Sep 20				71° +48°	5° −1°			
Sep 25				77° +49°	9° 0°			
Sep 30				83° +49°	13° +2°			

4. Lunar phases

Table 4 – Lunar phases for April–September 1998.

New Moon	March 28	April 26	May 25	Jun 24	Jul 23	Aug 22	Sep 20
First Quarter	Apr 03	May 03	Jun 02	Jul 01	Jul 31	Aug 30	Sep 28
Full Moon	Apr 11	May 11	Jun 10	Jul 09	Aug 08	Sep 06	Oct 05
Last Quarter	Apr 19	May 19	Jun 17	Jul 16	Aug 14	Sep 13	Oct 12

5. Daytime radio meter streams

Table 5 – Working list of daytime radio meteor streams. 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	
Piscids (Apr)	Apr 08–Apr 29	Apr 20	30°3	7°	+07°	07^h–14^h	08^h–13^h	low
δ-Piscids	Apr 24–Apr 24	Apr 24	34°2	11°	+12°	07^h–14^h	08^h–13^h	low
ε-Arietids	Apr 24–May 27	May 08	48°7	44°	+21°	08^h–15^h	10^h–14^h	low
Arietids (May)	May 04–Jun 06	May 16	55°5	37°	+18°	08^h–15^h	09^h–13^h	low
o-Cetids	May 05–Jun 02	May 19	59°3	28°	−04°	07^h–13^h	07^h–13^h	medium
Arietids	May 22–Jul 02	Jun 07	76°7	44°	+24°	06^h–14^h	08^h–12^h	high
ζ-Perseids	May 20–Jul 05	Jun 09	78°6	62°	+23°	07^h–15^h	09^h–13^h	high
β-Taurids	Jun 05–Jul 17	Jun 28	96°7	86°	+19°	08^h–15^h	09^h–13^h	medium
γ-Leonids	Aug 14–Sep 12	Aug 25	152°2	155°	+20°	08^h–16^h	10^h–14^h	low
Sextantids*	Sep 09–Oct 09	Sep 27	184°3	152°	00°	06^h–12^h	06^h–13^h	medium

Solar Longitudes for 1998

compiled by Rainer Arlt

As every year, a conversion table of dates to solar longitudes using [1] is given for planning observations and for the quick reduction of the times of maxima in any analysis to the actual date and time. Remember that the longitudes given are only valid for 1998. I am also repeating the conversion formulae for any time of the day. If you want to calculate the solar longitude $\lambda_\odot$ of a specific time of the day, you may use a linear interpolation between two dates. Supposed you have a certain *Date* and the *Time* in hours (UT), you get the solar longitude by

$$\lambda_\odot = \lambda_{\odot,\mathrm{Date}} + (\lambda_{\odot,\mathrm{NextDay}} - \lambda_{\odot,\mathrm{Date}}) \times \frac{\mathrm{Time}}{24\ \mathrm{h}}.$$

Alternatively, if you want to convert a certain solar longitude $\lambda_\odot$ in a time of the day, lookup the *Date* with the next-smaller solar longitude in the table and calculate

$$\mathrm{Time} = \frac{(\lambda_\odot - \lambda_{\odot,\mathrm{Date}})}{(\lambda_{\odot,\mathrm{NextDay}} - \lambda_{\odot,\mathrm{Date}})} \times 24\ \mathrm{h}.$$

Table 1 – Solar longitudes 1998. Dates refer to 0^h UT.

Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$
Jan 1	280.39	Mar 1	340.23	May 1	40.46	Jul 1	99.01	Sep 1	158.39	Nov 1	218.38
Jan 2	281.41	Mar 2	341.23	May 2	41.43	Jul 2	99.96	Sep 2	159.36	Nov 2	219.38
Jan 3	282.43	Mar 3	342.23	May 3	42.40	Jul 3	100.91	Sep 3	160.33	Nov 3	220.38
Jan 4	283.45	Mar 4	343.24	May 4	43.37	Jul 4	101.87	Sep 4	161.30	Nov 4	221.38
Jan 5	284.47	Mar 5	344.24	May 5	44.34	Jul 5	102.82	Sep 5	162.27	Nov 5	222.39
Jan 6	285.49	Mar 6	345.24	May 6	45.31	Jul 6	103.77	Sep 6	163.23	Nov 6	223.39
Jan 7	286.51	Mar 7	346.24	May 7	46.28	Jul 7	104.73	Sep 7	164.20	Nov 7	224.39
Jan 8	287.53	Mar 8	347.24	May 8	47.24	Jul 8	105.68	Sep 8	165.17	Nov 8	225.39
Jan 9	288.54	Mar 9	348.24	May 9	48.21	Jul 9	106.63	Sep 9	166.14	Nov 9	226.40
Jan 10	289.56	Mar 10	349.24	May 10	49.18	Jul 10	107.58	Sep 10	167.12	Nov 10	227.40
Jan 11	290.58	Mar 11	350.24	May 11	50.14	Jul 11	108.54	Sep 11	168.09	Nov 11	228.41
Jan 12	291.60	Mar 12	351.24	May 12	51.11	Jul 12	109.49	Sep 12	169.06	Nov 12	229.41
Jan 13	292.62	Mar 13	352.24	May 13	52.07	Jul 13	110.44	Sep 13	170.03	Nov 13	230.42
Jan 14	293.64	Mar 14	353.23	May 14	53.04	Jul 14	111.40	Sep 14	171.01	Nov 14	231.42
Jan 15	294.66	Mar 15	354.23	May 15	54.00	Jul 15	112.35	Sep 15	171.98	Nov 15	232.43

Table 1 – Continued.

Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$
Jan 16	295.67	Mar 16	355.23	May 16	54.97	Jul 16	113.31	Sep 16	172.96	Nov 16	233.44
Jan 17	296.69	Mar 17	356.22	May 17	55.93	Jul 17	114.26	Sep 17	173.93	Nov 17	234.45
Jan 18	297.71	Mar 18	357.22	May 18	56.89	Jul 18	115.21	Sep 18	174.91	Nov 18	235.46
Jan 19	298.73	Mar 19	358.21	May 19	57.86	Jul 19	116.17	Sep 19	175.88	Nov 19	236.46
Jan 20	299.75	Mar 20	359.20	May 20	58.82	Jul 20	117.12	Sep 20	176.86	Nov 20	237.47
Jan 21	300.76	Mar 21	0.20	May 21	59.78	Jul 21	118.08	Sep 21	177.84	Nov 21	238.48
Jan 22	301.78	Mar 22	1.19	May 22	60.74	Jul 22	119.03	Sep 22	178.82	Nov 22	239.49
Jan 23	302.80	Mar 23	2.18	May 23	61.71	Jul 23	119.99	Sep 23	179.79	Nov 23	240.50
Jan 24	303.82	Mar 24	3.18	May 24	62.67	Jul 24	120.94	Sep 24	180.77	Nov 24	241.52
Jan 25	304.83	Mar 25	4.17	May 25	63.63	Jul 25	121.90	Sep 25	181.75	Nov 25	242.53
Jan 26	305.85	Mar 26	5.16	May 26	64.59	Jul 26	122.85	Sep 26	182.73	Nov 26	243.54
Jan 27	306.87	Mar 27	6.15	May 27	65.55	Jul 27	123.81	Sep 27	183.71	Nov 27	244.55
Jan 28	307.88	Mar 28	7.14	May 28	66.51	Jul 28	124.76	Sep 28	184.69	Nov 28	245.56
Jan 29	308.90	Mar 29	8.13	May 29	67.47	Jul 29	125.72	Sep 29	185.68	Nov 29	246.57
Jan 30	309.92	Mar 30	9.12	May 30	68.43	Jul 30	126.68	Sep 30	186.66	Nov 30	247.59
Jan 31	310.93	Mar 31	10.11	May 31	69.39	Jul 31	127.63				
Feb 1	311.95	Apr 1	11.09	Jun 1	70.35	Aug 1	128.59	Oct 1	187.64	Dec 1	248.60
Feb 2	312.96	Apr 2	12.08	Jun 2	71.31	Aug 2	129.55	Oct 2	188.62	Dec 2	249.61
Feb 3	313.98	Apr 3	13.07	Jun 3	72.26	Aug 3	130.50	Oct 3	189.61	Dec 3	250.63
Feb 4	314.99	Apr 4	14.05	Jun 4	73.22	Aug 4	131.46	Oct 4	190.59	Dec 4	251.64
Feb 5	316.01	Apr 5	15.04	Jun 5	74.18	Aug 5	132.42	Oct 5	191.58	Dec 5	252.65
Feb 6	317.02	Apr 6	16.02	Jun 6	75.14	Aug 6	133.37	Oct 6	192.56	Dec 6	253.67
Feb 7	318.03	Apr 7	17.01	Jun 7	76.09	Aug 7	134.33	Oct 7	193.55	Dec 7	254.68
Feb 8	319.05	Apr 8	17.99	Jun 8	77.05	Aug 8	135.29	Oct 8	194.53	Dec 8	255.70
Feb 9	320.06	Apr 9	18.97	Jun 9	78.01	Aug 9	136.25	Oct 9	195.52	Dec 9	256.71
Feb 10	321.07	Apr 10	19.95	Jun 10	78.96	Aug 10	137.21	Oct 10	196.51	Dec 10	257.73
Feb 11	322.08	Apr 11	20.94	Jun 11	79.92	Aug 11	138.16	Oct 11	197.50	Dec 11	258.75
Feb 12	323.09	Apr 12	21.92	Jun 12	80.87	Aug 12	139.12	Oct 12	198.48	Dec 12	259.76
Feb 13	324.10	Apr 13	22.90	Jun 13	81.83	Aug 13	140.08	Oct 13	199.47	Dec 13	260.78
Feb 14	325.11	Apr 14	23.88	Jun 14	82.78	Aug 14	141.04	Oct 14	200.46	Dec 14	261.80
Feb 15	326.12	Apr 15	24.86	Jun 15	83.74	Aug 15	142.00	Oct 15	201.45	Dec 15	262.81
Feb 16	327.13	Apr 16	25.83	Jun 16	84.69	Aug 16	142.96	Oct 16	202.45	Dec 16	263.83
Feb 17	328.14	Apr 17	26.81	Jun 17	85.65	Aug 17	143.93	Oct 17	203.44	Dec 17	264.85
Feb 18	329.15	Apr 18	27.79	Jun 18	86.60	Aug 18	144.89	Oct 18	204.43	Dec 18	265.87
Feb 19	330.16	Apr 19	28.77	Jun 19	87.56	Aug 19	145.85	Oct 19	205.42	Dec 19	266.88
Feb 20	331.17	Apr 20	29.74	Jun 20	88.51	Aug 20	146.81	Oct 20	206.42	Dec 20	267.90
Feb 21	332.18	Apr 21	30.72	Jun 21	89.47	Aug 21	147.78	Oct 21	207.41	Dec 21	268.92
Feb 22	333.18	Apr 22	31.70	Jun 22	90.42	Aug 22	148.74	Oct 22	208.41	Dec 22	269.94
Feb 23	334.19	Apr 23	32.67	Jun 23	91.37	Aug 23	149.70	Oct 23	209.40	Dec 23	270.96
Feb 24	335.20	Apr 24	33.65	Jun 24	92.33	Aug 24	150.67	Oct 24	210.40	Dec 24	271.98
Feb 25	336.21	Apr 25	34.62	Jun 25	93.28	Aug 25	151.63	Oct 25	211.39	Dec 25	273.00
Feb 26	337.21	Apr 26	35.60	Jun 26	94.24	Aug 26	152.60	Oct 26	212.39	Dec 26	274.01
Feb 27	338.22	Apr 27	36.57	Jun 27	95.19	Aug 27	153.56	Oct 27	213.39	Dec 27	275.03
Feb 28	339.22	Apr 28	37.54	Jun 28	96.15	Aug 28	154.53	Oct 28	214.39	Dec 28	276.05
		Apr 29	38.52	Jun 29	97.10	Aug 29	155.49	Oct 29	215.38	Dec 29	277.07
		Apr 30	39.49	Jun 30	98.05	Aug 30	156.46	Oct 30	216.38	Dec 30	278.09
						Aug 31	157.43	Oct 31	217.38	Dec 31	279.11

Reference

[1] Steyaert, C., "Calculating the Solar Longitude 2000.0", *WGN* 19:2, April 1991, pp. 31–34.

Front cover photographs. Lately, we have difficulties in finding suitable photographs for the front cover. Once again, we call upon all meteor photographers to send us their best pictures. To be usable, the (*i*) the meteor shown must be bright, (*ii*) there must be enough background (many stars, the Milky Way, part of the horizon, etc.), and (*iii*) the photograph must be a sufficient contrast so that its interesting features will not disappear in the reproduction process.

The Leonids

Remembering the 1966 Leonids

George Spalding and Alastair McBeath

As attention focuses on the potential Leonid storm in 1998 or 1999, we remind observers that even non-storm rates from this shower can be worth watching, using the example of one observer's recollections of the 1966 Leonids over Britain.

1. Introduction

Much has been written in recent times about the possibility of a Leonid storm in November 1998 or 1999, with attention closely drawn to the most likely places on Earth that may witness the event. Most observers will not be able to travel far to attempt to see whatever happens for the shower, however, and some may well not wish to do so, preferring to view whatever occurs from their usual site.

Although seeing the sky filled with meteors every instant might be the dream-hope of many meteor watchers, we know that the short-lived nature of past high Leonid returns this century [1] means most watchers with this ambition may well be disappointed, if they are in the wrong place at the time any storm takes place.

Even so, Leonid activity may well exceed that noted by most people previously, on nights either before or after the "main event" itself.

It is with this in mind that we present the following details from the memory of one of us (George Spalding), during his observing campaign for the 1966 Leonids in Scotland. Also included are some comments on events at the time compared to now.

2. The 1966 Leonids over Scotland remembered

The greatest meteor shower in recorded history, it was said, and I missed it by only 9 hours.

Having made my first meteor observations in 1964 of the Geminids, I had become a first year student at St. Andrews University in Scotland by the time that the 1966 Leonid shower came around.

I still possess the timely duplicated set of notes sent out by the *BAA Meteor Section* Director of that time, Harold Ridley. But I do not recall that the publicity was anything like that attending the coming 1998-99 returns; possibly, this was because few people expected anything really sensational from the Leonids in 1966, given their relative failures in 1899 and in 1932-33.

At a meeting of the University Astronomical Society a week or so before the shower, the Leonids were debated and observations planned. However, in the event I found myself a lone observer.

I started my observational campaign on the fine night of November 13-14 from a site on the seaside, and saw my first Leonid at 0^h31^m UT. Out of 17 meteors, in two hours of observation, 4 were Leonids.

The next night, November 14-15, was fine again, but I was restricted to 35 minutes before midnight, seeing just 2 Leonids.

The big night of November 16-17 arrived, but with inferior conditions.

This time, I observed from the benches in the cricket pavilion not far from the University Observatory, with a good eastern horizon. It was rather uncomfortable—in those days I had not thought of deck chairs and sleeping bags!

The patchy cloud and occasional clear spells allowed only 1^h20^m total observing between 0^h00^m and 3^h15^m UT.

My total bag was rather a meager 19 meteors, but at least 10 of them were Leonids. Little did I know that my last meteor, a Leonid, would appear at 3^h12^m, less than 9 hours before the great peak seen in the USA.

The next night, November 17-18, having heard nothing from elsewhere, I was ready to observe again from the same venue.

Again there was patchy cloud, but the clear periods were at least longer than on the previous night.

Between 23^h50^m and 3^h15^m UT, I observed for 2^h50^m logging 61 meteors of which 48 were Leonids. (Even now I have never bettered that Leonid score on a single night, only approaching it 29 years later on November 17-18, 1995). There were some really marvelous Leonid meteors, including a magnitude −3 event at 1^h21^m with a glorious persistent train and a double maximum flare.

That ended my actual observations of the 1966 Leonids. I sent off a couple of postcards to Ridley, who wanted brief summaries in advance of detailed results.

The news of the great sight in the US Mid-West only trickled through to me days later at a meeting of my local Dundee Astronomical Society. In those days of course there was no e-mail nor the World Wide Web for quick access to information. However, I am surprised now that I do not recall checking the newspapers, television, or radio in detail. Perhaps this was because, as I said earlier, we had no reason to expect a sensation.

Though I actually got better results from the 1966 Geminids some three weeks later, the Leonids of that year did leave an indelible imprint on my memory. Hopefully these memories will be supplemented by more of the same over the coming few years. Also, having been born at the right time, I may live to see the showers around 2031!

3. Conclusion

As we can see, expectations from the Leonids now are far greater than in 1966, and there is the possibility that even a Leonid storm may not quite be the event some people anticipate, simply because there will not be the shock value of 1966 compared to the virtual non-events of 1899 and 1932-33. The 1900 Leonid events over Hudson Bay, when high rates occurred, went largely ignored for most of this century, we must not forget.

Another item that stands out from the above recollections of George Spalding is that even Leonid rates more than 12 hours after the storm were still good.

Perhaps the most important thing to stress is that it really does not matter what happens with the Leonid meteors showers in 1998 and 1999. What is important is that we should make detailed observations of whatever transpires, so that posterity will remember—and perhaps even thank—us for not squandering the opportunity to make the most detailed examination ever of this fascinating shower. And of course, we can all hope for the thrill of seeing something exceptional.

Now all we need are clear skies!

Reference

[1] J. Rendtel, R. Arlt, A. McBeath, "Handbook for Visual Meteor Observers", IMO, 1995, pp. 236–243.

Bulletin 11 of the International Leonid Watch: First Results of the 1997 Leonids

Peter Brown and Rainer Arlt

From early visual reports of the 1997 Leonid shower, a preliminary activity profile is constructed based on 2379 Leonids reported by 78 observers. A broad plateau in activity occurred between $\lambda_{\odot} = 235.^{\circ}0$ (eq. 2000) and $\lambda_{\odot} = 235.^{\circ}8$, with a most probable maximum at $235.^{\circ}16 \pm 0.^{\circ}04$ and an accompanying ZHR of approximately 150, though the peak values are based on only 5 individual ZHR measurements. Strong lunar interference precludes any definitive statement concerning the visual activity of the shower in 1997.

1. Introduction

As in the last 3 years, the 1997 Leonid return showed strong activity. The anticipated increase in 1997 was partially overshadowed by the presence of the Moon, which severely hindered visual observations. Fainter Leonids were all but invisible under the glaring moonlight, but the large numbers of bright fireballs clearly supported the notion that much-higher-than-usual activity was present.

We thank the many observers listed below who contributed to this preliminary analysis.

Abdo Sana'a (Jordan) Al-Alwanew Mohammad (Jordan), Al-Mualla Ramez (Jordan), Al-Niamat Ahmad (Jordan), Alvarellos Jose Juis (USA), Assmus Joseph (USA), Biliškov Nikola (Croatia), Brown Peter (Canada, observing from the USA), Collier Matthew (USA), Dalee Hani (Jordan), Davis Mark (USA), Fukuda N. (Japan), Fukui Keiiti (Japan), Furutome (Japan), Garaj Slaven (Croatia), Gliba George (USA), Gorelli Roberto (Italy), Gramer Lewis (USA), Hally Wayne (USA), Hasegawa Takasi (Japan), Hashimoto Takema (Japan), Hattori Yukiti (Japan), Haver Roberto (Italy), Hernandez David (Spain), Hostetter David (USA), Iiyama Oomi (Japan), Itou Daiyu (Japan), Izumi Kiyoshi (Japan), Johannink Carl (the Netherlands), Kadota N. (Japan), Kar Niladri (India), Kawai Y. (Japan), Kisanuki Atosi (Japan), Langbroek Marco (the Netherlands), Lukić Vladimir (Yugoslavia, observing from the USA), Lunsford Bob (USA), Maeda Kouji (Japan), Mameta Katuhiko (Japan), Matumoto H. (Japan), Miskotte Koen (the Netherlands), Muruyama T. (Japan), Nakamura Kiyohide (Japan), Nakazaka Y. (Japan), Naniwada K. (Japan), Nijland Jos (the Netherlands), Nishitani N. (Japan), Odeh Mohammad (Jordan), Odwan Ibrahim (Jordan), Oka Masayuki (Japan), Okayasu Hiroyuki (Japan), Okuda T. (Japan), Oonishi H. (Japan), Osada Kazuhiro (Japan), Saitou K. (Japan), Sanchez Javier (Spain), Satou Tatuo (Japan), Shioi Hiroyuki (Japan), Solano Ruiz Manuel (Spain), Stafford Mark (USA), Stomeo Enrico (Italy), Sugimoto M. (Japan), Sumikawa S. (Japan), Taibi Richard (USA), Takanashi Masaaki (Japan), Tamaki M. (Japan), Terakubo K. (Japan), Togni Rocky (USA), Toomey Michael (USA), Torigoe T. (Japan), Trigo-Rodriguez Josep M. (Spain), van Weerden Anne (the Netherlands), Yabu Yasuo (Japan), Yamaguchi Satiko (Japan), Yamanami Y. (Japan), Yoshimura Masaya (Japan), Yrjölä Ilkka (Finland), Zay George (USA), Zgrablic Goran (Croatia)

We also acknowledge observations from *AMOTA* (*Association of Meteor Observers in and around Tokyo Area*) derived from their WWW-site.

2. Activity profile

Due to the few magnitude estimates so far received it has not been possible to compute an r-profile for the stream in 1997. Given the strong moonlight, it is almost certain that any attempt to use magnitude data from the peak night will be heavily biased and produce artificially low values for the population index r.

We have adopted $r = 2$ in computing the ZHR profile. Given the r-profile from 1996 [1], this choice may be somewhat high for the broad, central portion of the stream and hence the ZHRs may be overestimated. The narrower outburst portion of the stream, however, is expected to show larger values of r and thus the highest ZHR values reported here may be more accurate.

The activity profile is shown in Figure 1.

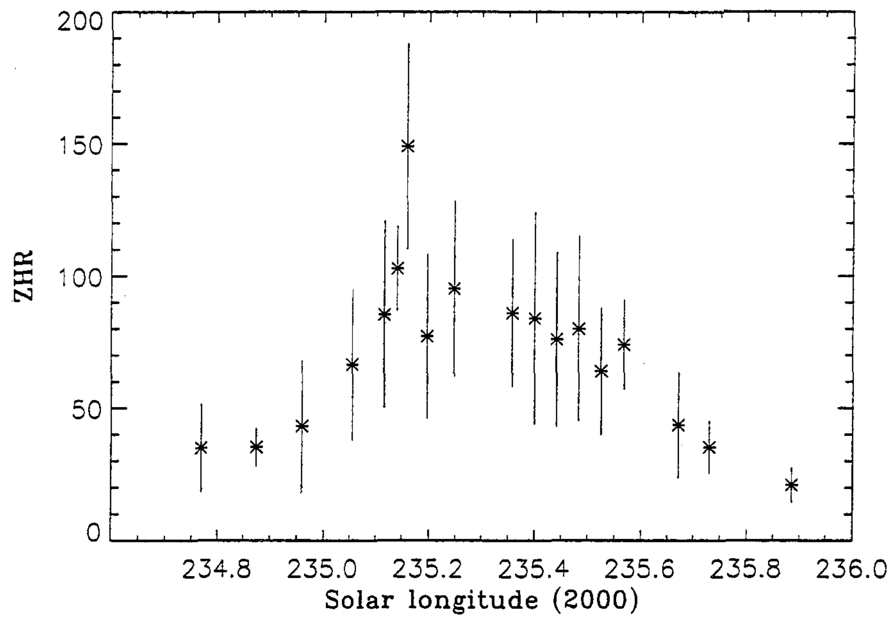


Figure 1 – ZHR versus solar longitude for the 1997 Leonid return.

The build-up in activity prior to $\lambda_\odot = 235.^\circ0$ is apparent, though the error margins (which represent standard deviations of the average of the individual ZHR determinations) are large. The peak shown at $\lambda_\odot = 235.^\circ16$ is based on 5 observations from 3 observers only and must be regarded as tentative at best. Particularly given that the next interval (just before $\lambda_\odot = 235.^\circ2$) shows a large drop in activity, the peak value may be erroneous. The large errors throughout reflect the poor lunar conditions and spread in reported ZHRs for similar time intervals; indeed activity is constant within error margins between $\lambda_\odot = 235.^\circ1$ and $\lambda_\odot = 235.^\circ5$, excluding the maximum point.

The decrease in activity after $\lambda_\odot = 235.^\circ5$ is also clear and very similar to that of the 1996 return [1]. While no r-values are computed here, contemporary reports of the shower [2] suggest significant numbers of fireballs were visible near the peak, and that these occurred in greater numbers than in the most active previous year of the current Leonid cycle (1994) [3]. This hints at a broad profile of relatively large particles.

The disappointing coverage near the peak leaves unanswered the question as to whether this was a true recurrence of the outburst peak detected in 1996 at $\lambda_\odot = 235.^\circ17 \pm 0.07$. That the 1997 maximum occurs at the same solar longitude as the 1996 outburst peak is highly suggestive, and may be the most compelling evidence to suggest that the higher average ZHRs reported at this location are real. It is likely that only radar observations of the stream from 1997 will be able to answer this question decisively.

We hope to present a more complete ZHR activity profile for the 1997 shower before the 1998 Leonids and urge observers who have not yet submitted their 1997 Leonid reports to do so promptly.

References

[1] P. Brown, R. Arlt, "Bulletin 10 of the International Leonid Watch: Final Results of the 1996 Leonid Maximum", *WGN* 25:5, October 1997, pp. 210–214.

[2] P. Brown, P., D.H. Levy, S.J. O'Meara, E.P. Bus, K. Suzuki, "Leonid Meteors 1997", *IAUC* 6772, 1997.

[3] P. Jenniskens, "Meteor Stream Activity. III. Measurement of the First in a New Series of Leonid Outburst", *Meteoritics and Planetary Science* 31, 199?, p. 177.

Radar Observations of the 1997 Leonids in Italy

Luigi Foschini, Giordano Cevolani, and Enzo Sbenaglia, CNR, Italy

Preliminary results of Leonid radar observations carried out during November 11–19, 1997, by using the forward scatter Bologna-Lecce radar facility in Italy, are presented. As in 1996, the Leonid maximum is incredibly obvious on November 17, with a prominent peak between 7^h and 8^h UT (exactly, at 7^h20^m–7^h40^m UT corresponding to solar longitudes $\lambda_\odot = 235\overset{\circ}{.}06$–$235\overset{\circ}{.}07$, eq. 2000.0). As a useful diagnostic tool for radio meteor observers, we utilized the enhanced counts of long-duration echoes having $T > 16$ s and $T > 64$ s to compare with the hourly echo profile deduced for $T > 1$ s (corresponding to all overdense meteors). Three activity spikes with peaks around 1^h–2^h, 3^h–4^h, and 7^h–8^h UT (the most prominent peak), are suggested to occur corresponding to solar longitudes between $\lambda_\odot = 234\overset{\circ}{.}75$ and $\lambda_\odot = 235\overset{\circ}{.}08$, even if these results based only on raw hourly radio meteor echo counts must be treated with caution because of correction factors and instrumental effects. When comparing the Leonid results of 1996 and 1997, the number of overdense meteors having $T > 1$ s has slightly increased in 1997, mainly in coincidence with the prominent maximum, whereas the number of long-enduring echoes has generally diminished throughout the whole morning. By considering the identical levels of transmitted power (0.25 kW) utilized in both years, it is suggested that the increase in the 1997 rates of the overdense meteors with $T > 1$ s during the time of maximum activity of the shower can be influenced by correction factors (i.e., the lost recording time in each hour due to the system saturation from very long-duration echoes).

Radar observations were performed almost without any interruption between November 11 and 19, 1997, utilizing the forward scatter (FS) Bologna-Lecce radar facility in Italy [1].

These are the main parameters of the FS meteor radar Bologna-Lecce:

- *transmitter location*: Budrio, near Bologna ($\varphi = 44\overset{\circ}{.}6$ N, $\lambda = 11\overset{\circ}{.}3$ E);
- *receiver location*: Lecce ($\varphi = 40\overset{\circ}{.}3$ N, $\lambda = 18\overset{\circ}{.}2$ E) in Southern Italy;
- *baseline Bologna-Lecce*: about 700 km;
- *power*: 0.25 kW;
- *frequency*: continuous wave frequency obtained by mixing 2 tones at 42.770 and 42.771 MHz, respectively;
- *transmitter*: 2 Rohde and Schwartz signal generators SMX;
- *antenna*: aerials of 5 Yagi elements at the transmitting and receiving stations, horizontally polarized, 15° elevation angle, 40° lobe width along the south-east direction.

The radio data used are all hourly raw counts over specific time intervals.

To a large extent, the radio activity follows the same geometrical conditions as for visual observations. Geometrical conditions imply that the Leonids are observable by radio techniques from a mid-latitude northern hemisphere site from about 22^h to 14^h local time each day around November 17, since the radiant culminates at around 6^h30^m local time. The radio echoes from overdense meteor trains were divided in class durations of 1–2, 3–4, 5–8, 9–16, 17–32, 33–64, 65–128, and more than 12 seconds, respectively.

The shower commenced to give clear signs of activity on November 15. High echo counts occurred on November 17 between 1^h and 11^h UT, when during 10 hours of observation 154 long-duration echoes having $T > 16$ s were registered (this number is lower than the corresponding rates registered in the same hours of November 17, 1996: 214 echoes with $T > 15$ s).

Figure 1 shows the 3D variations (*top*) and the relative section (*bottom*) of the number of all echoes as a function of the solar longitude (eq. 2000.0), observed in the period of November 11–19, 1997. Numbers in brackets represent hours and days. A greatly enchanced count of long-duration echoes having durations $T > 16$ s and $T > 64$ s and the comparison with echoes having durations $T > 1$ s (corresponding to all overdense meteors) was utilized as useful diagnostic tool to ascertain the shower activity.

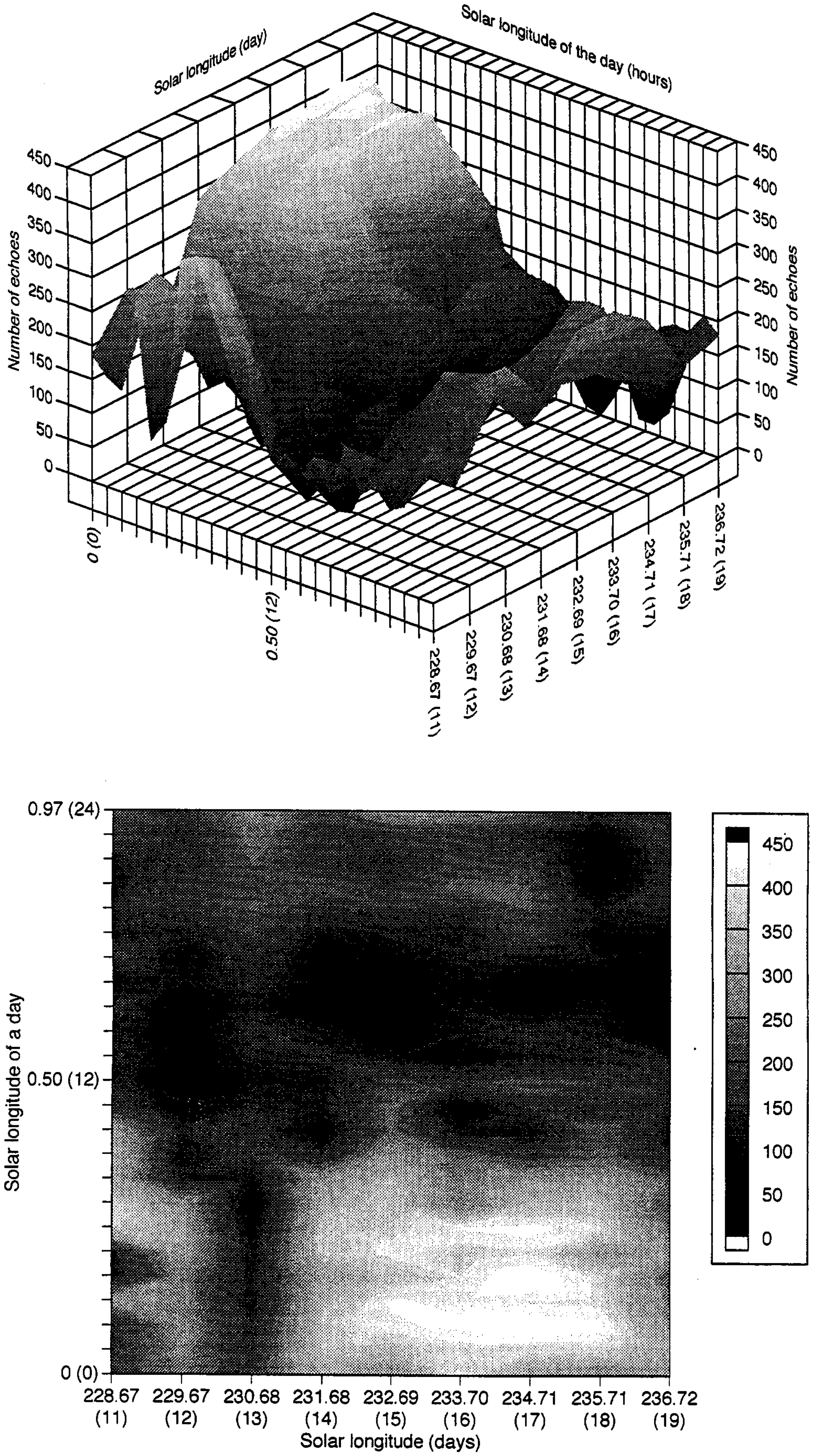


Figure 1 – This figure shows the 3D variations (*top*) and the relative section (*bottom*) of the number of all echoes as a function of the solar longitude (eq. 2000.0), observed in the period of November 11–19, 1997. Numbers in brackets represent hours and days.

Three activity spikes with peaks around 1^h–2^h, 3^h–4^h, and 7^h–8^h UT (the most prominent peak), are suggested to occur corresponding to solar longitudes between $\lambda_\odot = 234.^\circ75$ and $\lambda_\odot = 235.^\circ08$). On the basis of very long enduring echoes with $T > 16$ s, the peak activity of the 1997 Leonids occurred between 7^h20^m and 7^h40^m UT ($\lambda_\odot = 235.^\circ06$–$235.^\circ07$) in close agreement with the maximum of 1996 which occurred at the same expected time ($\lambda_\odot = 235.^\circ29$, eq. 2000.0) [1].

Figure 2 shows the 3D variations (*top*) and the relative section (*bottom*) of the hourly flux of overdense meteors with long-duration echoes ($T > 16$ s) as a function of the solar longitude (eq. 2000.0), observed in the period of November 11–19, 1997.

The comparison between results of radar observations of the 1996 and 1997 Leonids in Italy is useful when considering that the two November campaigns were carried out using the same levels of transmitted power (0.25 kW) whereas the 1994-1995 observations were performed at different power levels (1 kW) [2,3].

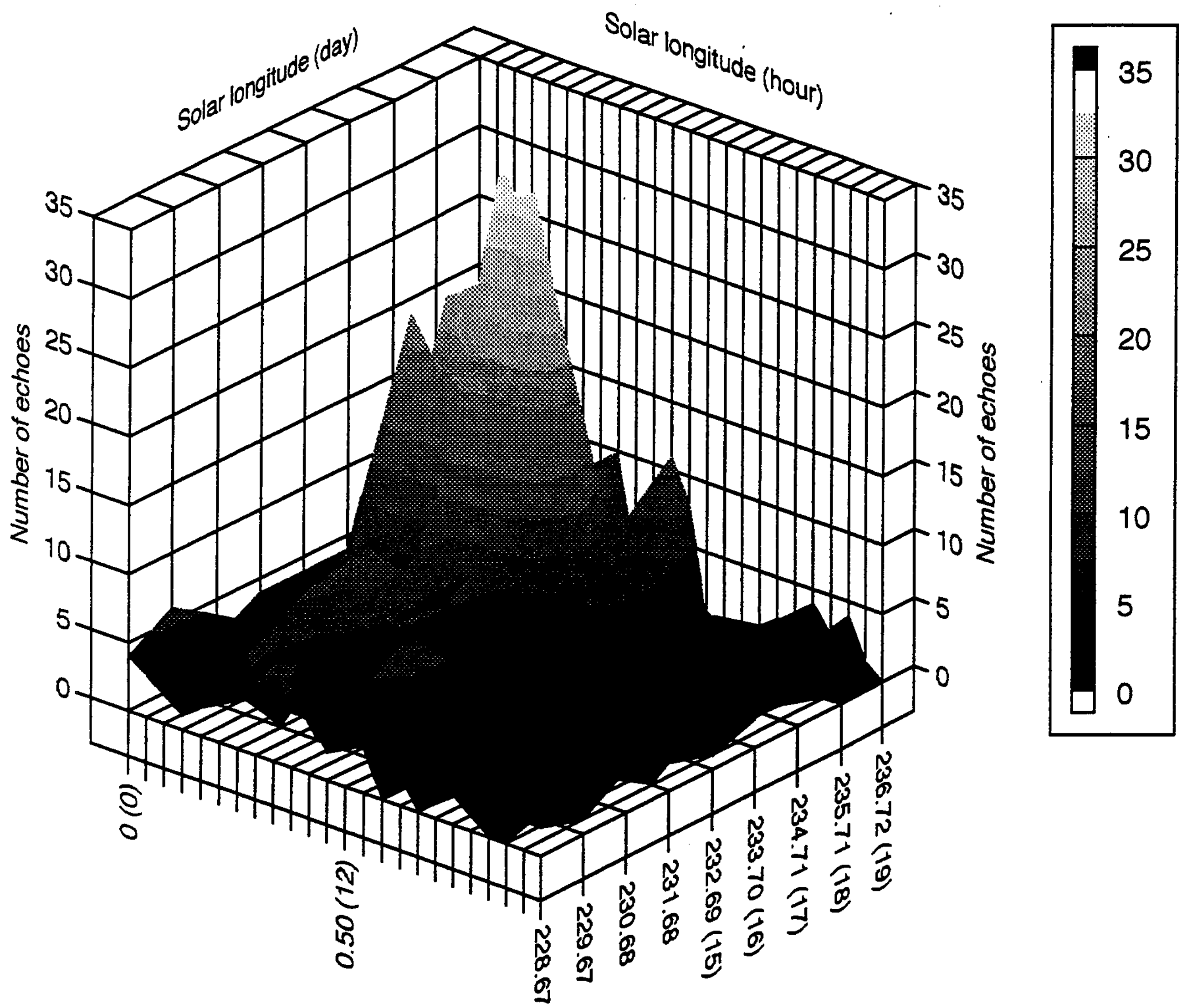
Figure 3 gives the plot diagrams of overdense Leonid meteors recorded by the Bologna-Lecce radar, having durations of $T > 1$ s, $T > 16$ s, and $T > 64$ s, relatively to November 17, 1996 and November 17, 1997 (the numbers at the edge represent the hours in UT and those inside give the hourly number of echoes).

By taking into account mainly very long-duration echoes, at least three sub-phases of the Leonid activity are evident in the shower display. the profile of the data shows a slow ascending branch and a more rapid descending one. This trend may be attributed both to a decreasing radiant elevation after the radiant culmination of the shower and a less favorable geometry for receiving signals mainly in a FS radar facility (i.e., the elevation angle of the aerials at the transmitting and receiving station with respect to where most Leonids are likely to appear at that time in the sky). Another aspect to stress is the complexity of the pattern relative to Leonids having $T > 1$ s which shows a prominent peak at 6^h UT when the shower radiant culminates and two secondary peaks, the first late in the morning (12^h UT) and the second one at 18^h UT. By considering that identical levels of transmitted power (0.25 kW) were utilized in 1996 and 1997, it is suggested that the increase in 1997 rates of overdense meteors with $T > 1$ s during the hour of maximum shower activity can be connected with the amount of lost recording time ("dead time") in each hour due to the system saturation from very long-duration echoes.

As a preliminary conclusion, the analysis of the hourly raw counts of the 1997 Leonids recorded at the Bologna-Lecce radar in November 11–19, reveals a lower activity with respect to the 1996 Leonids as far as the flux of long-duration echoes is concerned, whereas the number of the overall overdense meteors with duration $T > 1$ s significantly increased with respect to 1996. From November 15, even the number of the fainter meteors with $T < 0.25$ s corresponding to tiny particles increased similarly as in 1996 when a great deal of evanescent meteors (up to 50–60% of the overall echoes) was recorded during the time of maximum activity.

Figure 4 shows the 3D variations (*top*) and the relative section (*bottom*) of the hourly flux of fainter meteors with $T < 0.25$ s) as a function of the solar longitude (eq. 2000.0), observed in the period of November 11–19, 1997.

The increase in the number of fainter meteors is consistent with the interpretation that these evanescent meteors are composed of very young material possibly associated with the more active material of the stream [4]. Even a rough analysis of our data for the 1997 Leonids in Figure 1 reveals, in correspondence to the three different class durations ($T > 1$ s, $T > 16$ s, and $T > 64$ s), a constant peak at 3^h–4^h UT ($\lambda_\odot = 234.^\circ84$–$234.^\circ88$) more significant in amplitude than that observed 2 hours before. The recorded activity of the 1997 Leonids in Italy is probably influenced by correction factors and characteristics of the employed radar equipments. Instrumental effects (i.e., minimum signal threshold in radio receivers, antenna gain, differentiated levels of transmitted power, loss factors, radio echo ceiling effect depending on radar wavelength for different radars, ...) combined to the geometrical aspects of the radar facility, play an important role in the recorded time distribution of meteoroids.



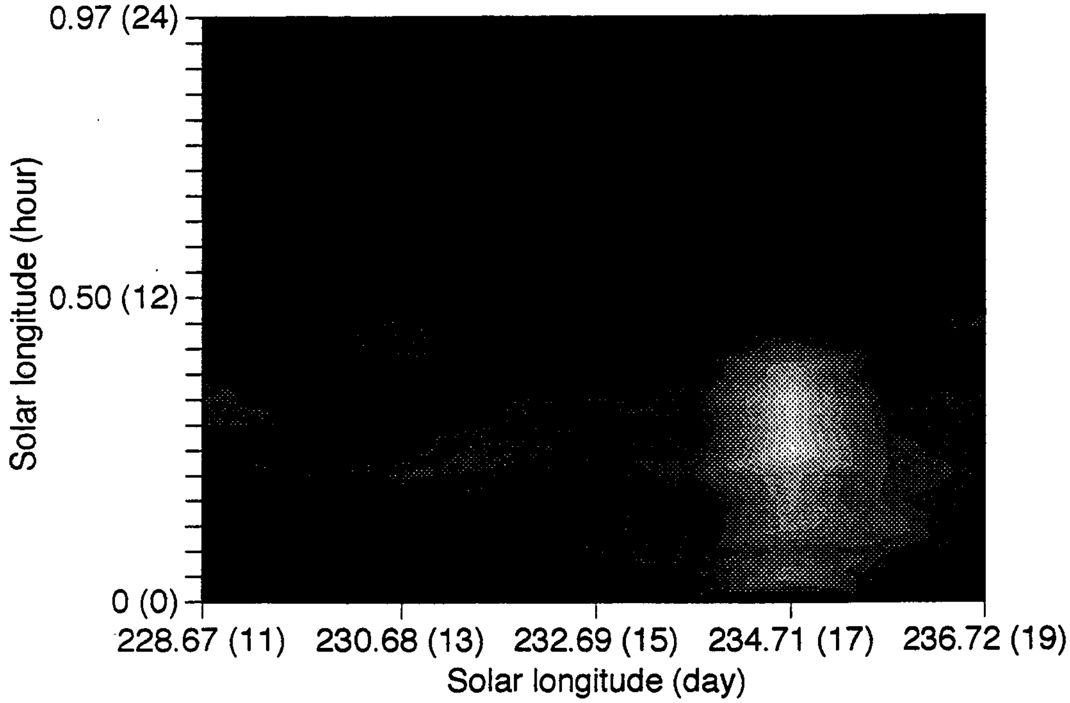


Figure 2 – This figure shows the 3D variations (*top*) and the relative section (*bottom*) of the hourly flux of overdense meteors with long-duration echoes ($T > 16$ s) as a function of the solar longitude (eq. 2000.0), observed in the period of November 11–19, 1997.

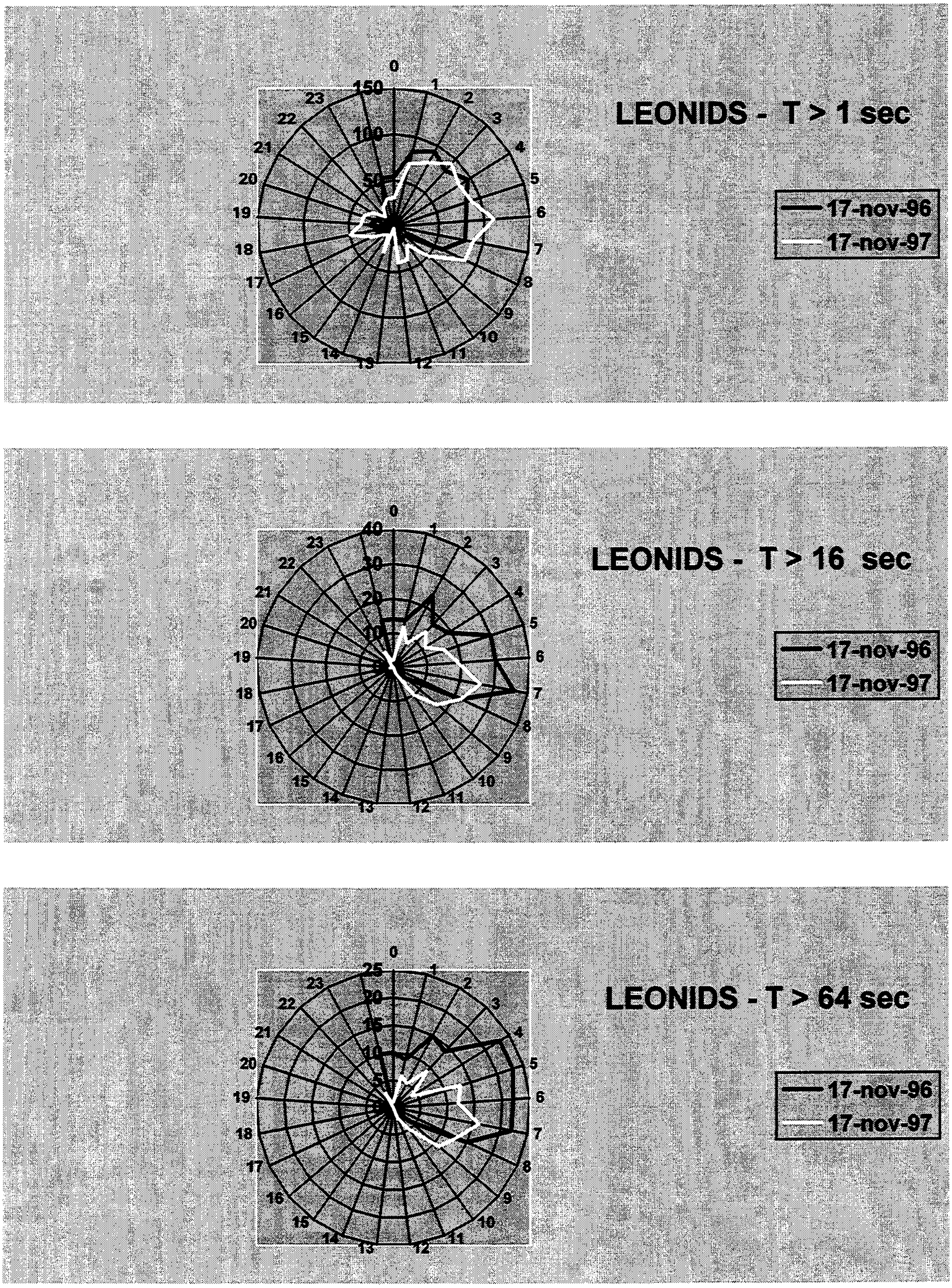


Figure 3 – This figure gives the plot diagrams of overdense Leonid meteors recorded by the Bologna-Lecce radar, having durations of $T > 1$ s, $T > 16$ s, and $T > 64$ s, relatively to November 17, 1996 and November 17, 1997 (the numbers at the edge represent the hours in UT and those inside give the hourly number of echoes).

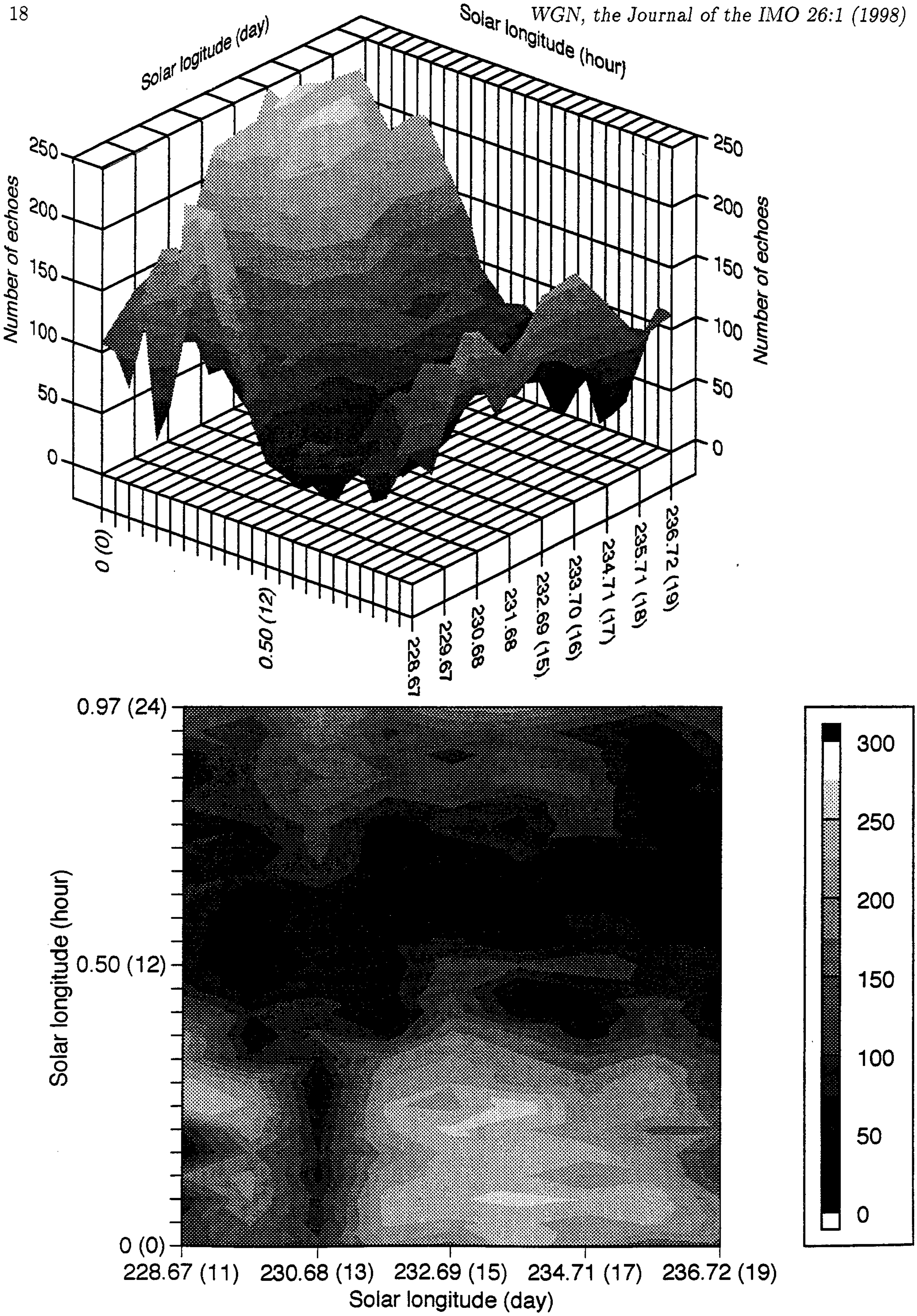


Figure 4 – This figure shows the 3D variations (*top*) and the relative section (*bottom*) of the hourly flux of fainter meteors with $T < 0.25$ s) as a function of the solar longitude (eq. 2000.0), observed in the period of November 11–19, 1997.

A useful diagnostic tool to highlight the activity of the shower is to utilize the number of long-duration echoes (having at least $T > 16$ s) since they are thought to be less influenced by technical aspects. Moreover, our results show that the hourly rates of meteor echoes may be influenced by changing the angle between the meteor shower radiant and the antenna beam orientation, which, at least in the case of the observation of meteor showers active for several days should be taken into account for the resulting meteor flux measurements. Another important aspect is that the detected echo rates at a forward-scatter system do not always fit the expected rates of meteor signals. It should be possible to solve only in part the problem that such uncorrected data create, by comparing the shape and character of cumulative meteor distributions obtained by other radio equipment.

Acknowledgments

We are grateful to G. Bortolotti, C. Franceschi, A.F. Gabucci, and G. Trivellone for their technical support during the observing period.

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Ongoing Meteor Work

The Makings of Meteor Astronomy: Part XV

W.F. Denning—The Doyen of Amateur Astronomers

Martin Beech, Campion College, University of Regina

On the occasion of the 150th anniversary of the birth of William Frederick Denning, an overview of the life of the work of this significant British amateur astronomer, in particular with respect to his meteor work, is given.

1. Introduction

This year celebrates the 150th anniversary of the birth of William Frederick Denning. Although he was not a professional astronomer in the usual sense of the epithet, Denning made significant contributions to the development of meteor astronomy and was an avid "sweeper" of comets and observer of the planets. In practice, his field of interest was both wide, and deep and his enthusiasm for observing inexhaustible.

We can not hope to review all of Denning's works in a study such as this. Likewise, we can not hope to present an in-depth review of his life. Indeed, the details concerning Denning's early life are still obscure and very little material relating to his personal thoughts has survived. There are threads, however, and a patchwork, rather than a tapestry, of his life is emerging. It is my hope to piece together as much of this patchwork as is possible.

2. The early years

William Frederick Denning was born in the small Somerset village of Redpost on November 25, 1848. At that time his father, Issac Poyntz Denning, was identified as an accountant. Interestingly, just four years earlier, on the day of his second marriage, Issac P. Denning had described himself as a schoolmaster. Denning[1]'s mother, Lydia Padfield, was the seamstress daughter of Richard Padfield, a wagon loader at Coal Barton Colliery. Issac Poyntz Denning's father, Issac Denning, is identified in 1844 as a retired Sergeant Major. Indeed, Issac Denning served in the 53rd Shropshire Regiment of Foot (now the King's Shropshire Light Infantry), and he saw action in the Peninsular Wars which helped establish the "Great Peace" between 1815 and 1914.

Virtually nothing is known of Denning's early childhood. When he was just eight years old, however, Denning and his family moved from the rural settings of Redpost to the City of Bristol. In the same year that the family moved to Bristol (1856), Issac P. Denning established the accountancy partnership of *Denning, Smith and Co*, and indeed, he was to work within this partnership until his death in 1884. Issac and Lydia Denning were to raise a total of four children, and Wiliam F. Denning, the eldest child, had a brother, Frederick, and two sisters, Emma and Margaret.

The Denning family seemingly had many relatives in the Bristol area, and Denning was to live within the City for the remainder of his life. Indeed, he only rarely left its confines. The Denning family prospered in Bristol, but, unfortunately, no details of Denning's formative years have survived. It is reasonable to assume, however, that he received a sound education. Certainly it would appear that Denning had a healthy, and athletic adolescence. Amateur meteor observer J.P.M. Prentice commented [1] on Denning that *"in his younger days he* [Denning] *was somewhat of an athlete, delighting in running and playing hockey, and a keen and skillful cricketer."* Denning's skill as a cricketer was described in several of his obituary accounts, and T.E.R. Phillips recounts [2] in particular that *"he once told the writer that W.G. had invited him to keep wicket for Gloustershire."* W.G., of course, was none other than Dr. William Gilbert Grace who captained the renowned *Gloustershire Cricket Club* from 1871 to 1898. Then, as today, such an offer would have only been extended to players of distinction. For reasons that we can only guess at, Denning declined Grace's invitation. One suspects, however, that the offer was declined because the young Denning had already set his sights on a career in astronomy. At the time that the offer to play for Gloustershire was made, Denning would have been in his early to mid-twenties.

Denning had a life-long interest in natural history, but began to specialize in astronomy at 17 years of age. In 1895 he wrote [3], for example, that he had *"been engaged, as an amateur astronomer, in observing celestial objects or in exploring the heavens, since 1865."* It is probably significant that within a few years of his decision to pursue astronomy, Denning was fortunate enough to witness the spectacular meteor storm of 1866, and the flight of an awe-inspiring fireball on the night of November 6, 1869. It may be possible to speculate that it was the observation of these two impressive events that turned Denning's interests towards meteor astronomy. The 1869 fireball event was particularly significant since it initiated an important series of correspondence with Alexander Stewart Herschel. During the mid to late 1800s, A.S. Herschel was one of the leading exponents of meteor astronomy in Britain, and he exchanged letters with Denning [4] from 1869 to 1907 (the time of Herschel's death).

3. The amateur astronomer

While meteor studies were to dominate Denning's later research interests, his early observational projects were many and varied.

[1] We shall generally use Denning to refer to W.F. Denning.

Denning purchased his first telescope, a 4.5-inch refractor, in 1866. As testament to his all-round enthusiasm and ability, it can be observed that, among Denning's first set of published notes, there are several accounts pertaining to sunspot groupings, the timings of Jovian satellite transits, and a record of a transit of Mercury [5].

Denning's first publications appeared in the *Astronomical Register*, and he began to submit material to this journal in 1868. The *Astronomical Register* had been founded by Sandford Gorton in 1863, and was the first British journal published with the amateur astronomer in mind [6]. Denning became a regular contributor to the *Register*, and he used its pages to describe, and initiate, a series of observational campaigns. Details of the first campaign that Denning organized can be found in a letter to the Editor dated March 16, 1869. Denning, along with sixteen other observers, proposed to continually monitor the Sun between March 14 and April 14 (1869), *"with the view of re-discovering the suspected intra-Mercurial planet Vulcan."* [7] It is not clear how, or when, the members involved in this study were first assembled, but it is probably safe to assume that the *Astronomical Register* was their common focus, and that the organizing correspondence followed exterior to its pages. While the search for Vulcan was unsuccessful (we, of course, now know that any such search would have to be unsuccessful), Denning's enthusiasm for organized observing clearly remained high, and, on July 1, 1869, he became one of the founding members, as well as the Treasurer and Secretary, of the *Observational Astronomical Society* (*OAS*). This unfortunately short-lived society was in many ways the forerunner of the present-day *British Astronomical Association* (founded 1890). The initial *OAS* membership was stated to be about fifty observers [8]. Denning compiled quarterly reports on the observations collected by the *OAS* members, and these were published in the *Astronomical Register* and the journal *Nature*. Denning was closely involved with several further campaigns intended to re-discover Vulcan, and (more fruitfully) in a series of studies of Venus.

Denning compiled reports for the *OAS* throughout 1870, and became Honorary Secretary to the society in 1871. Also in 1871, Denning purchased a 10-inch With-Browning reflecting telescope. This telescope became Denning's main research instrument and he used it to good effect in his subsequent planetary work.

In late 1871, Denning published, through Wymann and Sons of London, his first astronomy book. Titled *Astronomical Phenomena in 1872*, this text was seemingly written with the amateur astronomer in mind, and it was probably intended as a handbook for *OAS* members. The book, however, was reviewed in the influential journal *Nature* with the anonymous reviewer giving it a decidedly poor evaluation [9]. The reviewer was to write that the *"general remarks on astronomical observing ... are addressed to the simplest tyro, and are so meager as to give the impression of a want of accurate knowledge."* The review concluded that *"altogether the book is a very weak production."* One assumes that such a review would have disappointed Denning, and certainly no subsequent handbooks were produced.

It was presumably a disappointment to Denning that the *OAS* ceased activity in 1872. The last *OAS* report compiled by Denning [10] was published in May of 1872, and after that time, while individual notes by Denning, and other *OAS* members can be found in the literature, there are no more joint *OAS* projects reported. In December 1872, Denning published his first observational note [11] in the *Monthly Notices of the Royal Astronomical Society* (*MNRAS*). At about the same time that his first *MNRAS* note appeared, Denning proffered his candidacy for fellowship to the *RAS*. He was, however, unsuccessful in his first attempt at Fellowship, and was not in fact to be elected a Fellow until 1877. The *RAS* does not keep records outlining the reasons for non-election of candidates [12], but one can speculate that the demise of the *OAS*, of which Denning was a prominent member, and the poor review of his first book, were contributing factors.

Undaunted by the sour events of 1872, Denning continued to pursue his astronomical studies. Throughout the 1870s, the majority of Denning's published notes were concerned with the observation of meteors and the reduction of meteor radiants.

His first radiant catalog was published [13] in the *MNRAS* in 1876. This catalog was based on observations collected between 1872 and 1876. An interesting point concerning Denning's 1876 radiant catalog is that it was communicated to the Society by R.P. Greg. Along with A.S. Herschel, Greg was one of the foremost authorities on meteor astronomy in England at that time. Greg's endorsement of Denning's meteor work was no doubt an important factor in Denning's eventual election as a Fellow of the *RAS*.

Denning made his first truly significant contribution to meteor astronomy in 1877. It was in that year Denning, then 29 years old, was able to demonstrate a steady night by night movement in the Perseid meteor radiant. Denning's observations essentially confirmed, for the first time, a long postulated theoretical prediction. More significantly, however, in the following year (1878), Denning published his first paper suggesting that some meteor radiants were in fact stationary in the sky [14]. This important paper was controversial, since it suggested something entirely new. The stationary radiant hypothesis, as Denning's claim came to be called, was problematic, since it was clear from the outset that the origin of such meteoroid streams could not be explained through cometary decay [15]. The issue concerning the true existence of stationary radiants took many years to be resolved, and, even at the time of his death, Denning still firmly believed in their existence.

With the close of the 1870s, Denning began to publish an increasing number of notes on planetary observations (see Figure 1). Using his 10-inch With-Browning reflector, he embarked on a series of studies to determine planetary rotation rates. While he regularly observed Mercury, Venus, Mars, and Saturn, the majority of his attention was directed towards Jupiter. Great interest had been excited towards Jupiter after what is now known as the Great Red Spot came into prominence in 1878. Denning made a detailed historical study of the Red Spot's appearance (published in 1899), and, in his life time, recorded many thousands of Jovian surface transits.

Parallel to his increased interest in planetary observing, Denning also began to search for comets in the 1870s. His efforts were rewarded in 1881, when, on the morning of October 4, he discovered his first comet. This comet turned out to be a short-period comet, and the story of its discovery was often used by Denning as an example of why an *"observer should never hesitate."* [16] He noted, *"on July 11, 1881, just before daylight, I stood contemplating Auriga, and the idea occurred to me to sweep the region with my comet eye-piece, but I hesitated, thinking the prospect not sufficiently inviting. Three nights later, Schrabele, at Ann Arbor, U.S.A., discovered a bright telescopic comet in Auriga! Before sunrise on October 4 the same year, I had been observing Jupiter, and again hesitated as to the utility of comet-seeking, but, remembering the little episode in my past experience, I instantly set to work, and, almost at the first sweep, alighted upon a suspicious object which afterwards proved itself a comet of short period.* From all accounts, Denning took this cometary episode to heart, and, thereafter, never hesitated at the thought of making any observation. Indeed, on the comet-seeking front Denning continued to have a measure of success, discovering three more comets in 1890, 1892, and 1894. For each of these discoveries, he was awarded Bronze Medals by the *Astronomical Society of the Pacific*. Denning was also co-discoverer, with E.E. Barnard in America, of a comet in 1891.

By the mid-1880s, Denning's publication rate had risen to about 20 articles and observing notes per year, and his reputation as a dedicated and skilled observer was becoming widely known. His high standing in the amateur-astronomical ranks was recognized in 1887 when he was elected President of the *Liverpool Astronomical Society* (*LAS*). This society, which still thrives today, had been founded in 1881, and, at the time of Denning's election, boasted some 440 members world-wide. In addition to his election as President, Denning was also elected to the Directorship of the meteor and comet-seeking section, as well as the planetary (Jupiter) section.

Denning's return to organized amateur astronomy seems to have been largely successful. During his year-long Presidency, the *LAS* continued to prosper [17], and its membership increased to 641.

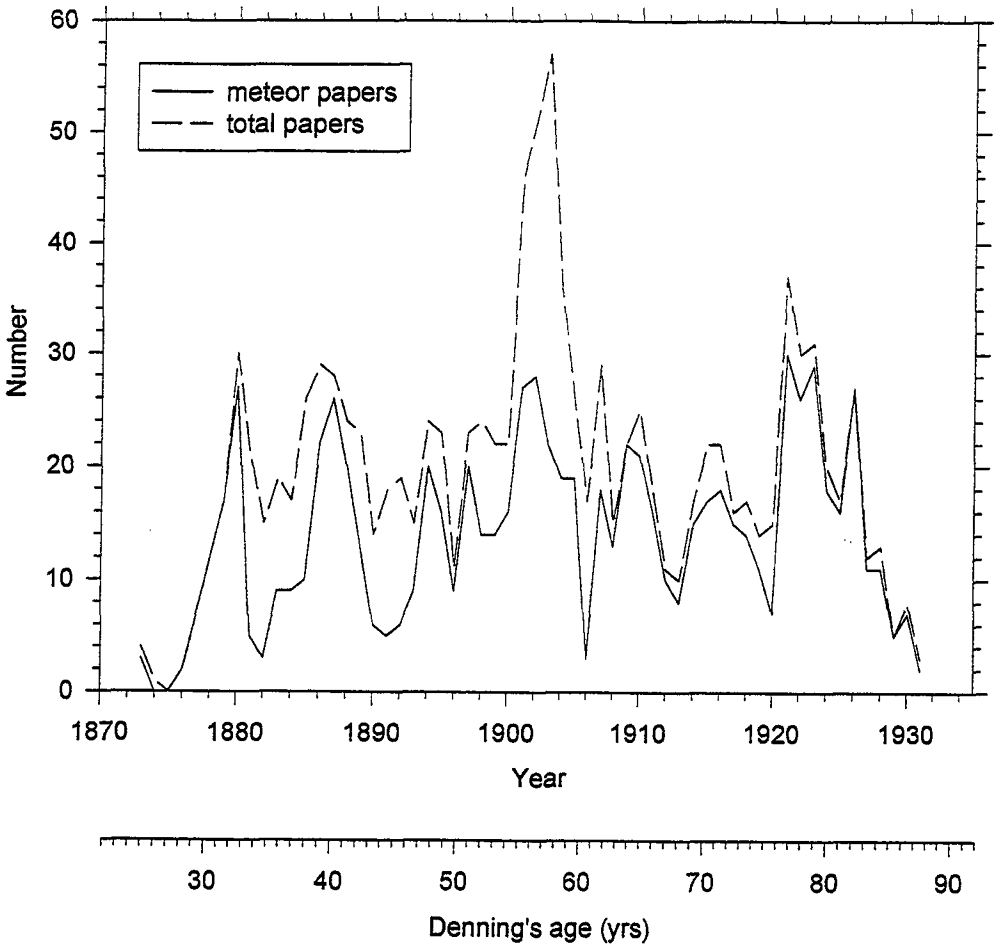

Figure 1 – Denning's annual publication rate. The solid line corresponds to the number of meteor-related papers, while the dashed line indicates the total number of papers published. The data used in the construction of Figure 1 represent a lower bound on Denning's actual output. He wrote widely, and the data only considered his contributions to the main journals of the time (e.g., *The Observatory* magazine, *MNRAS*, *JBAA*, *Astr. Nachr.*, *Nature*, *Knowledge and Science News*). In total, Denning published 1179 papers in the major astronomical/science journals between 1873 and 1931. Of these, 825 (70%) relate to meteor studies, 153 relate to Jovian studies, and 88 relate to cometary observations. The remainder of the total relates to many diverse topics. Denning achieved a remarkable average publication rate of 23 papers per year for 58 years. The yearly rate shows a marked peak circa 1903. This peak encompasses the time at which Denning was awarded a Civil List pension (1904), and presumably represents a period in which his financial situation was significantly improved and in which he had more time to dedicate to his observations. Denning's health took a dramatic down turn circa 1906, and, thereafter, he elected to abandon planetary observations all together. The vast majority of the "extra" papers between 1902 and 1905 were concerned with observations of the planet Jupiter. There is an interesting circa 10-year cycle in the publication rate for which I can offer no explanation.

The Society held monthly meetings in several centers throughout England. Denning was a regular attendant at the divisional meetings held in London, and there he read a series of papers on meteors, comets, and planetary observing. He also wrote a collection of articles on telescopes and telescopic work for the society's journal. These articles were later collected and expanded to form his second book. Denning's new work, entitled *Telescopic Work For Starlight Evenings*, was published in 1891 and, just like his first book, was reviewed in *Nature*. This time, however, the text received whole-hearted praise [18]. The anonymous reviewer wrote, *"As might be expected from such an experienced and enthusiastic observer as Mr. Denning, this book is thoroughly practical. He is not content with describing the beauties of the skies, but gives invaluable information as to how to see them better."* With similar praise, the reviewer concluded, *"Everyone who uses a telescope, or who intends to use one, of whatever dimension, should read Mr. Denning's book."*

Figure 2 – It is not known when this picture of W.F. Denning was actually taken. He is seen here with his 10-inch With-Browning telescope. The pictures dates probably from circa 1880.

Following his term as President to the *LAS*, Denning served as Vice President to the society through 1888. After this time, he was only to continue his involvement with organized amateur astronomy through the newly formed *British Astronomical Association* (*BAA*). The announcement to establish what was to become the *BAA* appeared in the *English Mechanic* magazine on July 18, 1890. Interestingly, while Denning certainly read this magazine, he made no attempt to become involved with the initial formation of the association. One wonders if memories of the short-lived *OAS* tempered his outlook on the prospects for this new amateur body. If this was the case, he had certainly changed his mind by June 1891, since on that date, having been described by the association's President as *"an earnest and successful comet-seeker"*, Denning was elected a *BAA* member. He was also invited to be the first Director of the association's comet section [19]. The chief objectives of the *BAA*'s Cometary Section were later outlined by Denning as *"comprising the discovery of new comets, nebulae, and recording telescopic meteors."* [20] At its inception, next to Denning, there were three other observers in the comet section. This was to rise to seven observers by the time Denning retired his Directorship in 1893. Denning cited poor health as the reason for stepping down from office, and it would appear that the general state of his well-being deteriorated from about 1890 onwards.

In addition to being elected Director of the *BAA*'s cometary section, Denning was elected [21] a Corresponding Fellow of the *Astronomical and Physical Society of Toronto*, in Canada, in 1891. This society, later to become the *Royal Astronomical Society of Canada* (*RASC*), had approached Denning with reference to his work as an observer, and upon his being a prolific writer. Denning became a regular contributor to the *Journal of the RASC*, and, within its pages, was to publish several articles popularizing meteor astronomy [22].

Denning's high standing as an observer, both within the British Isles and around the globe, was recognized in the 1890s through the award of several prestigious medals. The French *Académie des Sciences* was to bestow their Valz prize on Denning in 1895 in recognition of his meteoric studies [23]. The *RAS* also honored Denning [24] by the award of their highest medal, the Gold Medal, in 1898. This latter honor, bestowed in his fiftieth year, marked the zenith of Denning's career. His skill as a planetary observer and recorder of meteors was now universally recognized. Not just in the scientific domain, however, Denning's authority extended even to the literary world. Writing in his new book, *The War of the Worlds* (published 1898), the renowned novelist H.G. Wells was to open Chapter 2 as follows:

> *"Then came the night of the first falling star. It was seen early in the morning rushing over Winchester eastward, a line of flame, high in the atmosphere. Hundreds must have seen it, and described it as leaving a greenish streak behind it that glowed for some seconds. Denning, our greatest authority on meteorites, stated that the height of its first appearance was about ninety or one hundred miles. It seemed to him that it fell about one hundred miles east of him."* [25]

During the last few years of the 1890s, Denning was to publish several important studies on meteor astronomy. In 1897, his third book, *The Great Meteoric Shower of November*, appeared [26]. This work was solely concerned with the Leonid meteor shower, and, as with *Telescopic Work For Starlight Evenings*, was based on a collection of articles previously published in the astronomical literature. This third book was a grand synthesis of virtually all that was known about the shower, and its text offered an historical survey along with the results of many collected observations.

In 1899, Denning published what was to become one of his most important works [27], the *General Catalogue of the Radiant Points of Meteoric Showers and of Fireballs and Shooting Stars Observed at more than one Station*. In brief, this catalog was a general review of Denning's work on the determination of meteor radiants. The *General Catalogue* was appropriately published in the same year that Denning held the Directorship of the *BAA*'s Meteor Section. Denning was to hold this office for just one year, and again was to cite poor health for retiring from the post. It is not entirely clear what form of ill health Denning was suffering from at this time, but it is noteworthy that he had also cited health problems as the reason for not attending the ceremony at which his *RAS* Gold Medal was awarded [24].

In 1904, at the age of 56 years, Denning was awarded a Civil List Pension by the British Government [28]. This pension which amounted to £3150 per annum, was presented *"in consideration of his services to the Sciences of Astronomy, whereby his health has become seriously impaired, and of his straitened circumstances."* In 1906, Denning's health took a sufficiently bad turn that he elected to abandon planetary observing altogether, and he thereafter concentrated his efforts towards naked-eye astronomy, and the reduction of meteor radiants.

The first decade of the 20th century delineates a clear transitional period in Denning's life. Not only was his health deteriorating, but he became an increasingly reclusive figure. From circa 1900 onward, he saw few people, and only rarely left his home. Certainly, it would seem that he did not travel beyond the confines of Bristol. During the last thirty years of his life, Denning's only contact with the astronomical community was by extensive correspondence. It is a sad misfortune that only a small fraction of this correspondence seems to have survived to the present day. One of the largest surviving fragments of correspondence, however, is that with A.S. Herschel. And, even this collection of letters, is unfortunately one-sided with only the letters from Herschel to Denning being extant [4]. The Herschel-Denning correspondence that has survived to the present day dates from the period August 31, 1871, to September 12, 1900. The letters cover all aspects of meteor astronomy, and offer a few tit-bits of personal information, and activities. Most of the correspondence, however, deals with the exchange of observational data.

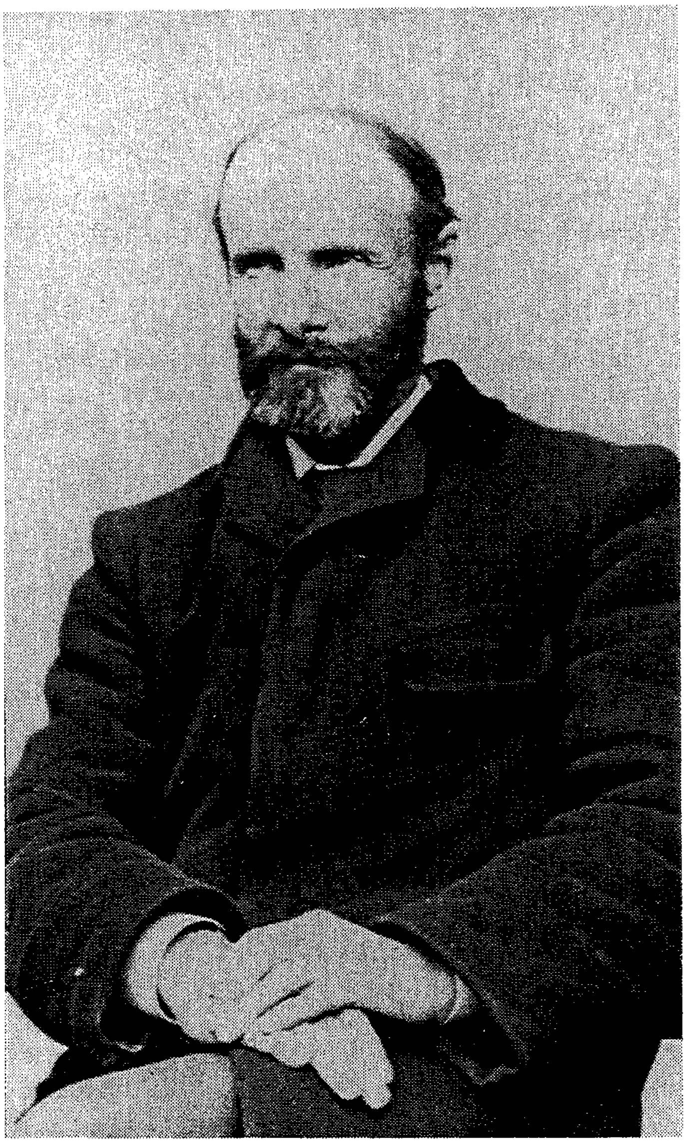

Figure 3 – This photograph of W.F. Denning was taken in 1904, the year that Denning received a Civil List pension "in consideration for his service to the sciences of astronomy."

Alexander Herschel died in 1907, and Denning was to write his obituary [29] for the journal *Nature*. In his account, Denning explained that *"it is not too much to say that, without the deep interest incited by Prof. Herschel's letters, the meteoric observations obtained at Bristol during the past thirty-five years may never have been made."* Indeed, Denning lost an important friend and confidant when Herschel died. Not only had Herschel openly encouraged Denning in his meteoric work, but he was also a strong supporter of the stationary radiant concept.

The stationary radiant issue had by circa 1910 become very controversial, and Herschel's death left Denning with virtually no supporters from within the ranks of the "professional" astronomers.

It is probably safe to suggest that some of Denning's growing reclusiveness was due to the increasing number of attacks on the stationary radiant concept. Some hint of Denning's bitterness towards this controversy can be found as early as 1891 when he wrote that *"as a rule, amateurs should avoid controversy, because it very rarely clears up a contested point ... it wastes time, and often destroys that good feeling which should subsist amongst astronomers of every class and nationality ... competition and rivalry in good spirit increases enthusiasm, but there is little occasion for the bitterness and spleen sometimes exhibited in scientific journals."* [16, p. 56]

For the moment, we simply observe that the existence of stationary radiants was an issue that dominated the last thirty years of Denning's life. It is also worth noting that Denning's continued belief in the existence of stationary radiants saw him become increasingly alienated from the main-stream of astronomical thought.

Denning quietly continued his work on the reduction of meteor radiants throughout the second decade of the 20th century. He was to return to the astronomical lime-light, however, in 1920 when, on the night of August 20, he discovered a nova in the constellation of Cygnus [30]. This discovery offers clear testament to Denning's tenacity as an observer and to the great acuity of his septuagenarian eyes.

In 1922, Denning's standing as a respected meteor observer was further acknowledged by an invitation to become the first President of the *Commission des étoiles filantes* in the newly formed *International Astronomical Union (IAU)*. Denning had in fact been approached with the offer in 1919, and some measure of his dire situation at that time can be found in one of the few surviving letters that he wrote to his niece (Christine Gravely) [31]. In a letter dated November 25, 1919, Denning commented,

> [I have] *been placed at the head of a committee of the International Astronomical Union appointed to study and advance our knowledge of meteors and meteoric phenomena. I hope to manage it all by correspondence. The first meeting does not take place until 1922 in Belgium, and it is quite a strain that someone will have to be chairman in my absence."*

Denning continued, in the same letter to his niece,

> *"my night-watchings have been few lately—I find it rather trying to be sitting out in the garden for hours on these damp cold nights. If I could take solid food and use a hamper, all could be easy but things are different with me now to what they were 40 or 50 years ago when I found it quite pleasant to be out in the frost all night long!"*

Understandably, advancing age and ill health were having their effect on Denning's ability to observe and participate in astronomical research. It would also appear that his spirits were at a low ebb. Writing again to his niece on September 4, 1923, Denning explained,

> *"I am sorry not to have answered your letter before, but I have done very little writing indeed for some weeks having been suffering more than usual. Your bright and interesting letter was very entertaining and was read by me with great pleasure at a dull time.*
>
> *I am glad you still find enjoyment in natural history subjects. If I could only get into the fields, I should watch the birds more and make notes of what I saw and heard, but I am not often out in my own garden now, and I have made hardly any observations during the last two years.*
>
> *This has been detrimental to me in various ways. I used to have the expectation of a night's successful observation and after that the discussion of my results, and comparison with details obtained before proved engrossing. It passed the time agreeable and occupied my thoughts—whereas now I have no new work to think about or fresh discoveries to look forward to. Day and night succeed each other with dull monotony.*
>
> *You were kind enough to inquire about the articles I had been writing lately for a serial now being issued entitled The Splendour of the Heavens. It is a grandly illustrated work. I have written rather long chapters in part 6 and 9, and another chapter on shooting stars will be printed in part 11 or 12. The work is full of most attractive pictures, and I believe they will be appreciated by everyone fond of astronomy."*

The book that Denning refers to in this letter, *The Splendour of the Heavens*, was edited by W.H. Steavenson, and was destined to become a popular, and widely read astronomy text. Steavenson was to later recall [32] a visit to Denning's home at this time (circa 1922).

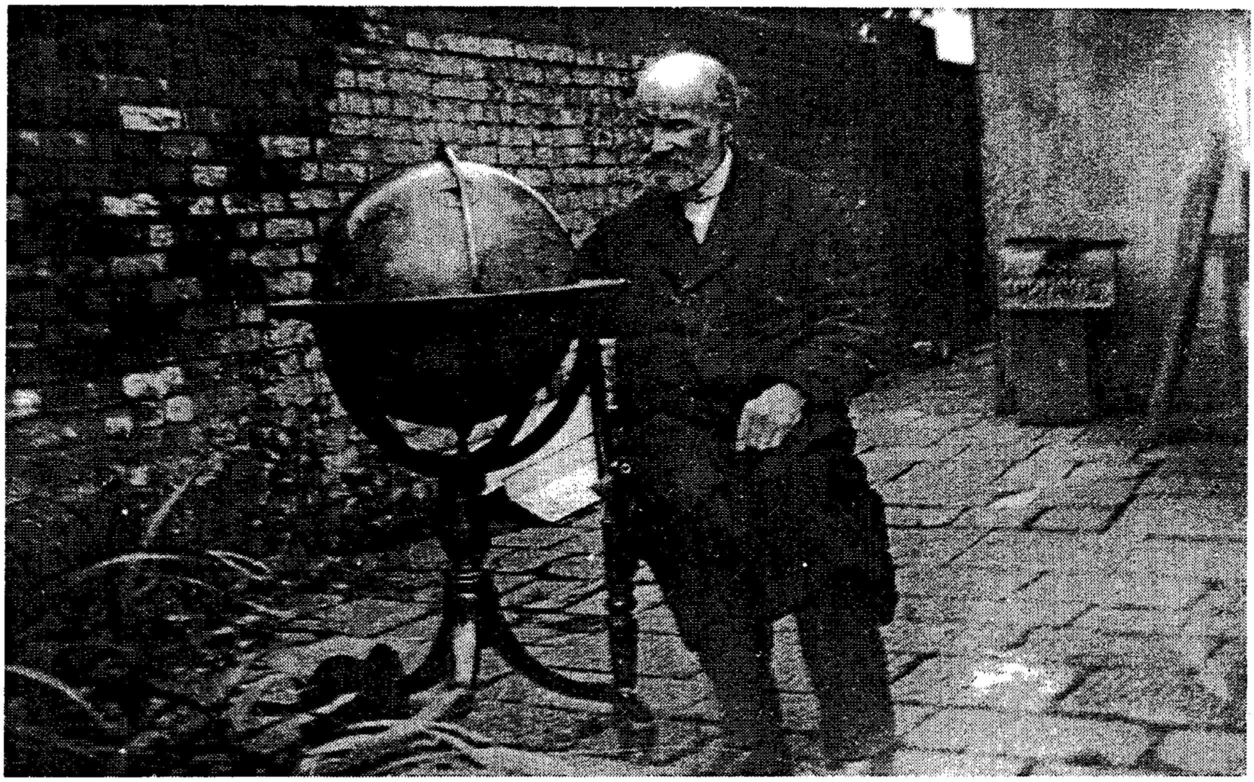

Figure 4 – W.F. Denning with the 18-inch Cary's globe that he used to trace meteor paths. This photograph was taken from Denning's Egerton Road address in August 1924 when he would have been 76 years old. Denning's globe forms part of the *Royal Astronomical Society*'s instrument collection and can be seen at Burlington House to this very day.

He remembered being greeted by a subdued figure draped in an old overcoat warming himself by a fire in surroundings of dank poverty. It is also at this time, the story is recounted, that the young boys of Denning's street (Egerton Road) used to taunt and shout at him whenever he left the house [32]. It would seem that Denning's reclusive, poverty-stricken life-style, along with his "strange" interest in the stars had become the cruel butt of school boy humor.

In 1927, Denning was awarded the degree of Master of Science, honoris causa, by the University of Bristol. Denning's health at that time was sufficiently poor that he was unable to attend the award-giving ceremony. Indeed, he was even unable to receive a deputation from the University. His degree was eventually conferred in absentia [33]. It is fitting that Denning's final academic award for services to astronomy was bestowed by his "home-town university," and the degree represents a well-deserved crown on a life dedicated to the furtherance of meteor science. Right up to the very last, Denning was recording and collating meteor data, and his final observing note, published in the *Observatory* magazine, appeared just a few weeks before he passed away [34]. At the age of 83 years, Denning died on June 9, 1931, the cause of death being determined as auricular fibrillation.

Denning's death was announced in the *Times* newspaper on June 10, and a brief biographical account was published the following day. The June 11th "special article" was written by Sir Henry Maddocks, K.C., who heralded Denning as the *"doyen of amateur astronomers."* In unison with the astronomical community, the City of Bristol also honored Denning's achievements by erecting a memorial tablet at his home (of the previous 26 years) in Egerton Road. At this ceremony Dr. Knox Shaw, President of the *RAS*, remarked that *"Mr. Denning was an amateur in the true sense of the word. He studied the heavens not in the hope of gaining fame or renown, but because he could not help it."* [35]

4. The other side of the man

We have now accomplished the main chronological description of Denning's life. There are, however, a few points that should be addressed before we close our review.

One issue that has proved difficult to fully determine, is how Denning made a living—that is, how did Denning acquire money for his every day expenses? Several of his obituary accounts [1,2] suggest that Denning was a trained accountant, but there is in fact no evidence to support this claim. Certainly Denning's father (Issac Poyntz Denning) was the leading partner in the accountancy firm *Denning, Smith and Co.*, but Denning himself was apparently never on the official payroll. The partnership of *Denning, Smith and Co.*, is described in the 1868 Trade Directory for Bristol as being a *"public and private accountants, auctioneers, bankruptcy, insolvency, and general agents, valuers, etc."* Later directories indicate that Denning's brother, Frederick Denning, became a partner in the company, and that, circa 1890, the partnership was to become just *Denning, and Co.* While Denning, and other family members, are listed in the various name directories for Bristol throughout the 1880s and 1890s, at no time is Denning ever described as an accountant. It would seem that the obituary accounts are somehow confused. Confused, that is, in the sense that Denning was never a fully trained, registered, and practicing accountant. Further confusion is also evident from the observation that Denning's father, Issac Poyntz Denning, was referred to in several obituary accounts as having been "Borough Accountant of Bristol." This was never the case. Certainly, it is possible that he may have undertaken occasional work for the City, but not through the auspices of an official civic office.

Writing in 1905, H. Macpherson noted [36] that Denning followed a journalistic line of work. This would make more sense when one considers Denning's life style. It would not have been easy to hold down a full time day-job, and spend as much time observing as Denning evidently did. Certainly journalism, and popular writing, were two ways that Denning would have made some money. Many newspaper articles and popular accounts by Denning are in existence, and one can find general astronomy articles by him in, for example, the *Boys Own Magazine*, and *Encyclopedia Britannica*. It has been suggested that Denning received occasional monies from Queen Victoria to carry on his work [37]. Again, it has not been possible to confirm this, although such gifts were indeed conferred on occasion [38]. Maddocks [39] also notes that Denning's income had *"been argumented in recent years* [circa 1920?–1930] *by subscription among his brother astronomers who have thereby shown their appreciation of his quality."*

The only regular source of income that can be attributed to Denning is that of his Civil List Pension, which was awarded in 1904. He was, however, 56 years old when this was first paid out. It would seem from the available information that Denning followed no full-time accountancy career. He did generate, however, a small income from both writing and journalism, and possibly by some part-time accountancy work. On a few occasions, Denning's income was complemented by prize money. The Valz Prize (awarded by the French *Académie des Sciences*), for example, came complete with a cash award of F 460. The suggestions that Denning led a reserved and frugal life would certainly appear to be true. Some further indication that Denning was unable to fully support himself financially is offered by the fact that he was listed as living at the same address as his parents in the 1880 and 1890 Bristol Name Directories. He would have been respectively 32 and 42 years of age in those years. Denning moved to his last, and probably best known address, 44 Egerton Road, in 1906. That he was able to support himself there in the long term was, no doubt, due to the financial security afforded by his Civil List Pension.

As testament to his all-round character, it is worth pointing out that not all of Denning's writings were concerned with astronomical research. Indeed, Denning would on occasion express his thoughts and feelings through prose and poetry. There is no direct evidence to support the notion that Denning was a deeply religious man, but it is clear that he rejoiced in the study of nature, and in the observation of the heavenly cycles. Being self-taught, and with no formal scientific training, Denning relied purely on what he saw with his eyes when formulating ideas, making no speculative suggestions above or beyond what he observed. In this sense Denning, was a true Baconian scientist. Certainly, for so it would seem, Denning was driven to make his observations by a quest for truth. Not only the truth, however, Denning also believed in a sense of scientific continuity. He was to write, for example, *"the work of observations must go on continuously. It* *is like a river which runs endlessly along the shores of time connecting the past with the present and the present with the past."* [40] For Denning, the act of observing was part and parcel a quest for understanding, and a contribution to the "river" of knowledge. Denning's feelings towards observing are further expressed in his comments concerning the supposed observation (in 1900) of markings on Saturn's disk: *"it resolves itself into a question of ethics. There are men who will report nothing but what they are absolutely certain is presented to their eyes, and are unbending in their regard for the truth."* [41] Denning's outlook on life was guided by high principles, and it would seem that truth, continuity, and personal integrity were the underlying ethics that Denning employed in his studies.

There is no great evidence to support the idea that Denning was a "serious" poet. Rather it would seem that he occasionally used poetic language to express his enjoyment at participating in the scientific process. What poetic verse Denning did write may have been fanciful and romantic, but it was not romantic in the poetic sense. The romantic poetry of Wordsworth and Keats, after all, was essentially a reactionary backlash against the critical rationalism of science. In this manner, Denning's few surviving poems have more in common with the works of Mark Akenside and James Thomson, poets who rejoiced at the wealth of knowledge that scientific study brought forth, than with those of his contemporaries such as Tennyson and Hardy, who were more inclined to see nature and its study in a darker and more ominous light [42]. One example where Denning used both prosaic language and poetry to express his feelings can be found in an article written circa 1895. In this account, Denning rejoices at the imminent arrival of spring [43], and he expounds,

"Oh, Spring! Dear Spring! Thou more dost bring
Than birds, or bees, or flowers—
The good old times, the holy prime
Of Easter's solemn hours;
Prayer's offer'd up and anthems sung
Beneath the old church towers."

Following this triumphant outpouring, Denning continues, *"The opening of the snowdrop and crocus tells us that spring is near, the bloom of the primrose and violet brings us the realization. March, though it has its keen winds and sometimes wears a wintry frown, yet proves that the dark days are past, and, towards the end of the month, gently introduces us to the summer's advent in the person of her younger and sweeter sister spring."* There is a clear sensitivity in Denning's writing, and, indeed, one can sense that he has a deep respect for nature. Clearly, Denning experienced a heart-felt joy in observing the seasonal change.

Smatterings of other poetic verse can be found in Denning's *Telescopic Work For Starlight Evenings*. Concerning the observation of Mercury, Denning was to write the following.

"Come, let us view the glowing west,
Not far from the fallen Sun;
For Mercury is sparkling there,
And his race will soon be run.
With aspect pale, and wav'ring beam,
He is quick to steal away,
And veils his face in curling mists,
Let us watch him while we may."

In similar lyrical tones Denning was to write of the planet Saturn,

"Muse, raise thy voice, mysterious truth to sing,
How o'er the copious orb a lucid ring,
Opaque and broad, is seen its arch to spread
Round the big globe, at stated periods led."

Interestingly, while the study of meteors was one of Denning's major pre-occupations, only one poem on this topic seems to have seen print. This poem, simply called *Falling Stars*, appeared in the *Journal of the Royal Astronomical Society of Canada* in 1915, and was written just two days after his 66th birthday [44]. The poem is worth re-producing in full, since its verse does offer some insight into Denning's personal thoughts and feelings:

Bright falling stars I greet you with a smile,
While you beguile,
My loneliness, with pleasure pure and sweet
In moments fleet.
In coloured beauty and in lustre dressed,
Never at rest,
You span the sky and guild the heav'nly way
With sparkling ray.
I only know the moments of your birth,
Above the earth;
As she performs her yearly round in space
You run your race
And pierce the blue just as a flashing blade
Too quick to fade.
Along your flight the burning embers sow
An after-glow,
To mark your path amid the stars of night,
With guiding light.
I never know the instant when you will
Disturb the still
Of Heaven's stars and speed athwart the sky
All silently.
Nor can I tell in Nature's open book,
Just where to look,
To watch your coruscations wax and fade
Amid night's shade.
Adown the east or west your fiery ball
May headlong fall,
Or, slowly, stream along the starry height
In graceful flight.
Whene'er you come you bring a joyous thrill
My soul to fill.
Oh messengers from distant worlds! I yearn
Your tale to learn,
And I await, amid earth's frosted dews,
Celestial news.

This poem is one of pure celebration. It celebrates the phenomena of shooting stars, and it celebrates the joy inherent to their study. It is also a personal poem that hints at loneliness, and pain.

Denning's reclusiveness was a well-known characteristic, and he seems to have had few close and personal friends. Denning mostly made contact with the outside world through an extensive correspondence, and, within this correspondence, he only occasionally offered some personal thoughts. In a letter to Grace Cook [45], however, Denning wrote of the fatigue that he experienced after a long observing session: *"I fancy it does me good intellectually and physically to be at work exercising my patience in this way. Anyone who really loves the stars for their own sake need never despair of finding, sooner or later, and whatever troubles may oppress him, not only a solace but a supreme happiness in contemplating them."* He also wrote to Cook on another occasion commenting that once the *"spirit of the night"* appeared to him after a long night's observing session. Upon being asked if he [Denning] would see her again, the "spirit" replied that *"at some hour when you feel weary with your labors and the night is far spent I will come to cheer you."*

We have now to conclude our brief look into the life and times of William Frederick Denning. The patchwork that constitutes the legacy of this great amateur observer is by no means finished, but at least some structure and color has been added to its form.

I do not think that Denning had any delusions of greatness, although I do believe that he was a great amateur astronomer. In this manner, our parting image of him should be one of a passionate and dedicated astronomer, a man enthralled by the heavens and a man who was dedicated to the act of observing. Denning's image is not one of a great and revered genius of science, rather it is one of a gentleman who found his peace amongst the stars. He found joy under the dark Bristolian skies while those around him slept snugly in their beds. It is a shadowy image that we see moving at the telescope, an earnest observer silhouetted against the crisp dark sky, and it is with Denning's contented words that we conclude our imagery: *"I have supped and imbibed moderately, and even had my 'weed' at the telescope. When I discovered the periodical comet of 1894, on March 26 of that year, I was enjoying my pipe, and it is fortunate for me that the little stranger was not blotted out amid the wreaths of smoke."*

Acknowledgments

Many people have helped me during my researches on Denning's life and works. I am deeply grateful to George Spalding, formally Director of the *BAA* Meteor Section, who supplied many insightful comments about Denning's work. Maurice Brain of the *Bristol Astronomical Society* kindly supplied me with photocopies of two letters that Denning wrote to his niece. James Muirden was also kind enough to supply some details from his own researches. Peter Hingley, Librarian to the *Royal Astronomical Society*, helped me with obscure references on numerous occasions. Mr. E.C. Wright, Registrar and Secretary, University of Bristol, kindly supplied me with information concerning Denning's honorary degree, and Mr. A. Derrett, Assistant Registrar to the Royal Archives, Windsor Castle, helped me with details concerning Denning's supposed Royal patronage payments.

Notes and references

The biographical details presented above form part of a small booklet that I have produced on the life and works of Denning. I would be happy to provide any interested reader with a copy of this booklet upon request (e-mail: `beechm@leroy.cc.uregina.ca`).

[1] J.P.M. Prentice, *Journal of the British Astronomical Association* 42, 1931, pp. 36–40.

[2] T.E.R. Phillips, *Observatory magazine* 54, 1931, pp. 276–282. Many obituaries were written for Denning, and, in addition to those by Prentice [1] and Phillips, further accounts can be found in the *Monthly Notices of the Royal Astronomical Society* 92, 1932, pp. 248–250, and in *Nature* 128, 1931, pp. 12–13. Denning in fact used his knowledge of cricket on at least one occasion (*Nature* 51, 1895, pp. 320–321) to illustrate his frustration at the manner in which some observatories set about making meteoric observations. He noted that *"it seems to be the fashion at certain observatories to set a number of observers (some of whom have perhaps never registered a meteor path before) watching and recording meteors, and then to investigate their results as though they could be thoroughly depended upon. It is similar to placing a man, who has never played in a cricket match before, as wicket-keeper to fast bowlers like Mold, Richardson, and Woods, and expect his performance to be creditable."* The analogy is in fact a good one, and Denning was often critical of the many poor observational accounts that found there way into the astronomical literature.

[3] These comments were found in an article entitled "A self-made English Astronomer," published in the *North British and Ladies Journal*, April 4, 1904.

[4] M. Beech, "The Herschel-Denning Correspondence", *Vistas in Astronomy* 34, 1992, pp. 425–447.

[5] See the *Astronomical Register* 6, 1868, p. 92, for Denning's very first publication. This article was concerned with observations of Jupiter's satellites. Further notes by Denning are found in the same volume of the *Register* on pages 137, 256, and 266.

[6] P. Johnson, "The Astronomical Register", *Journal of the British Astronomical Assoc.* 100, 1990, pp. 62–66.

[7] W.F. Denning, "The Supposed New Planet Vulcan", *The Astronomical Register* 7, 1869, p. 89. The first supposed sighting of Vulcan was made on March 29, 1859, by the French country doctor Edmond Lescarbault. Denning seems to have been very interested in re-discovering this planet, and he even alluded to having seen it himself. Writing in 1871 (*Astronomical Register* 9, p. 287) Denning commented that *"some years ago, I saw, what I supposed must have been, a planetary body in transit across the Sun."* Denning's memory was not too clear on when his observation was made, but he noted *"it must have been between June, 1860, and June 1863, and I imagine the season was either spring or autumn."* In the years stated, Denning would have been between 12 and 15 years old. Denning was later to write of Lescarbault [16, p. 350] that he *"obviously lacks the experience and caution necessary to command credit."* These comments followed in the wake of Lescarbault's announcement that he had discovered a "new star" in Leo on the night of January 11, 1891. Incredibly, this "new star" was not a nova, but the planet Saturn, and indeed, Denning's comments seem apt.

[8] H.F. Newall, in *History of the Royal Astronomical Society: 1820–1920*, Blackwell Scientific Publications, Oxford, 1987, p. 135.

[9] Anonymous review in *Nature* 4, 1872, pp. 261–262.

[10] W.F. Denning, *Nature* 6, 1872, p. 94.

[11] W.F. Denning, "Observations of Luminous Meteors", *Monthly Notices of the Royal Astronomical Society* 33, 1872, pp. 93–95.

[12] P. Hingley, *Royal Astronomical Society Librarian, personal communications*, 1990.

[13] W.F. Denning, "Radiant-Points of Shooting Stars", *Monthly Notices of the Royal Astronomical Society* 37, 1876, pp. 282-284.

[14] W.F. Denning, "Suspected Repetition, or Secondary Outbursts from Radiant Points; and the Long Duration of Meteor Showers", *Monthly Notices of the Royal Astronomical Society* 38, 1878, pp. 111–114.

[15] That meteoroid streams could be produced through cometary decay was realized in the mid 1860s. The Italian astronomer Giovanni Schiaparelli first demonstrated this in 1866 when he found that the Perseid meteoroid stream had orbital parameters similar to those of periodic comet Swift-Tuttle. I discuss the history of meteoroid stream formation in M. Beech, *WGN* 24:3, 1996, p. 89. A more detailed understanding of the cometary-meteoroid stream formation process did not become available until well into this century. This work was initiated by Fred Whipple during the 1950s. A general introduction to cometary physics is given by J.C. Brandt and R.D.C. Chapman in *Introduction to Comets*, Cambridge University Press, Cambridge, 1981.

[16] W.F. Denning, in *Telescopic Work for Starlight Evenings*, Taylor and Francis, London, 1891, p. 79.

[17] "Report from the Seventh Annual Meeting, 1888, July 9", *The Observatory magazine* 11, 1888, pp. 309–311.

[18] Anonymous review in *Nature* 44, 1891, p. 467.

[19] The first President of the *BAA* was Captain William Noble, and his comments concerning Denning can be found in the *Memoirs of the British Astronomical Association* 36:2, 1948, p. 10.

[20] W.F. Denning, *Journal of the British Astronomical Association* 1, 1891, p. 490.

[21] Denning's Fellowship was announced in the *Trans. Phys. Soc. Toronto* 2, 1891, p. 45.

[22] M. Beech, "William Frederick Denning: in quest of meteors", *Journal of the Royal Astronomical Society of Canada* 64:6, 1990, pp. 383–396.

[23] *Denning's award of the Valz Prize was announced in Nature 53, 1896, p. 215.*

[24] The President's address at the presentation of Denning's Gold Medal is reproduced in the *Monthly Notices of the Royal Astronomical Society* 63, 1898, pp. 242–253. Denning did not attend the presentation due to poor health. Denning's Gold Medal is presently on display in the *Royal Astronomical Society*'s Fellows Room at Burlington House in London.

[25] H.G. Wells, "The War of the Worlds", Pan Classics, Pan Books Ltd, London, 1975.

[26] This book was based on a collection of articles previously published in the *Observatory magazine*. A favorable review was given to the volume in *Nature* 57, 1897, p. 7. Denning was to later produce another book that was based on collected *Observatory magazine* articles. This book, *The Planets Mercury and Venus*, appeared in 1916, and was reviewed in the *Observatory* 39, 1916, p. 469.

[27] *Memoirs of the Royal Astronomical Society* 53, 1899, pp. 203–292.

[28] *House of Commons paper* 201, The British Government Archives, 1905.

[29] W.F. Denning, *Nature* 76, 1907, p. 202.

[30] W.F. Denning, *Nature* 105, 1920. p. 838. A review of observations collected at the Greenwich Observatory, London, concerning this nova is given by W.J. Luyten, *Monthly Notices of the Royal Astronomical Society* 81, 1920, pp. 61–65. See also M. Beech, "Denning on Novae", *Journal of the British Astronomical Association* 103, 1993, p. 130.

[31] I am indebted to Maurice Brain for making copies of several letters by Denning available to me.

[32] J. Muirden, *personal communications*, 1989.

[33] E.C. Wright, Registrar and Secretary, University of Bristol, *personal communications*, 1987. Although the award given by Bristol University was to be the last Denning received while alive, he was posthumously honored by having craters on the far side of the Moon, and the surface of Mars, named after him.

[34] W.F. Denning, "Autumnal Meteors", *Observatory* 54, 1931, pp. 271–272.

[35] Memorial speech by H. Knox Shaw reproduced in the *Western Daily Press*, December 19, 1931.

[36] H. Macpherson, in *Astronomers of Today*, Gall and Inglis, London, 1905, pp. 172–178.

[37] M. Brain, *personal communications*, 1989.

[38] A. Derrett, Assistant Registrar to the Royal Archives, Windsor Castle, *personal communications*, 1989.

[39] H. Maddocks, "Mr. W.F. Denning: Doyen of Amateur Astronomy", *The Times*, Thursday, June 11, 1931, p. 16, column b.

[40] This reference is based on a newspaper cutting among the Denning archives of the *British Astronomical Association*'s Meteor Section. The article was clearly published in a newspaper, but it is not clear whether it was a national or provincial paper. The article was seemingly written circa 1900.

[41] W.F. Denning, "Notes on Saturn and His Markings", *Nature* 67, 1900, p. 237.

[42] M. Beech, "Meteor Imagery in English Poetry", *New Comparison* 7:2, 1989, pp. 99–112.

[43] *As with reference [40], this quotation is taken from a cutting in the Denning archive. This article was written circa 1895..*

[44] W.F. Denning, "The Claims of Meteoric Astronomy", *Journal of the Royal Astronomical Society of Canada* 9, 1915, pp. 57–60.

[45] A.G. Cook, *Journal of the British Astronomical Association* 42, 1931.

The Importance of the Magazine "Orion" in Early East-European Meteor Work

Andrei Dorian Gheorghe and Alastair McBeath

We present a discussion of the Romanian astronomical magazine *Orion*, whose first appearance was 90 years ago in 1997. This journal helped encourage East-European meteor observing in the early years of this century, and in its second series, more recently, was instrumental in reawakening astronomical interest in Romania in the immediate post-communist years. We also briefly look at some poetic representations of meteors in Romanian art.

1. Introduction

The period around the end of the 19th and start of the 20th centuries was an important one in many fields of studies across Europe and North America, when the groundwork for most of the modern sciences was being laid down or developed. For the first time, larger numbers of amateurs were encouraged, and became able, to participate in subjects previously considered the province of a wealthy few. Various new societies and journals were set up to cater for the needs of these people, just as the *IMO* was founded in 1988, with this journal *WGN*. Many of the Western societies and magazines have become well-known across the world, even those that no longer survive, but events in Eastern Europe are often less well-known beyond the countries involved, chiefly due to subsequent events during this century.

Here, we wish to examine a Romanian journal, *Orion*, and its impact on early East-European meteor work, particularly in Romania and Moldavia, during the opening years of the 20th century. The magazine itself has appeared in two series' to date, between 1907 and 1912 (under Victor Anestin) and 1990 and 1993 (under Dānut Ionescu). However, firstly, we shall make some comments on the long history of interest in meteors to be found in Romanian myths and folklore.

2. Meteor myths and poems

Victor Anestin (1875–1918), already mentioned above, was the most important of the early Romanian astronomical popularizers. At the meeting of the *Romanian Academy* on April 27, 1912, he presented the essay "Comets, Eclipses and Fireballs Observed in Romania between 1386 and 1853 from Manuscripts and Documents" [1]. This suggests a long-lived interest in meteors in Romania, which is backed-up by a large number of popular beliefs, superstitions, tales and especially several lyrical works.

The fundamental national Romanian myth-ballad *Miorita* (The Little Ewe), written down from oral tradition by Vasile Alecsandri (1821–1890), contains the lines: *"And a star fell/ At my wedding party,"* where the "shooting star" is a sign of the speaker's impending death [2]. In the early tale *Zburatorul* (The Flying Being), re-written as poetry by Ioan Heliade Radulescu (1802–1872), we find the popular definition of a fireball: *"Dragon of light with a fiery tail"* [3]. We also discovered the popular exhortation: *"Fire, my little fire,/ . . . / You must become a dragon/ With golden scales/ . . . / With a tongue of fire/ And go to my lover/ Striking him with your tail . . . /"* [4]. Meteors were viewed as instruments capable of carrying "messages" like this between a girl and her future lover, or as being able to indicate the direction in which her love-to-be lived.

In more modernly-created Romanian poetry, we still find this interest in the heavens and meteors. The national poet Mihai Eminescu (1850–1889) wrote in *Luceafarul Hyperion*: *"A sky of stars below/ A sky of stars above/ He looked like an unbroken flash/ Lost between them./"* [5]. As a further example, clearly drawing on known scientific information, Gabriel Donna wrote in *Moartele Cerului* (The Dead Ones of the Sky): *"Is the comet smashed in its race?/ Does it seed falling stars on its orbit?/"* [6]. Meteors seem to be almost an integral part of Romanian artistic expression, scarcely surprising, as bright meteors and meteor storms have inspired and terrified people for millennia, the world over. We have examined Romanian meteor myths more fully elsewhere [7].

3. Early Romanian astronomy and "Orion"

Many of the key workers in Romanian astronomy in the late 19th and early 20th centuries were aided and encouraged by the great French astronomer and astronomical popularizer Cammile Flammarion (1842–1925), and many became members of the French Astronomical Society set up by Flammarion. Among these were Victor Anestin, Victor Daimaca (later the first Romanian to discover a comet, C/1943 R1 Daimaca, found in 1943 just three months before his second comet, C/1943 W1 Gent-Peltier-Daimaca), and Constantin Parvulescu (later a leading stellar astronomer, and after whom asteroid (2331) Parvulescu is named), all of whom went on to become important contributors to *Orion*, after Victor Anestin founded the magazine in 1907.

The magazine was very popular from the start, as the only national astronomical publication in Romania, and it attracted so much attention that in 1908, Anestin was inspired to found the *Flammarion Romanian Astronomical Society*, which all of the leading Romanian astronomers of their day rapidly became involved with. *Orion* was naturally adopted as the Society's official journal, issue 2 (15 September 1908) bearing a special three-color cover print in honor of the event, showing an imaginary view across the surface of Mars, complete with a lake (perhaps of ice), and dark linear chasms, looking very unlike Lowell's Martian canals! The Society's inaugural president was the retired Admiral Vasile Urseanu (1848–1926), the first Romanian to command a warship in the Atlantic Ocean, and a tremendous character. In 1908, Urseanu built a public observatory in Bucharest in the shape of a yacht! This building is still used today as the headquarters of the *Bucharest Astroclub* and the *Municipal Popular Observatory*.

From the outset, Orion had a friend in high places. Spiru Haret (1851–1912; a lunar crater is named after him), involved with solar system studies and celestial mechanics and considered by many the first Romanian genius in astronomy, also led the Ministry of Instruction between 1907 and his death. With responsibility for education, he protected Orion, by ensuring all the secondary schools in Romania subscribed to it. Unfortunately, after his death, despite being very favorably commented on by King Carol I, the Romanian Patriarch, and Cammile Flammarion, amongst others, *Orion* ran out of money, and was forced to cease publication in 1912.

Regrettably, no known complete collection exists, so we are unsure exactly how many issues were eventually published. However, during its brief life, the journal had assisted in a "golden age" of Romanian astronomy, in the period before the Great War, and meteor work had benefited alongside many other topics.

4. Meteor work in "Orion"

Of the surviving issues, number 4 (15 October 1908) is the first to bring meteors to prominence, with a cover illustration of a meteor radiant, where many meteor streaks radiate away from the center, just as would have been plotted by a good observer (and similar to what we might expect to find today). Unfortunately, there is no caption to this, and no stars are shown on the diagram. While the declination of the radiant can be easily determined as $\delta = +25° \pm 5$, the right ascension scale has $\alpha = 90°$ at its center, decreasing to about $\alpha = 45°$ towards both left and right edges. The shower shown might thus be the Leonids, but on the whole, bearing in mind the magazine's name, we feel it is more likely to be the Orionids, despite the discrepancy between the modern radiant position and this one.

The earliest published meteor observations are in the February 1909 issue, pp. 21–22, and discuss three fireballs, all noted as being brighter than Venus, seen on August 13, 19, and 22, 1908, the latter two both by the same couple in Bucharest. In honor of its being the first meteor report we have found, we reproduce the August 13 report in translation here:

> *"Mr. D. Calcude from Tecuci* [in Moldavia, then Romania's easternmost region] *observed on the night of August 13, 1908, a very great falling star, at about 1 a.m. civil time. Although the Moon shone with all its might, this meteor brightened more than Venus. It appeared under Altair in Aquila and traveled towards Vega, leaving a luminous train, and broke into three almost equal parts, which disappeared simultaneously."*

Issue 15-16, also from 1909, pp. 154–155 contains a short article on the Perseids by Victor Anestin, which we translate here, as we feel it is of particular interest:

> *"Some evenings before August 10, and for some evenings after that, there is a celestial phenomenon, perhaps not so commanding as in the past, but very interesting even now. Especially from the star eta in Perseus, countless falling stars are to be seen at this time. This phenomenon has long been secularly known, and is recognized by peasants in other countries too. Sometimes, up to 60 falling stars are seen* [per hour?] *coming from the constellation Perseus.*
>
> *These falling stars are distinctive because of their high speed and the persistent wakes left in their paths for one or two minutes. Every night, the Perseid radiant displaces a little further to the east, which is different to the radiants of other, similar, rains of falling stars. The Perseid orbit cuts the Earth's orbit perpendicularly. The Perseid bodies are considered to be remnants of Comet Tuttle* [now called Swift-Tuttle]*, which in 1862 passed very close to the Earth, and which has a revolution period of 131 years. The Perseids seem well-dispersed on this orbit, because we meet them every year at the same time, more or less.*
>
> *The easiest astronomical observation is that of falling stars, and the Perseids especially are most interesting.*
>
> *On July 19, this year, I looked for the appearance of the first Perseids, and I observed that part of the sky between 11:30 p.m. and 12:50 a.m. At 11:45 p.m., one Perseid, magnitude 4; at 12 a.m., another Perseid, magnitude 1, superb, with a trajectory at a perfect right-angle to Deneb. At 12:45 a.m., one Perseid, magnitude 3, passed to γ of Cassiopeia; at 12:47 a.m. one Perseid which traversed the square of Pegasus, magnitude 4. At 12:50 a.m., another Perseid, magnitude 4, traveled from vita* [alpha] *in Andromeda to γ of Pegasus.*
>
> *Almost all these Perseids had a bluish color, and were swift. However, they did not leave any trace behind them.*
>
> *Probably by the beginning of August, we will record a minimum of 50–60 Perseids per hour."*

Apart from being a creditable observation of the Perseids so early in July, and setting aside the minor inaccuracies we would recognize modernly, including the rather optimistic estimate of Perseid rates at the start of August, perhaps the most surprising comment is the orbital period of the Perseids' parent comet, which most people thought until its return of 1992 was about 120 years. It is worth noting too that Perseid activity declined dramatically between 1910 to 1915, reaching a minimum ZHR of just 4 in 1911, before returning strongly again in 1920, which explains Anestin's comments on the shower not being as impressive as in the past. His remarks on visual meteor observing being the easiest type of astronomical observation remain just as true today, of course.

The April-May 1911 issue of *Orion*, p. 114, contains a detailed report by Victor Anestin on a brilliant bolide that had occurred on April 29 of that year, which was witnessed from several locations over a large part of the country (sightings from at least seven named towns in eastern and central Romania, including the capital Bucharest, are mentioned, for instance). The details are very similar to what we often find in casually-seen fireball reports today, and we feel sure the following comments will seem all-too familiar to those who have attempted analyses of such events: *"It is very regrettable that the greatest part of them* [the witnesses] *were not familiar with the constellations."*!

Unlike much of the rest of the journal, which was written in Romanian, this report was published in the international scientific language of the day, French. This demonstrates that in the intervening time, Victor Anestin, as editor-in-chief of *Orion* and secretary of the *Flammarion Romanian Astronomical Society*, had also become an unofficial point of contact for all the Romanian meteor observers, and that the journal was being circulated not just within Romania.

Immediately following the bolide report, on pp. 114–115, under the heading "Astronomical Observations," we discovered another surprise: *"Mr. Odiseu Apostol from Turnu Severin* [in south-western Romania] *has sent us some falling-star observations.* ***He systematically observes celestial phenomena, using the observing plan for such observations from the Central Meteor Bureau in Hamburg, led by Mr. Birkenstock."*** (our bold-face). This is an unusual notice concerning the level of international meteor activity and cooperation in those days. Perhaps colleagues in Germany can enlighten us as to the activities of this "Central Meteor Bureau," and what happened to it?

Some notes from Mr. Apostol's observations follow, and Victor Anestin concludes the item by noting that *"These observations, made from different towns, will help in the discovery of new radiants of falling stars..."*

A further set of meteor observations, made by the 19-year old Victor Daimaca, are also given in this issue of *Orion*, again on p. 115, and, as with the bolide report, these too are published in French. Unfortunately, as we have seen, *Orion* ceased publication in 1912, and no further meteor reports were found in the surviving later issues.

5. "Orion" revisited

Later governments in Romania looked unfavorably on astronomy, and the communist régime banned its teaching in schools altogether, so the promising beginnings and first flowering of Romanian astronomy that Victor Anestin and others had begun, was crushed and all-but forgotten. When the 1989 revolution swept the communists from power in Romania, Dānut Ionescu single-handedly re-started *Orion*, having first obtained the legal right to be the continuer of Victor Anestin's *Flammarion Romanian Astronomical Society*. The first issue of the second series of *Orion* appeared in November 1990, and soon began featuring articles by the new generation of Romanian astronomers, including the meteor observers, led by Valentin Grigore. Valentin had actually begun reviving meteor astronomy in Romania in 1989, but *Orion* gave a further boost to his efforts.

Ten issues of this new *Orion* appeared, until the May-June issue of 1993, despite increasing financial difficulties in its production. Unfortunately, Dānut's health worsened, and he was forced to halt production of Orion, but, luckily, in October 1993, he was able to begin broadcasting a weekly astronomical radio program, "Contact Astronomic," regularly featuring leading members of the astronomical community, and in a very real sense, this program has become a broadcast version of Orion in all-but name.

Meanwhile, the *Romanian Society for Meteors and Astronomy*, *SARM*, had been formed by Valentin Grigore, and, in spite of financial problems there too, it still continues its good work, including the three-week festival of astronomy during July and August, *Perseide*, another of Valentin's brainchilds. Although Romanian astronomy had to survive without any form of national magazine throughout 1994 and 1995, in 1996 a new journal was launched—*Noi Şi Cerul* (Us and the Sky)—which now features articles from a broad spectrum of Romanian and other astronomers, and, just as Orion used French to communicate with its international audience, so Noi Şi Cerul is now beginning to use English sections to explain its activities to the wider, international audience. Valentin was instrumental in setting this journal up too, and it is now edited by Gelu Claudiu Radu, another leading Romanian meteor astronomer.

6. Conclusion

So, 90 years on from the first publication of *Orion*, Romanian astronomy, and meteor astronomy, are again starting to thrive, and participate in the work of the international science community. We wish all involved a far more successful and trouble-free 90 years ahead than those now passed!

Finally, and in-keeping with the spirit of Romanian culture, which has always mixed artistic expression with its science, we present a poem dedicated to Victor Anestin and his memory.

Orion, Orionids...
One day, the goddess Artemis
Slyly killed the hunter Orion
For her pleasure.
But, later, Comet Halley
Honestly revived him...
For our pleasure!
(Andrei Dorian Gheorghe)

Acknowledgment

The authors wish to express their grateful thanks to Dānut Ionescu for making many materials from the original Orion series available to them while preparing this article.

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Observing Meteors During Moonlight

Mihaela Triglav

Problems with observing meteors when the Moon is high in the sky are discussed. The relation between the visual limiting magnitude and the Moon's phase is also presented. The function of the limiting magnitude versus the phase of Moon is derived from the lunar eclipse on September 16, 1997.

1. Moon and meteor observations

The bad effect of moonlight on the meteor observations, in particular the different perception of meteors and resulting errors in meteroid fluxes, are primarily considered by the observer when planning a major-shower watch. Usually, the observer rather decides not to observe than to find out how the moonlight really influences the number of registered meteors.

In [2], where the method of the calculation of meteoroid fluxes is described, a correction factor for the moonlight is used. This factor was derived empirically and was applied to three major meteor showers. In this case, the correction factor is independent of the elevation of the Moon above the horizon and is related to the Moon's phase only. So the question is how the perception of the meteors is affected by the moonlight on average.

During my observation, I noticed that the moonlight disturbance depends on the distance of the observed part of the sky from the Moon. The closer our observing center is to the Moon, the greater is the influence on the number of meteors seen. The reason for this effect is partly the decrease of visual limiting magnitude, but it is possible that we can not see even those meteors which we would normally see at such a limiting magnitude [3]. That is because of the vicinity of the bright object in our field of view, and therefore, our eye pupils are not fully opened. To avoid this, we must choose the field of view far enough from the Moon.

2. Observing meteors during a lunar eclipse

Although a lunar eclipse is very exciting on its own, it is even more interesting to observe meteors in the hour of the eclipse's totality period. The sky becomes dark, and the Milky Way shows some of its wonders.

The last total eclipse of the Moon on September 16, 1997, was a great opportunity to observe the change in visual limiting magnitude during the eclipse. It is a convenient way to study the relation between the visual limiting magnitude change and the phase of the Moon, because other disturbing factors which affect observations are more or less constant. That means we can neglect the factor of the cloud coverage (if the weather is stable for at least two hours) and the influence of the changing elevation of the Moon above the horizon (elevation does not vary much within two hours).

I could not see the beginning of the eclipse from my observing site at Javornik observatory, so I started to count the stars in the *IMO* areas to estimate the visual limiting magnitude [1] at the middle of totality. This way, we can start with higher visual limiting magnitude so our eyes can easier adapt when we get from dark to brighter skies.

From the previous knowledge of the moonlight effect on the limiting magnitude, I supposed that the limiting magnitude is dependent on the distance between the Moon and our observing area. So I used two fields for observations. The first one was in a 20°-radius area around the Moon. It was area No. 6 (Pegasus), and because it was the only one in close neighborhood of the Moon, I got just one set of results, whence the error assumptions can not be made for this area. The second field in the sky was more than 60° away from the Moon. It was divided into three areas: No. 14 (Cygnus), No. 5 (Aquila), and No. 7 (Cepheus).

I could not start at the beginning of the eclipse because it was not completely dark at that time, and the Moon was below the horizon. The beginning of the eclipse was at 17^h08^m UT, the totality began at 18^h15^m and ended at 19^h18^m UT. I started approximately at the center of the total eclipse at 18^h45^m UT. For about one hour and 40 minutes, I counted stars every ten and then even every five minutes. The end of my observation coincided with the end of the eclipse (the shadow of the Earth completely disappeared from the Moon's disk).

Table 1 presents the fact that during totality the limiting magnitude is the same in both areas as expected. The totality has the same effect as the New Moon. Differences between the areas become very n obvious when the phase of the eclipse is similar to the First Quarter. At approximately 20^h05^m UT the determination of the lowest limiting magnitude in the first area was not possible, because the triangle in this area supports only determinations of limiting magnitude greater than 4.7. The limiting magnitude dropped, but I can not say how rapidly.

How the phase of the Moon or lunar eclipse affects darkness of the sky can be seen from the following. At 20^h00^m UT when the umbra covered half of the Moon, similarly to the First or Last Quarter, I could not see the Milky Way anymore. It was interesting to observe how the moonlight lit up more and more of the surrounding sky. Until the phase of the Moon was smaller than First Quarter, the Moon illuminated only the neighboring sky (approximately 2°). Then this ring of brightened part of the sky was growing. At "Full Moon," the whole sky was lit up by moonlight.

In the area more than 60° apart from the Moon, meteors can be observed with the Moon above horizon almost until the First Quarter and from the Last Quarter on, if we are satisfied with a limiting magnitude of roughly 5.0. After the First and until the Last Quarter it is better to observe when the Moon is under the horizon as is recommended in the reference [1], too.

Table 1 – Change in the limiting magnitude in both lm areas. The third column describes the lunar eclipse phase in terms of usual phases of the Moon. Only that phase which started at some time within this interval is noted. It does not mean that the phase started at the beginning of that interval. Because only one star-count area was used for the determination of the limiting magnitude in the close area (20° apart from the Moon), the error bars are not calculated and observations are not included in Figure 1.

Period (UT)	Lm in 1st area (20°)	Lm in 2nd area (60°)	Phase of the Moon
18^h45^m–18^h48^m	6.2	6.2 ± 0.1	
18^h55^m–18^h57^m	6.2	6.1 ± 0.3	
19^h04^m–19^h06^m	6.2	6.1 ± 0.1	
19^h14^m–19^h16^m	5.9	5.9 ± 0.2	
19^h25^m–19^h26^m	5.9	5.8 ± 0.4	end of New Moon
19^h31^m–19^h34^m	5.7	5.7 ± 0.3	
19^h43^m–19^h44^m	5.4	5.6 ± 0.3	
19^h49^m–19^h51^m	4.7	5.4 ± 0.2	
21^h54^m–21^h55^m	4.7	5.1 ± 0.2	First Quarter
20^h00^m–20^h01^m	4.7	4.9 ± 0.3	
20^h05^m–20^h06^m	<4.7	5.0 ± 0.2	
20^h11^m–20^h13^m	<4.7	4.6 ± 0.2	
20^h17^m–20^h18^m	<4.7	4.4 ± 0.3	
20^h21^m–20^h22^m	<4.7	4.2 ± 0.4	
20^h25^m–20^h26^m	<4.7	4.2 ± 0.4	Full Moon

It would be nice to find out the correlation between the phase of Moon and the number of meteors seen from the recordings. It must be stressed that my observations bear large errors, because there was only one observer. For an accurate function of the limiting magnitude change, a lot more observations would be needed. If we observe during moonlight periods, we could cover a longer period of visibility of any meteor shower.

Nevertheless, we can say that we can observe meteors during the total eclipse of the Moon. We should plot them preferably.

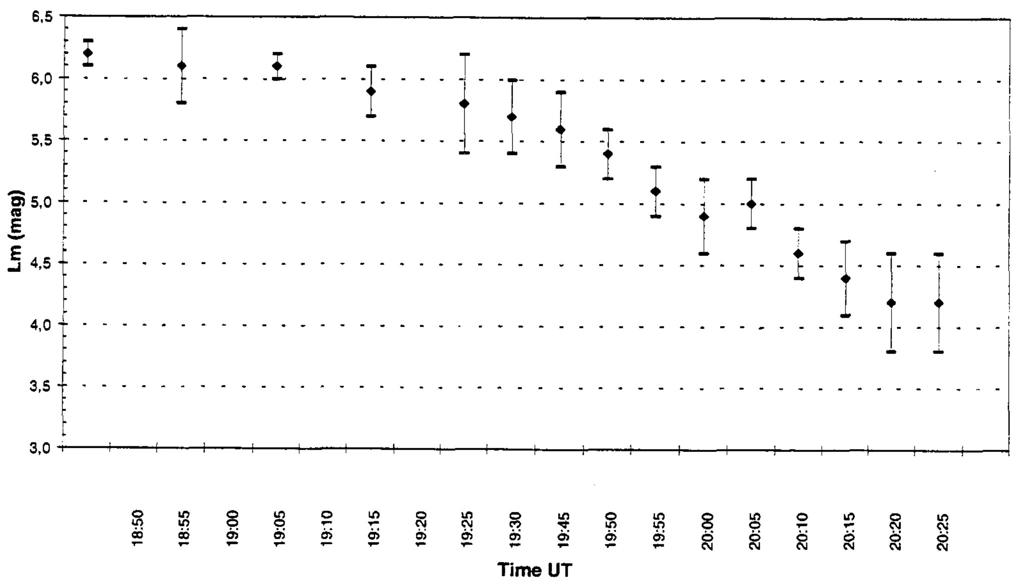

Figure 1 – Limiting magnitude in the second area, 60° from the Moon.

From Figure 1, we can see that the limiting magnitude is almost constant during the totality; we will not lose a lot of our observing time to count the stars in the *IMO* areas. It is recommended to check the limiting magnitude as often as with ordinary visual observations. That is every half an hour, if the weather conditions remain the same.

The next occasion to practice meteor observing during a partial eclipse of the Moon will be on July 28, 1999, and it will be seen from the USA, Asia and Australia.

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An Audio Time Marker

Ilkka Yrjölä

An audio time marker to be used in combination with visual observations is described

All forms of logging meteors have their own advantages and disadvantages. After first having used a PC to log meteors when visually observing and the year after pen and paper, it was now time to try a tape recorder. It is not so easy to carry things to the observing spot in thick snow, or finding them, if you drop something on the way. A tape recorder in your pocket does not tie your hands, or fall off easily. It is a cheap solution, virtually eliminates dead time, but does lack an internal time marker. It was obvious one had to be invented.

A new recorder was sold at 25 USD at the local shopping mall and seemed to fit the job perfectly. It had a VAS (Voice Activated System in recording), but since the unit had to be kept warm inside the sleeping bag during cold winter observing sessions, and use of record/stop buttons seemed an unattractive option, I decided I needed an external microphone for comfortable use.

A surplus monophone was rewired so that its PTT (Push To Talk) switch would short the microphone line when not pressed. When PTT was pressed, VAS activated the recorder and stopped it soon after releasing. After removing the unused loudspeaker from inside the monophone casing, there was now left some empty space. In a brief discussion with Tietomyrsky OY's staff, we decided to apply one of their most economic educational microcomputer kit to create time marks on the audio tape. A week later, I installed the prototype with suitable software in to the monophone and tested it in observation. It worked perfectly right away. With a headset type microphone, the time coder could be located in a small enclosure connected between the microphone and recorder. The best place for the unit would be inside the tape recorder, but there is no room for it. On the other hand, this way you may use it with any tape recorder.

Using the marker is very easy, since the user interface has only two buttons. The observer powers the microcomputer (μC) on and first pressing of PTT sets the time to 00 minutes. This is done at the hour or at the session start. Only minute marks are needed in this application (00–59). Then the observer presses the PTT button and dictates on the tape the meteor he saw in the usual way. When he releases the PTT, the μC senses this and sends from one of its I/O lines a sound coded time signal. After the time code is recorded, VAS soon stops the tape and the μC goes to sleep mode waiting for a new PTT press. So, where is the keyboard? No keyboard is used, only power and PTT switches.

Table 1 – Morse code for digits.

0	1	2	3	4	5	6	7	8	9
-	.-	..---	...--	....-	.....	-....	--...	---..	-.

The code used by this software version is the oldest digital code, called Morse.

Time mark duration is some 2 seconds on the prototype. Recording one meteor takes some 8 seconds of tape with the time mark and VAS lag, so a C-60 tape can be used to log over 2×200 meteors, which is usually enough for one night. Please note that the warning given on the use of VAS in the IMO's Handbook [1] is not valid in this case, since the pressing of PTT causes an impulse that starts the recording and causes no loss of first syllables.

Later, when listening to the tape, the gaps created by VAS (2–4 seconds) are useful to space the logged events and relief rush from the process. The coded numbers have a certain logic in them and therefore are fairly easy to learn to decode by ear. Shortened code versions for numbers 0, 1, and 9 were used in the prototype. The code is already know to perhaps millions of persons around the world and still in wide use. Other coding schemes would require some decoding equipment to be used. A speech synthesiser-clock is one possibility, but not this simple, small and cost effective.

The Atmel AT89C2051 microcomputer has 2 kbytes of FLASH memory, 128×8 bytes of RAM, works with 3Vdc, and in this configuration consumes only 0.4 mA of current. A coin-sized 3V lithium battery should last over 500 hours of observing. The size of the PCB with components is approximately 27 by 23 by 10 mm with the IC on a socket. This unit containing only 10 components can be made available as a kit. Interested persons may contact me via e-mail (`oh5iy@sci.fi`). Note that new chips are blank and the unit works only if the software is programmed in it.

The Visual Meteor Software V4.3 was modified to make the use of this logging method easier. The OFF-line observing mode is used with the tape recorder and the minute marks post edited on the observing log file. You find the VMS software package on my homepage `www.sci.fi/ oh5iy` (`visual.zip`). The manufacturer's homepage is `www.tietomyrsky.fi`.

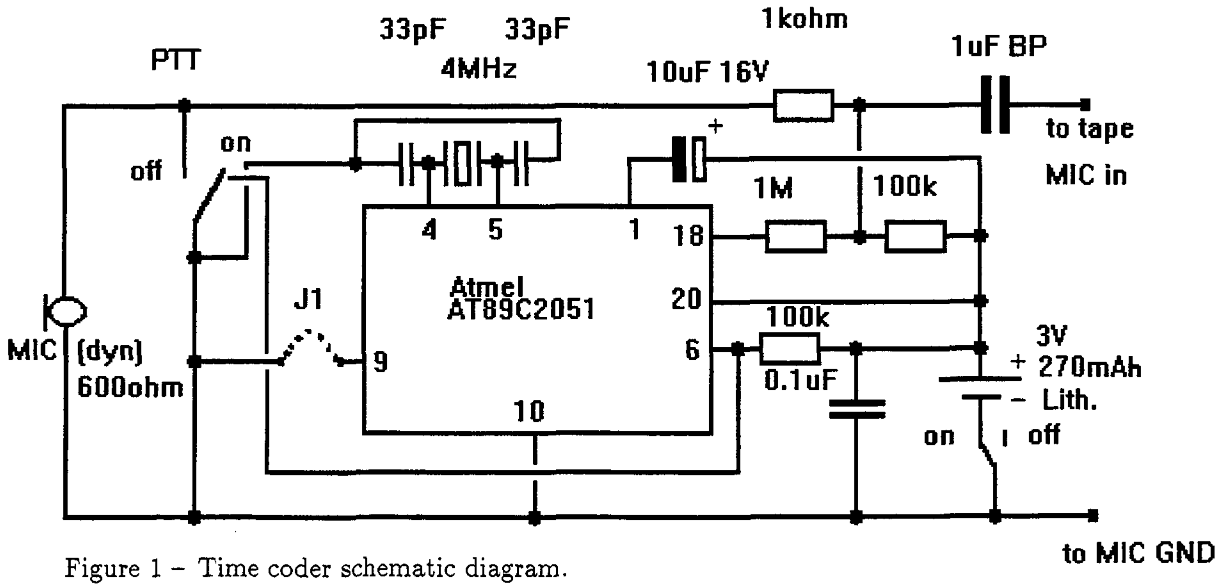

Figure 1 – Time coder schematic diagram.

Reference

[1] J. Rendtel, R. Arlt, A. McBeath, "Handbook for Visual Meteor Observers", IMO, 1995, p. 43.

Observational Results

SPA Meteor Section Results: March–April 1997

Alastair McBeath

Details of observations and news submitted to the *SPA Meteor Section* from March and April 1997 are presented. Several bright fireballs were noted during March, together with minor shower activity, notably from the Virginids and γ-Normids. The first definite sighting of the zodiacal light from the UK for some considerable time was reported on March 29 too. Full Moon prevented visual observations of the Lyrids in April, but radio results show a slightly later peak time than expected, around 4^h–8^h UT on April 22 ($\lambda_\odot = 32\overset{\circ}{.}11$–$32\overset{\circ}{.}27$, eq. 2000.0), perhaps with two main phases, around 4^h–6^h UT and 7^h–8^h UT. Increasing activity due to the η-Aquarids was also noted in the final few days of April.

1. Introduction

Aside from the usual distractions of moonlight problems, this year, accounting for the Lyrids in this period, and the weather, northern hemisphere observers also had Comet Hale-Bopp to watch during the evenings—or indeed all night from more northerly sites—and all this helped reduce interest in covering the visual meteor activity in both months. Even so, the hours' totals were very healthy, as shown in Table 1, and the radio observers continued their sterling work of routine meteor monitoring.

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

Month	Visual	VIR	ETA	Meteors	Photo	Trails	Radio
March	99^h	50	–	630	249^h	2	1303^h
April	134^h	53	49	711	188^h	0	1812^h

Photographic observations came from the following *Arbeitskreis Meteore* (*AKM*) members in Germany: Axel Haubeiß, André Knöfel, Jürgen Rendtel, Heinz Ringk, Nikolai Wünsche; and Vasile Micu in Romania. One trail each was secured by Vasile and Axel. All the *AKM* details here were taken from the journal *Mitteilungen des AKM*, issues 5 to 8 (1997), thoughtfully provided by Ina Rendtel.

Most of the radio details were extracted from *Radio Meteor Observation Bulletins* (*RMOB*s) 44 (April 1997) and 45 (May 1997), kindly submitted by Christian Steyaert. The radio workers involved were Maurice de Meyere (Belgium, *RMOB*), Ghent University (Belgium, *RMOB*), Kimio Maegawa (Japan, *RMOB*), Chikara Shimoda (Japan, *RMOB*), Robert S. White (England). The normal practices for handling unprocessed radio data, outlined previously, were followed, and the radio graphs with this paper were chosen as being representative of the overall radio results from March and April.

The contributing visual observers included: *AKM* members Ralf Kuschnik, Jürgen Rendtel, and Petra Rendtel (all in Germany), Charlotte Bland (England), Tim Cooper (South Africa), Shelagh Godwin (England), and Graham Wolf (New Zealand).

2. March

Meteor activity is generally considered to reach its annual low during February and March north of the equator, and sites in both hemispheres recorded generally normal rates of sporadics and low Virginid activity all month. This was borne out by the radio data (see Figure 1), but most of the significant March peaks found recently [1] were confirmed by the active operators. Maurice de Meyere suffered hardware problems throughout the first half of March, so only two data sets covered the entire month, however.

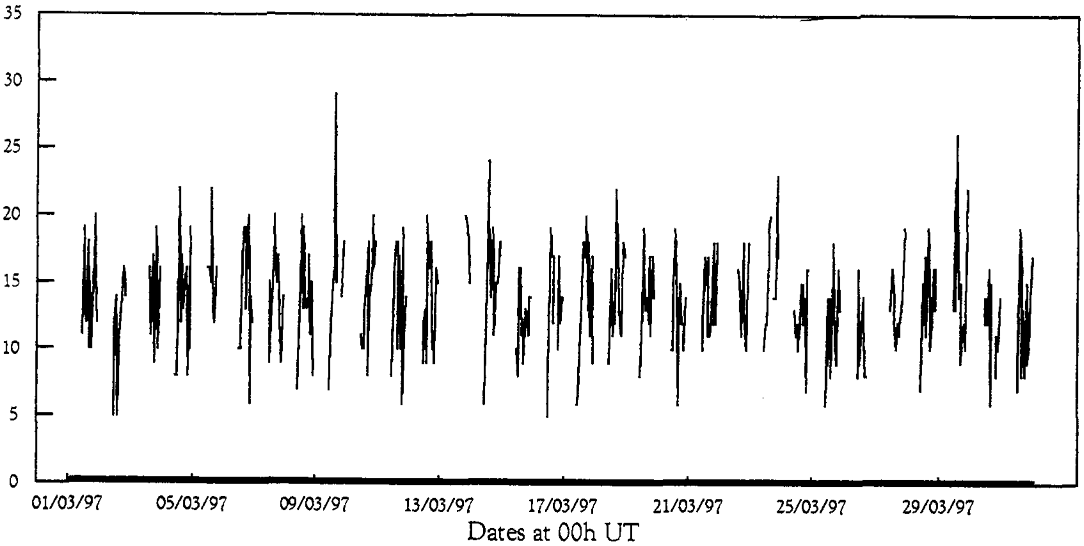

Figure 1 – Raw hourly radio meteor echo counts during 1997 March, from data collected by Chikara Shimoda, given in *RMOB* 44 (April 1997). Gaps indicate when his system was not operating. Note that the x- and y-axis scales vary from graph to graph in the radio results here.

The solar longitude (eq. 2000.0) peaks confirmed included those at $\lambda_\odot = 340°–341°$ (part of the $\lambda_\odot = 333°–342°$ period), $\lambda_\odot = 344°$, $\lambda_\odot = 346°$, $\lambda_\odot = 350°$, $\lambda_\odot = 353°$ (part of the $\lambda_\odot = 352°–355°$ period), $\lambda_\odot = 357°–358°$, $\lambda_\odot = 359°–2°$ and $\lambda_\odot = 4°$ (parts of the extended $\lambda_\odot = 0°–4°$ period), and $\lambda_\odot = 7°–8°$.

In New Zealand, Graham Wolf detected weak activity from the γ-Normids. This was most obvious on March 14, close to the expected peak, but rates were perhaps slightly higher on March 11 as well, and were readily noticeable between March 11 and 15 overall.

Four significant fireballs were reported. On March 6, two magnitude $-9/-10$? events occurred within twenty minutes of one another, at 17^h26^m and 17^h45^m UT, respectively, over Romania (two separate sites). Then, on March 27, two more major meteors were recorded, one each from UK and New Zealand sites. The UK event remains rather mysterious, as only vague press notices were received on it—any actual observations would be most welcome!—but it may have passed near the eastern coast of England during the early evening hours.

The New Zealand fireball was recorded at ten locations. It occurred at 13^h10^m UT, and reached a magnitude of about -18 or so, crossing NW to SE above the northern third of South Island, ending up out over the Pacific Ocean off Kaikoura. Acoustic noises were heard quite loudly at many sites, after a delay of up to 10–12 minutes, including those at Wellington and Foxton on North Island some 150–250 km from the projected ground track! The trajectory was perhaps up to 200–300 km long, and took between 3–6 s to complete, as noted from the better observations. A mean path length and time implies a velocity of about 55 km/s. Even the national newspapers covered this meteor, and thanks are due to expatriate New Zealander Penny Feltham, now living in the UK, for early news of the fireball, and Graham Wolf for collecting detailed results from the witnesses.

On March 29, during a visit to the Dartmoor area of south-west England, Jürgen Rendtel made an observation of the evening zodiacal light cone, while viewing Comet Hale-Bopp around $20^h30^m–21^h00^m$ UT. He comments that the light was noticeably bright, and that it could be easily seen in eastern Taurus and around Aldebaran (α Tauri). As with many of the night-sky glows—aurorae, noctilucent cloud, etc.—it is often an observer's experience and ability that count when hunting for them, and so it was here. No doubt, many other people were out in the UK observing the comet at the same time, many of them from specially-sought darker-sky sites, but no other sightings of the zodiacal light were received before this report was written. For more details on observing the zodiacal light, and the subject generally, see [2] and references.

3. April

A surprisingly poor month for northern visual workers, even allowing for the loss of the Lyrids, although again, low Virginid activity was seen during the first half at least. A few Sagittarids were being reported by our southern hemisphere contributors by late month too.

Useful Lyrid data came from the radio observers, however, and the peak seems to have fallen well for the Europeans this year, with a clear maximum between 4^{h} and 8^{h} UT on April 22 ($\lambda_{\odot} = 32.^{\circ}11y$–$32.^{\circ}27$, eq. 2000.0)—see Figure 2. Two sub-phases within that period were apparent, at around 4^{h}–06^{h} and 7^{h}–8^{h} UT, with most set-ups registering either higher or more sustained count levels during the second period, which equates to $\lambda_{\odot} = 32.^{\circ}23$–$32.^{\circ}27$. If this was equivalent to the visual maximum, it was slightly later than predicted, but the radio peak was certainly shorter than the radio-visual peak seen in 1996 [3]. The first phase in the 1997 radio data was closer to the expected maximum time, certainly.

The Japanese radio workers were not best-placed to take advantage of the Lyrids' peak, but even so, a respectable spike in echo counts was recorded on April 22 (see Figure 3), and enhanced long-duration echo-numbers ($D > 20$ s) were recorded in excess of normal by Kimio Maegawa on both April 22 and 23 (not illustrated here).

Checking the April radio data with those in [1] gave the following solar longitude peak confirmations: $\lambda_{\odot} = 14°$–$17°$ (the extension of the $\lambda_{\odot} = 17°$–$18°$ period), $\lambda_{\odot} = 20°$, $\lambda_{\odot} = 22°$–$24°$, $\lambda_{\odot} = 27°$ (but only weakly; part of the $\lambda_{\odot} = 25°$–$27°$ spell), $\lambda_{\odot} = 30°$–$32°$ (the extended $\lambda_{\odot} = 31°$ period; Ghent University data only suggested $\lambda_{\odot} = 29°$–$33°$, but all were naturally strongest at $\lambda_{\odot} = 32°$), $\lambda_{\odot} = 34°$–$40°$ (the extended $\lambda_{\odot} = 34°$ and $\lambda_{\odot} = 40°$ periods, probably due to increasing η-Aquarid rates).

The improvement in meteor activity towards the April-May boundary was obvious in southern hemisphere and all radio data, and the visual workers confirmed this was chiefly due to the η-Aquarids livening up.

Tim Cooper in particular managed watches in the pre-dawn hours on every night from April 26-27 to 29-30 and on into early May, especially to cover the shower. Both he and Graham Wolf noted observed shower rates of around 3–5 an hour as April ended, yielding ZHRs of 10–20, much as indicated in [4].

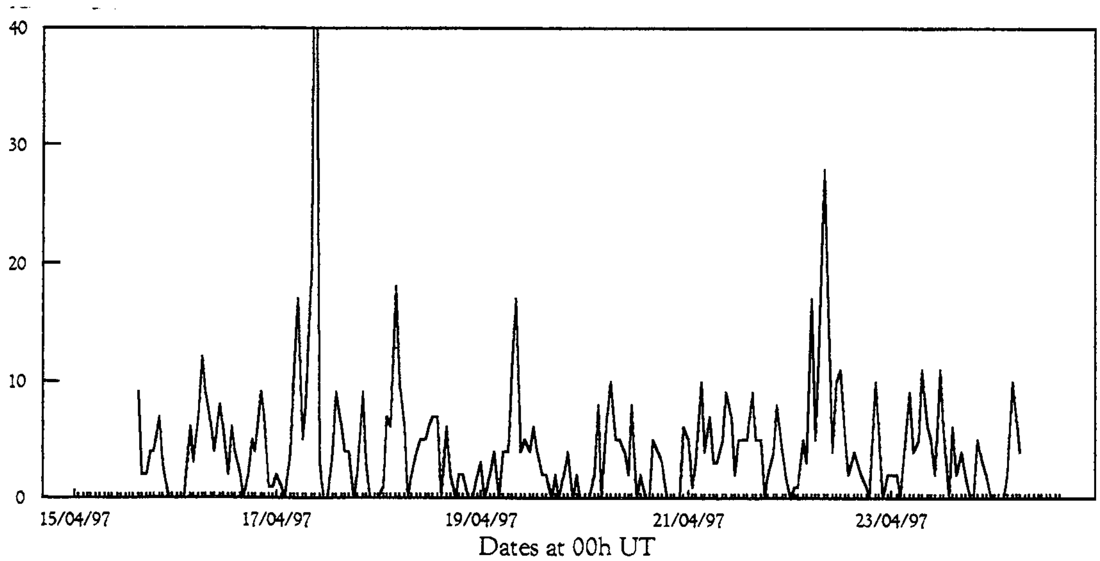

Figure 2 – Raw hourly radio meteor echo counts between April 15, $15^{h}00^{m}$ UT, to April 24, $8^{h}20^{m}$ UT, 1997, (when the system crashed), from data collected by Robert S. White. The very high spike (72 echo-counts) on April 17, 9^{h}–10^{h} UT seems to be due to interference. The Lyrid spike on April 22 is well-seen.

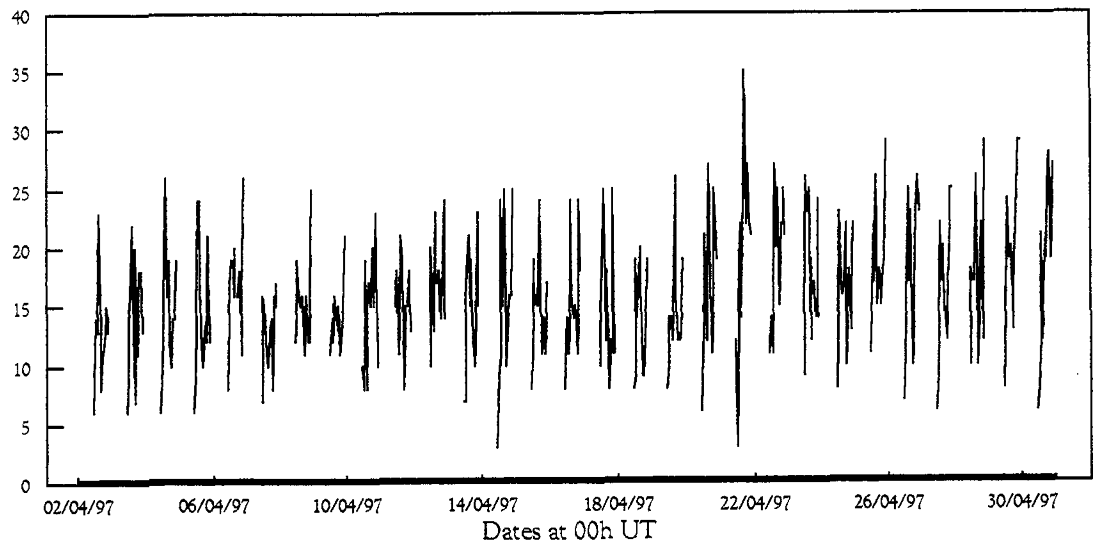

Figure 3 – Raw hourly radio meteor echo counts during April 1997, from data collected by Chikara Shimoda given in *RMOB* 45 (May 1997). The Lyrids are much in evidence on April 21-22, and note the gradually rising activity towards the end of April, as the η-Aquarids start to appear.

Acknowledgments

As is customary, my grateful thanks go to all the observers who have produced and submitted data during this period, as well as to all the Section's correspondents, who have continued to provide lively support. Clear skies to all!

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[1] A. McBeath, "The Forward Scatter Meteor Year", in *1997 IMC Proceedings*, Petnica (in preparation).

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[4] J. Rendtel, "The η-Aquarid Meteor Shower in 1997", *WGN* 25:4, August 1997, pp. 153–156.

SPA Meteor Section Results: May–June 1997

Alastair McBeath

Results collected by the *SPA Meteor Section* from May and June, 1997, are given. Some excellent visual and radio η-Aquarid data was secured during May, the best set of observations on this shower ever amassed by the Section, confirming a maximum on May 5, although radio rates were extremely good for about a fortnight from late April to mid-May. In May and June, visual observers recorded low Sagittarid rates too. Radio observers struggled against Sporadic-E (Es) and the effects of thunderstorms throughout June, but still made useful observations of the June daytime showers. These were most notable in the second week of June.

1. Introduction

Conditions in the UK were unhelpful during both months, although the midsummer twilight is always an added problem for northern hemisphere observers, especially during June. The observing totals were still very good, however, as demonstrated in Table 1.

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

Month	Visual	SAG	ETA	Meteors	Photo	Radio
May	129^h	96	779	1785	131^h	1741^h
June	86^h	57	–	577	120^h	1999^h

All the photographic results were submitted by the German *Arbeitskreis Meteore* (*AKM*) observers of the all-sky *European Fireball Network*, but they have so far discovered no trails. The photographers included Axel Haubeiß, André Knöfel, Jürgen Rendtel, Heinz Ringk, and Harald Seifert. The *AKM* details were extracted from *Mitteilungen des AKM*, issues 7 and 8 (1997), kindly sent by Ina Rendtel.

Radio observations came from: Maurice de Meyere (Belgium, *RMOB*), Ghent University (Belgium, *RMOB*), Werfried Kuneth (Austria, *RMOB*), Chikara Shimoda (Japan, *RMOB*), Robert S. White (England), Ilkka Yrjölä (Finland, *RMOB*). The *Radio Meteor Observation Bulletin* (*RMOB*) data came from Bulletins 46 (June 1997) and 47 (July 1997), and many thanks go to Christian Steyaert who provided copies of these. Routine raw radio data analysis techniques were employed, as usual, and representative graphs chosen from the available data.

Our visual reporters comprised

> *AKM* members Ralf Koschack, Ralf Kuschnik, Sirko Molau (Chech Republic and Jordan), Mirko Nitschke (Jordan), Jürgen Rendtel (Germany and Jordan), Petra Rendtel, Janko Richter, Thomas Schreyer, Harald Seifert, Ulrich Sperberg (all in Germany, except where noted), Charlotte Bland (England), Eva Bojurova (Bulgaria), Jay Brausch (North Dakota, USA), Tim Cooper (South Africa), Richard Livingstone (Wales), Graham Pointer (England), and Graham Wolf (New Zealand).

In addition, Tim Cooper helpfully submitted a recently published report paper on the 1997 η-Aquarids [1], which contained details of observations by three other South African observers.

2. May

The chief highlight of May was the superb coverage of the η-Aquarids during the first half of the month, the most extensive set of η-Aquarid results available from *SPA Meteor Section* data ever. The amount of *IMO* visual data has already resulted in a detailed global report [2], showing the overall brightness of the shower meteors, something the majority of visual η-Aquarid observers commented on when sending their reports. No especially brilliant shower fireballs were seen, despite this. There did seem to be a slight discrepancy in the ZHRs noted by observers north and south of the equator (slightly higher ZHRs to the south), as was also found in [3], although the mean value from all our available data was 75 ± 15 at best on May 5. Train details from the South African observers suggested that about 50% of η-Aquarids left trains this year, the longest lasting for 30 s, from a magnitude -3 event.

Highest radio echo counts occurred on May 5 around 5^h–8^h UT over Europe ($\lambda_\odot = 44\overset{\circ}{.}78$–$44\overset{\circ}{.}90$, eq. 2000.0), as shown in Figure 1. This certainly supports the earlier maximum found in [2], although regrettably, there are no observations from the actual maximum time suggested, of around 22^h UT on May 4. This timing would have been well-placed for the Japanese observers, but only Chikara Shimoda in Japan has so far submitted data from May, and he was not operating his set-up after 17^h UT on May 4 until 11^h UT on May 5. The overall effect of the η-Aquarids on radio echo counts is long-lasting, as Figure 2 shows, with activity building from soon after the Lyrids in April, right through until almost mid-May. There are, however, several other, lesser, showers active during this period, which may well contribute to a smoother appearance in the radio profile than was found in the visual η-Aquarid results alone.

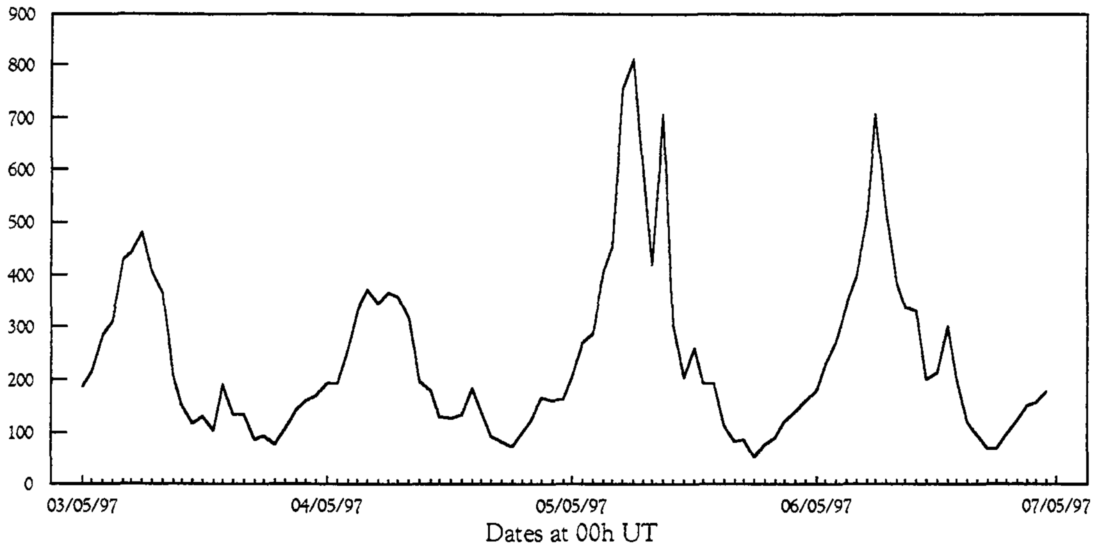

Figure 1 – Raw hourly radio meteor echo counts from May 3 to 6, 1997, as recorded by Ilkka Yrjölä, given in *RMOB* 46 (June 1997). The η-Aquarids' main peak is clearly shown on May 5. Note that the x- and y-axis scales vary from graph to graph in the radio results here.

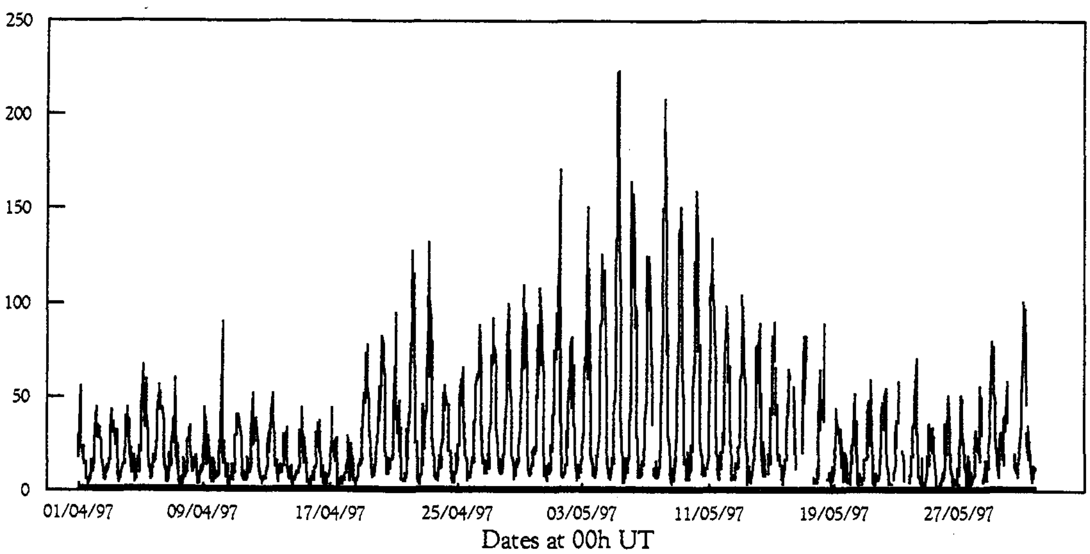

Figure 2 – Raw hourly radio meteor echo percentage reflection time totals ($\times$10) from 1997 April and May, as collected by Ghent University equipment, given in *RMOB*s 45 and 46 (May and June, 1997, respectively). Note the Lyrid peak in April, and the climbing η-Aquarid activity that starts soon afterwards. By late May, radio counts are rising again as the June daytime shower maxima approach. The gaps in the second half of May are chiefly due to Es.

Visual observers do not have to put up with the problems of Es and thunderstorms, both of which prevented radio observing at various times during parts of May and June this year, but the trade-off is in the better "view" northern hemisphere radio operators have of the η-Aquarids as a whole.

May produced low Sagittarid activity as well, as noted by almost all the visual observers, but observed rates from this source were never exciting. In the recent past, the period between $\lambda_{\odot} = 66°70°$ (May 27–31) has shown marginally higher Sagittarid rates [4], but there were only slight signs of better ZHRs in late May this year. All the significant radio peaks found in [5] were confirmed by most active observers, although Es and thunderstorms in late May hampered European recording particularly.

Another zodiacal light observation, to go with his UK sighting of March 29, was provided by Jürgen Rendtel from his expedition to Jordan on May 6, from where the light might be expected to be a rather easier target than further north in Europe. Jürgen noted that the evening light cone was not as apparently bright as it had been from Dartmoor in March, although it was seen while checking on Comet Hale-Bopp again. The light was noted in eastern Taurus between 17^h50^m and 18^h20^m UT.

3. June

Low Sagittarid activity continued all month, as viewed visually, with no real indications of a precise peak, although rates did seem to be marginally higher in the first week of the month than during late May. Too few data are available to confirm this, however.

Five sites on North Island, New Zealand, reported a bright bolide of about magnitude -15 at 6^h20^m UT on June 13. The object appears to have passed across the southern part of the Island, and over the Cook Strait, but as all the observers were to the east of the track, it is difficult to pin its trajectory down with any certainty. Acoustic "booms" were definitely heard at four locations up to four minutes later (longer times naturally equating with greater distance from the projected ground track). As seems almost customary, any meteorites would have ended up in the sea!

Figures 3 and 4 give a view of the radio activity detected during June, which along with May, is generally the highpoint of the radio year for sustained echo rates. The patchy coverage over Europe was a major feature this year, with a lot of Es events, and a great many thunderstorms too, posing serious difficulties. Even so, most of the previously-detected significant echo peaks from [5] were recorded again. The 1997 peaks, confirming earlier results unless noted, were at $\lambda_\odot = 72°$ (perhaps the poorly-confirmed peak at $\lambda_\odot = 71°?$), $\lambda_\odot = 73°$, $\lambda_\odot = 75°$–$82°$ (Es in Europe was a problem, but an extension of this period to perhaps $\lambda\odot = 87°$ was noted at several sites), $\lambda_\odot = 84°$, $\lambda_\odot = 89°$–$97°$ (although coverage was again patchy, and the Japanese data show a weaker confirmation). The Arietid and ζ-Perseid peaks, which are so close temporally that in the radio data, they blend into one significant enhancement for much of the second week in June, and the β-Taurids in late June were much in evidence, but more results from years in which Es is less troublesome are needed to examine the activity of these daytime streams better.

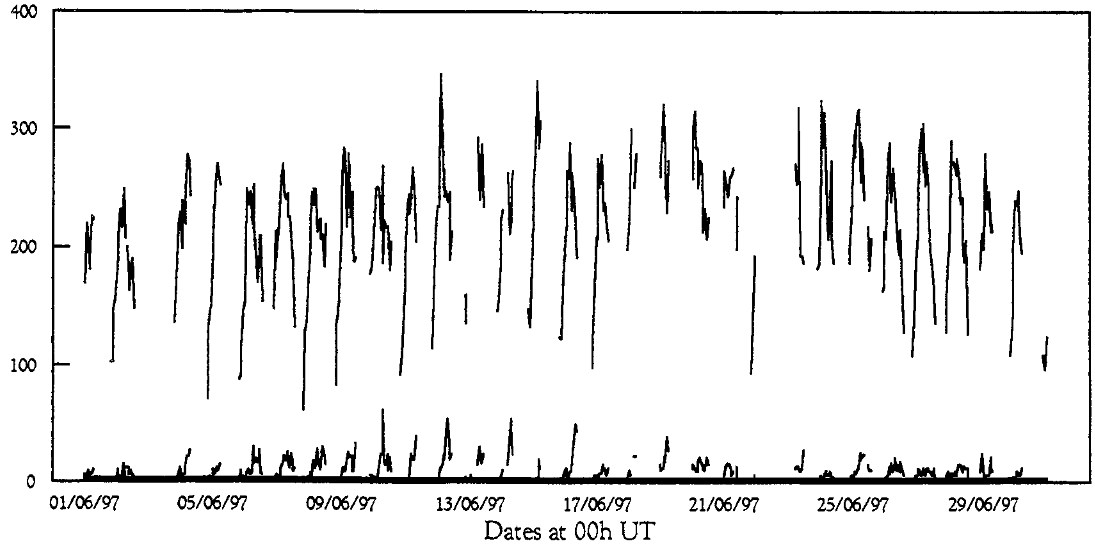

Figure 3 – Raw hourly radio meteor echo counts from 1997 June, as collected by Werfried Kuneth, given in *RMOB* 47 (July 1997), whose system was running for at most 18 hours a day, from about 20^h–13^h UT. The upper line represents all the recorded echoes, while the lower one gives the numbers of long-duration echoes ($D > 6.5$ s). This long-duration echo data provides useful evidence confirming the strength of the Arietids and ζ-Perseids in the first half of June. The patchy coverage is typical of the Es and thunderstorm problems during the European summer this year.

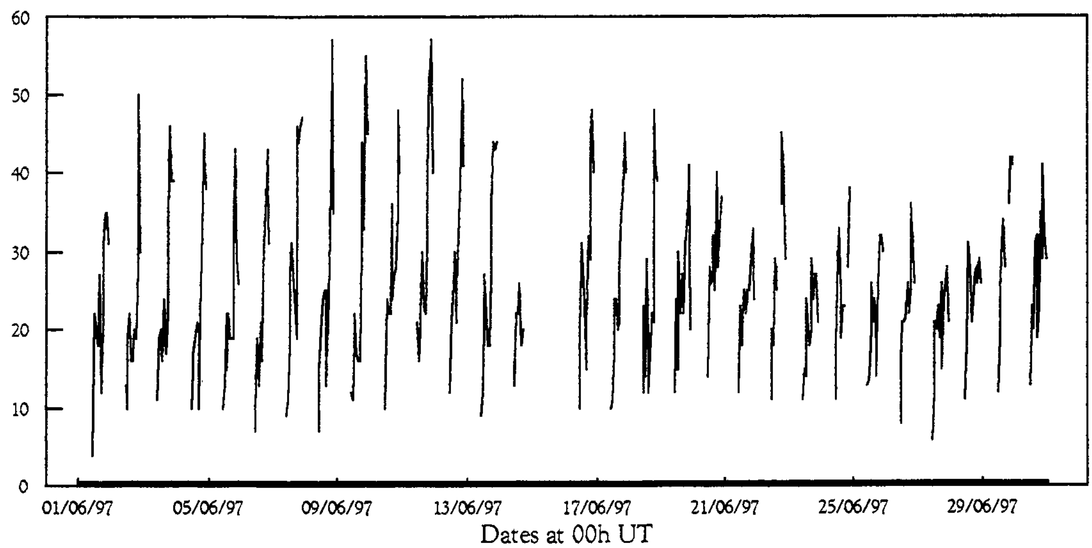

Figure 4 – Raw hourly radio meteor echo counts from June 1997, as collected by Chikara Shimoda, given in *RMOB* 47 (July 1997). His set-up was operated from 11^h–22^h UT on a normal day. Problems with Es were much less severe for Japan than Europe, but some gaps are apparent nonetheless.

Acknowledgments

Many thanks, as always, are due to all the contributing observers and correspondents. Keep up the good work, and clear skies!

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[2] J. Rendtel, "The η-Aquarid Meteor Shower in 1997", *WGN* 25:4, August 1997, pp. 153–156.
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BAA Observations of the 1997 Perseids: A Preliminary Report

Neil Bone

An overview is given of the *BAA* observations of the 1997 Perseids.

Following a run of several years with poor weather over the shower maximum, observers in the UK enjoyed a little more success for the Perseids in 1997. As seems to have been the pattern in recent years, the northern half of the British Isles was favored on August 12-13. Observers in the south had their best skies late on August 11-12. In several areas, the clearest conditions were found after maximum, on August 13-14. Several good nights were also available during the run-up to peak, and only August 10-11 seems to have been completely lost from the UK.

Up to the end of September, reports totaling 236^h38^m watch time, amounting to 3947 meteors (790 sporadics, 2756 Perseids, and 401 others) were received from the 77 observers listed below, for the interval August 1-2 to 15-16, inclusive. Observations have been reduced as previously [1,2] to give corrected sporadic hourly rates (CHRs) and Zenithal Hourly Rates. Data for nights between August 6-7 and 15-16 are shown in Table 1.

Table 1 – Perseid data from members of the *BAA* in August 1997. The columns list the date in August 1997, the time (UT), the solar longitude ($\lambda_\odot$), the observing time ($T_{\rm eff}$), the limiting magnitude (Lm), the cloud correction factor (F), the number of sporadics (Spor) and Perseids (Per), the CHR of the sporadics, the radiant altitude ($h_{\rm rad}$), and the ZHR of the Perseids.

Aug	Time	$\lambda_\odot$	$T_{\rm eff}$	Lm	F	Spor	Per	CHR	$h_{\rm rad}$	ZHR
6	22^h59^m	135°54	5.08	5.48	1.05	9	20	6.5 ± 2.2	37°0	16.4 ± 3.7
7	00^h34^m	134°60	1.75	5.80	1.05	14	19	19.9 ± 5.3	46°2	28.7 ± 6.6
7	22^h38^m	135°48	4.00	5.64		8	17	5.8 ± 2.1	34°6	17.0 ± 4.1
7	23^h25^m	135°51	2.83	5.55		11	11	12.5 ± 3.8	38°9	13.9 ± 4.2
8	00^h40^m	135°56	2.07	5.63		2	8	2.8 ± 2.0	47°4	11.0 ± 3.9
8	22^h26^m	136°43	1.70	5.25		5	12	13.7 ± 6.1	32°3	38.4 ± 11.1
8	23^h25^m	136°47	2.00	5.25		3	14	14.0 ± 8.1	38°8	32.5 ± 8.7
9	01^h00^m	136°53	1.00	5.40		3	5	11.6 ± 6.7	49°6	16.8 ± 7.5
9	02^h00^m	136°57	1.00	5.40		2	7	7.7 ± 5.5	57°1	21.3 ± 8.1
9	22^h32^m	137°39	4.00	5.39		12	28	11.7 ± 3.4	34°8	31.7 ± 6.0
9	23^h34^m	137°43	4.01	5.41		12	23	11.4 ± 3.3	40°2	22.6 ± 4.7
10	00^h28^m	137°47	6.00	5.48		11	41	7.7 ± 2.3	46°9	22.4 ± 3.5
10	01^h38^m	137°52	3.75	5.55		9	34	10.5 ± 3.5	54°8	25.0 ± 4.3
10	22^h32^m	138°35	1.00	6.00		1	12	1.8 ± 1.8	38°6	29.5 ± 8.5
11	04^h30^m	138°59	1.00	6.80		8	21	8.0 ± 2.8	39°6	32.9 ± 7.2
11	05^h30^m	138°63	1.00	6.80		18	23	18.0 ± 4.2	47°1	31.4 ± 6.5
11	06^h30^m	138°67	1.00	6.80		14	38	14.0 ± 3.7	55°0	46.4 ± 7.5
11	22^h19^m	139°30	2.83	5.30		4	23	6.2 ± 3.1	33°5	41.1 ± 8.6
11	23^h21^m	139°34	4.00	5.45	1.04	9	48	8.5 ± 2.8	39°7	47.9 ± 6.9
12	00^h25^m	139°38	4.75	5.38	1.07	6	57	5.4 ± 2.2	46°8	42.9 ± 5.7
12	01^h22^m	139°42	5.50	5.55	1.06	18	94	11.2 ± 2.6	53°7	50.6 ± 5.2
12	02^h25^m	139°46	2.25	5.47		7	40	11.0 ± 4.2	61°3	48.9 ± 7.7
12	05^h55^m	139°61	0.50	5.20		2	4	19.8 ± 14.0	32°5	45.2 ± 27.6
12	06^h30^m	139°63	0.50	5.30		2	7	17.5 ± 12.4	37°1	64.7 ± 24.5
12	07^h10^m	139°66	0.50	5.50		2	10	13.7 ± 9.7	42°4	69.7 ± 22.0
12	08^h00^m	139°69	0.50	5.60	1.11	1	12	6.7 ± 6.7	48°9	76.3 ± 22.0
12	08^h32^m	139°71	0.50	5.50	1.11	3	16	22.8 ± 13.2	52°9	104.7 ± 26.1
12	09^h34^m	139°75	0.50	5.60		3	15	18.1 ± 10.5	59°7	75.0 ± 19.4
12	22^h49^m	140°28	4.00	5.82		10	57	5.8 ± 1.8	39°0	40.5 ± 5.4
12	23^h46^m	140°32	5.93	5.90	1.02	9	128	3.2 ± 1.1	44°2	52.7 ± 4.7
13	00^h39^m	140°36	7.50	5.84		27	171	8.1 ± 1.6	50°2	52.2 ± 4.0
13	01^h55^m	140°41	2.50	6.50		9	110	3.6 ± 1.2	60°5	50.6 ± 4.8
13	02^h30^m	140°43	1.00	5.70		4	28	10.7 ± 5.4	64°9	61.2 ± 11.6
13	04^h30^m	140°51	1.00	6.80		11	36	11.0 ± 3.3	40°6	55.3 ± 9.2
13	05^h45^m	140°56	1.50	6.80		14	61	9.3 ± 2.5	50°1	53.0 ± 6.8
13	23^h24^m	141°27	2.00	5.89		4	28	4.2 ± 2.1	40°1	36.6 ± 6.9
14	00^h30^m	141°31	5.90	5.83		31	104	14.4 ± 2.6	48°3	39.4 ± 3.9
14	01^h39^m	141°36	5.17	5.88		20	88	10.3 ± 2.3	56°9	34.5 ± 3.7
14	02^h35^m	141°40	2.00	5.65		5	26	14.2 ± 6.4	64°2	29.9 ± 5.9
15	01^h36^m	142°31	9.09	5.78	1.02	27	81	8.3 ± 1.6	56°8	20.1 ± 2.2
16	02^h20^m	143°31	1.33	6.01		6	8	11.0 ± 4.5	63°3	10.2 ± 3.6

The *BAA* Perseid observers in 1997 were as follows:

L. Barbour, S. Barnes, J. Bingham, P. Bispham (Germany), N. Bone, B. Boots, G. Bostock, C. Bradley, P. Brown, A. Ciavarella, L. Chatfield, J. Cook, B. Debenham, A. Drummond, C. Durman, J. Duthie, S. Easter, L. Entwisle, s. Evans, A. Farr, D. Gavine, J. Glover, D. Gordon, M. Green, C. Hall, A. Heath, A. Hopwood, J. Hubble, D. Jenkinson, N. Jenkinson, G. Jones, R. Livingstone, K. Mackay, S. McAlister, A. McBeath, A.

McCrea, T. McEwan, H. McGee, A. Mark, E. Mark, P. Mark, T. Markham, M. Mercer, R. Milgate, S. Moore, S. Morley, T. Moseley, C. Newman, J. Olesen (Denmark), M. Payne, J. Pickard, R. Pitaluga (Gibraltar), G. Pointer, N. Quinn, A. Quirk, G. Ross, R. Schmude (USA), J. Shanklin, D. Shepherd, J. Shepherd, J. Smith (Canada), P. Smith, G. Spalding, M. Stephens, D. Storey, S. Sullivan (Canada), M. Taylor, C. Thomson, I. Thurlberg, S. Thurlberg, J. Tollor, A. Tully-Jackson, A. Vincent, F. Vincent, and I. Wood.

Perseid activity showed its usual slow rise during early August. Observations made late on August 11-12 indicate more substantial rates as the shower approached the expected August 12, 15^{h} UT maximum [3]. By dawn, ZHR had reached about 50.

BAA observers based in Western Europe were, naturally, too far east to have much chance of seeing any residual activity from the "early" Perseid peak associated with the recent perihelion of Comet 109P/Swift-Tuttle. Having been much diminished from its early 1990s level at the previous Perseid return [2], it seemed likely that this "spike" might have disappeared by 1997. Observations reported from the United States suggest otherwise [4]. Further results from Richard W. Schmude Jr., a regular *BAA* contributor from Georgia, UAS, confirm elevated Perseid rates for a short period around August 12, 1997, $9^{h}30^{m}$ UT ($\lambda_{\odot} = 139\overset{\circ}{.}71$). An hour later, activity had returned to more "normal" levels.

Observers in the northern UK were able to follow the Perseids' decline from maximum on the evening of August 12-13, when ZHRs of the order of 50 were again found. Observed rates were still respectable on August 13-14, with ZHR of the order of 35–40. Rates then halved nightly up to August 15-16, by which time the Moon was well in the way.

Having been far from either of the 1997 peaks, many *BAA* observers found the rates "disappointing," compared with those found in the past, more favorable years. Compounding the relatively low activity, there seem to have been few particularly bright Perseids visible at UK longitudes this time round. The only reported fireball was a magnitude −6 Perseid with a 14-second persistent train at August 12, $22^{h}33^{m}$ UT, seen by Melvyn Taylor from North Yorkshire. Overall Perseid and sporadic magnitudes are compared in Figure 1. Mean magnitudes of +2.02 for Perseids and +3.03 for sporadics were found. Persistent trains were left by 24.3% of Perseids compared with 4.3% of sporadics.

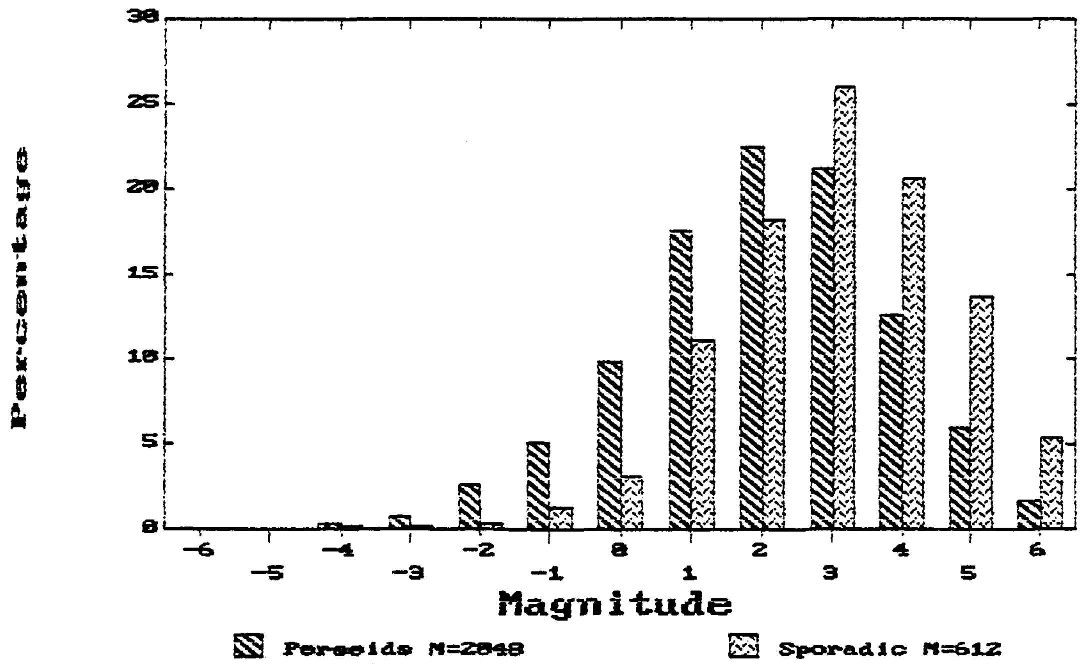

Figure 1 – Overall magnitude distribution of Perseids and sporadics observed by *BAA* observers in 1997.

Overall, 1997 brought a slight improvement in fortunes for most *BAA* observers with respect to the Perseids, but the better weather found UK watchers "stranded" some way from the maxima. It is hoped that good conditions will allow the established maximum to be well covered in 1998, though moonlight will interfere. As ever, thanks are expressed to all contributors.

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A Preliminary Report from Dutch Data on Substructure during the 1997 Perseid Maximum

M. Langbroek, M. de Lignie, C. Johannink, K. Miskotte, and J. Nijland

Preliminary analytical results are reported on a part of the Perseid observations conducted by the *Dutch Meteor Society* during the nights of August 11-12 and 12-13 of 1997. The analysis was conducted with the aim of tracing possible substructure in the activity profile during these nights. There is no clear evidence for an increase in either rates or meteor brightness around passage of the node of Comet 109P/Swift-Tuttle near 1^h–2^h UT on the night of August 11-12 in our data. Clear substructure is present however in the data from August 12-13. Rainer Arlt discovered a peak in Perseid activity near 0^h UT in the data from this night [1], which clearly shows up in the current analysis too. It concerns a short-lived peak ($B \approx 25$, $2 \times 1/e$ duration $0\overset{\circ}{.}03$ or approximately 45 minutes) with maximum ZHR around 120 near 23^h45^m UT ($\lambda_\odot = 139\overset{\circ}{.}630$, eq. 1950.0).

1. Introduction

The summer of 1997, which featured the warmest August month since the start of measurements in 1706 for our country, has provided a unique opportunity for observers in the *Dutch Meteor Society* (*DMS*) to monitor the larger part of the ascending slope and maximum of the Perseids. Observations were possible during each night from August 4-5 until August 12-13, while several observers also managed to gather data in July. Such a long stretch of clear nights is almost unprecedented in the 18 year history of *DMS*, and, therefore, most observers took up this opportunity with a lot of enthusiasm. Though sky conditions on a few nights were modest and a few stations lost one or two nights to local haze, the conditions were quite good on average, with some nights (e.g., August 10-11 and 11-12) featuring excellent observing conditions with limiting magnitudes that, for some stations, went up to +6.9. A multi-station photographic network of 5 stations was employed from August 4-5 until August 12-13. Station Biddinghuizen took the opportunity to test new both more compact and more accurate photographic equipment build for the upcoming Leonid expeditions of 1998 and 1999. The aim of the new equipment is to obtain more accurate speed determinations (resulting in smaller deviations in determined semi-major axis for fast meteors like Leonids) by using aperture of larger focal length, a finer grained film, and a faster rotating shutter. In Biddinghuizen alone, the photographic campaign resulted in 127 exposed photographic films, about 4570 negatives to be inspected for meteors, and some 210 photographed meteors (presumably, about 1/2 to 2/3 of these will be multistation with the other photographic stations).

This report deals with a part of the visual data from the nights of August 11-12 and 12-13. The preliminary analysis employs the data gathered by the five authors of this report from three localities, Biddinghuizen (MISKO and LANMA), Lattrop (JOHCA and LI MA), and Dijkgatsbos (NIJJO), each pair some 100–150 km apart. The aim was to trace possible substructure in the activity profile of these nights. The employed reduction procedures are outlined in [2] and several previous contributions by the main author to this journal. The data are stored in the archives of the *DMS* and the *IMO*'s *VMDB*.

2. August 11-12

The authors collectively gathered 1299 Perseids this night. The results are shown as the black blocks in Figure 1. Data gathered during twilight and moonlight (before 22^h30^m UT) have been omitted.

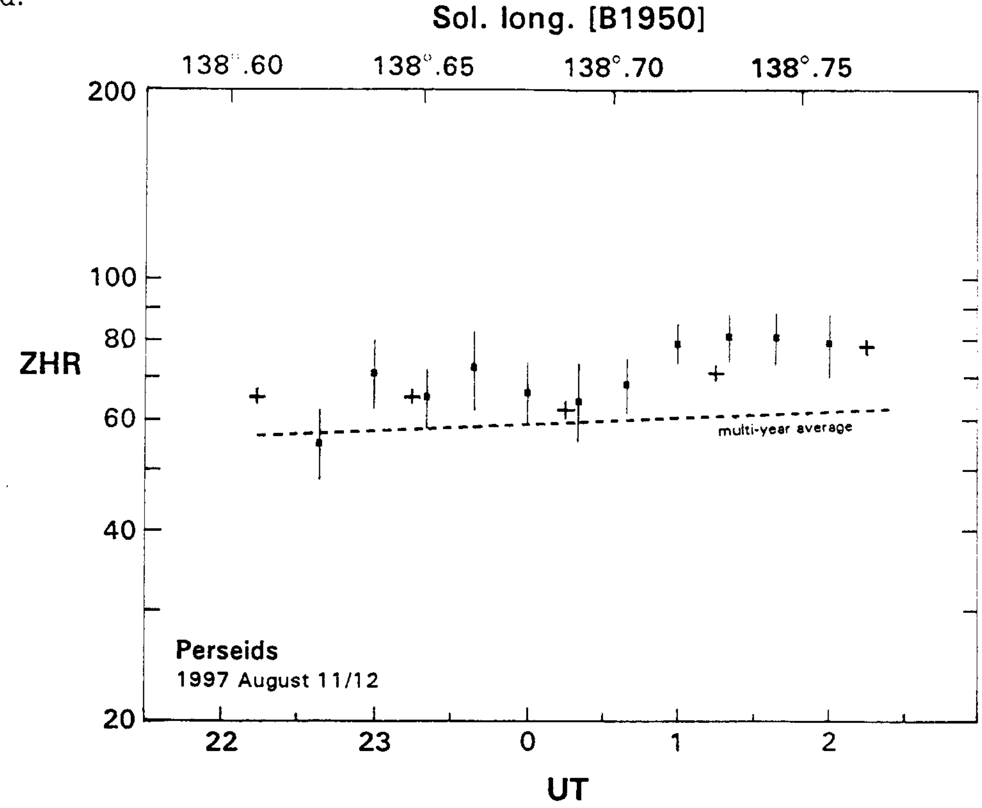

Figure 1 – Results of the observations during the night of August 11-12, 1997.

Dutch observers will remember this night because of the two spectacular −5 and −4 fireballs that appeared within a minute at $1^h08^m25^s$ and $1^h09^m02^s$ UT. This, and the appearance of a −3 meteor some 15 minutes earlier, probably sparked the impression expressed by some that the number of bright meteors and possibly also rates in general increased around 1^h UT, short before passage of the node of Comet 109P/Swift-Tuttle (such a short-lived secondary peak in activity around nodal passage was present in 1993 near the base of the ascending slope of the outburst of that year [3]). This is not substantiated by the data reported on in this paper, however. The Perseid population index was determined for the periods before and after 0^h UT by comparing $\log(N_{\text{Per}}/N_{\text{Spor}})$ per magnitude. On a scale with r_{Spor} at 3.4, both periods result in an r-value of 2.1 ± 0.2 for the magnitude range of +1 to +5. In addition, we plotted the fraction of bright Perseids $N_{\leq 0}/N_{>0}$ in approximately 1-hour intervals for each observer. For 4 out of 5 observers this fraction remained fairly constant over the night, with no evidence for a peak in the relative number of bright meteors around 1^h UT. The fifth observer (one of the Lattrop observers) shows a dramatic change in the relative number of bright meteors after 23^h UT. Since moonset was around 22^h30^m UT, we suspect that this observer either overestimated meteor brightness after or underestimated meteor brightness before moonset. If we look at the rates depicted in Figure 1, we can only conclude that there is no clear evidence for an increase in rates around 1h UT either. Rates are slightly above the multi-year average (dashed line, [2]), but remain within the approximately 20% variation introduced by solar activity [2], and the slope follows the trend quite well.

3. August 12-13: a sub-peak around $23^{h}45^{m}$ UT

The authors collectively gathered 1092 Perseids this night. The results are shown in Figure 2 as the black blocks. This time, only data from twilight and data with radiant altitudes below 35° have been omitted.

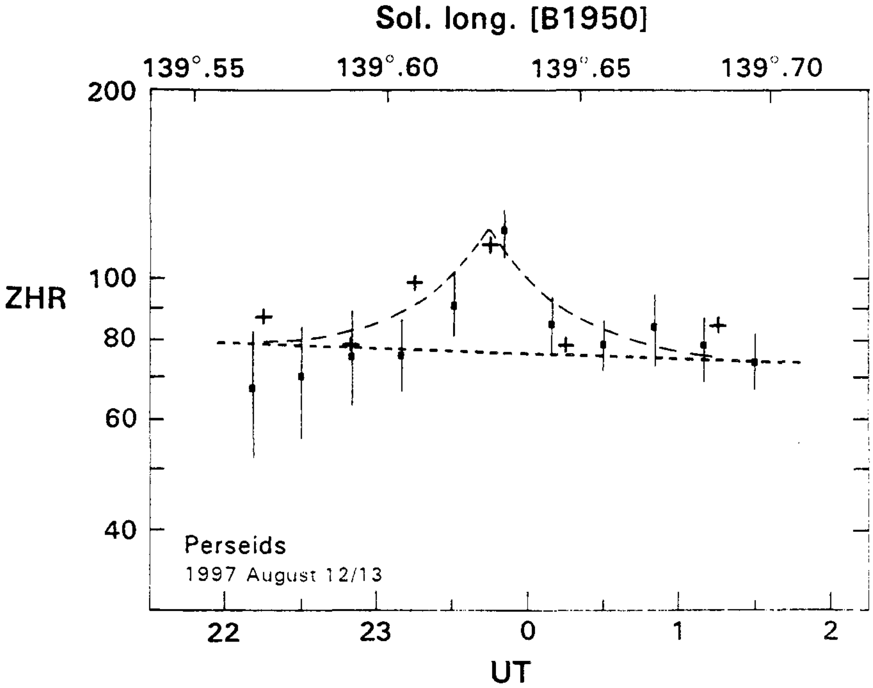

Figure 2 – Results of the observations during the night of August 12-13, 1997.

Note that the data from before 23^{h} UT might have suffered slightly from moonlight. Moonset was at approximately $23^{h}05^{m}$ UT. At Biddinghuizen, this night started with some cirrus that, however, dissolved before $22^{h}50^{m}$ UT (only data gathered after $22^{h}50^{m}$ UT were included for this station). The crosses in Figure 2 refer (as in Figure 1) to the results of a preliminary analysis by Rainer Arlt [1], and are plotted for comparison. Since (due to a slightly different selection of parameters and the additional correction for perception differences in the current analysis) the absolute levels of activity determined in both analysis can not be directly compared, we scaled the *IMO* results by a factor 1.24 to bring them to a same level.

There seems no clear evidence for a change in population index over the profile for this night, though we should keep in mind that the data sample is relatively small. The population index was determined at 2.5 ± 0.2. Comparing this with the value of 2.1 ± 0.2 determined for the previous night, this seems to corroborate the general impression expressed by several observers that, during the night of August 12-13, the meteor brightness was weaker than during the previous night, and it is in line with the notion that the population index of the Perseids slightly increases around maximum and quickly decreases after maximum [4].

In his preliminary analysis of *IMO* data [1], Rainer Arlt discovered the presence of a sub-peak in activity just before 0^{h} UT. This sub-peak clearly shows up in the present analysis too (Figure 2). Highest rates are reached around $23^{h}45^{m}$ UT, some 5 hours after the annual stream maximum [2,4], with a peak ZHR in the order of 120, a factor 1.5–1.6 above the general trend in rates for this part of the descending branch of the Perseid main peak (bold dashed line, [2]). The peak is steep (and might be slightly skewed), with a B value of around 25 (see [2]) and a $2 \times 1/e$ duration in the order of only 0°.03 or about 45 minutes.

In terms of peak position, slope steepness, and relative strength the results of the current analysis match the results of Arlt's analysis extremely well, as can be seen in Figure 2 (we should note however that the data of 4 observers are included in both analysis).

The character of the peak might lead one to suspect some relation to the "recent" perihelion passage of the parent comet, 109P/Swift-Tuttle, but some caution is necessary. The peak occurs rather far from the cometary node. Moreover, it is not clear at all at present if this peak is an annual feature or not.

For example, radio data seems to suggest that it might have been present in 1995 [5]. Visual data from 1993 and other years, however, seem to show no trace of it [3-4], but before taking this for granted we plan to re-analyze the data from 1993 (and other years) in shorter reduction intervals.

It is intriguing to note that an analysis of photographic data from the *IAU* photographic database at Lund by Lindblad and Porubčan [6] does show a peak around this solar longitude, though it is marginal in respect to the scatter in their analysis, and some sample bias might have played a part. The most fascinating aspect about this photographic sub-peak (designated as "old Perseids" by Lindblad and Porubčan) is that it seems to be present only in the data from before 1960 and seems virtually absent in the data from 1960 to 1985 [6].

During the August 12-13 sub-peak, our network gathered several photographic multi-station events. If the subpeak is indeed due to a "fresh" dust component, this might reveal itself in the radiant and orbital data of these meteors. For example, meteors from the 1991, 1993, 1994, and 1996 Perseid outburst components clearly clustered in radiant position and orbits when compared to the annual stream component [7–8], as did the 1995 outburst Leonids [9]. Reduction of the 1997 photographic data is currently in progress.

Acknowledgments

We thank Peter Bus, Casper ter Kuile, and Olga van Mil for discussions and suggestions.

The 1997 photographic campaign was supported by a generous material grant from Kodak Netherlands B.V.

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The October 1997 Orionids and Taurids in New Zealand

Graham W. Wolf

October 1997 data for the Orionid and Taurid Meteor showers, as secured by the author from his new site, are presented. Despite some lunar pollution around the time of shower maximum, rates were still lower than normal. Numerous sporadic fireballs were also observed. Train and color data are also presented, forming part of a personal longitudinal study of Southern showers, for the global *IMO* Network.

The author observed on 16 dates during October 1997, for a total of 67.5 hours. During that period, he observed 559 meteors (190 shower members and 369 sporadics). Of the sporadics, 16 were Fireballs (magnitude −3 or brighter). The observing site was "Crowther Road, Moore's Valley," some 6.9 km by road, and about 4 km direct, from the author's residence, at $\lambda = 174°58'36''$ E, $\varphi = 41°14'20''$ S, $h = 50$ m. Personal "site testing" the previous month consistently indicated that Zenith Limiting Magnitudes (ZLMs) on clear moonless nights there are $+6.4 \pm 0.2$.

Table 1 – Magnitude distribution of the observations of Graham Wolf in October 1997

Shower	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4
STA							1	4	12	1	
NTA							1	4	11	5	
ORI						8	24	16	40	47	6
SPO	1	1	8	6	5	28	39	44	107	106	24

For sake of direct train and color comparisons with previous reported data by Jeff Wood (of the long disbanded *NAPO Meteor Section*, and *ASIMO*, which he directed from Perth, Australia, the author has "binned" both his own STA and NTA data together, and reclassified them as TAU.

Table 2 – Train and color data from the observations of Graham Wolf in October 1997. Of the 151 Orionids considered, 42 showed a train, and of the 39 Taurids considered, 2 showed a train. Comparisons are made with 1987 data reported by Jeff Wood [4]. For 1992 observations, Valentin Grigore [5] reported a train percentage of 20% for the Orionids.

Orionids			Taurids		
Property	Wolf 1997	Wood 1987	Property	Wolf 1997	Wood 1987
Trains	30 %	20 %	Trains	5.1%	3 %
Yellow	38 %	35 %	Yellow	39 %	38 %
Red	4.0%	1.7%	Red	2.5%	No data
Blue	2.0%	5.1%	Blue	7.7%	6.9%
White	56 %	54 %	White	51 %	45 %

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Addresses of authors not mentioned above

G. Cevolani et al., FISBAT/CNR, via Gobetti 101, I-40129, Bologna, *Italy*
M. Beech, Campion College, Univ. of Regina, Regina, *Saskatchewan S4S 0A2, Canada*
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I. Yrjölä, Jukolantie 16, FIN-45740 Kuuk, *Finland*
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