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october 1988

the international circular for meteor observers

Detail of a fish-eye photography of a fireball of magnitude -4 to -5 on May 13, 1988 at $22^h52^m40^s$ UT from Potsdam, GDR, with a f/3.5 30 mm lens on ORWO NP27 film (400 ASA) with a 12.5 s^{-1} rotating shutter. The photo was exposed from $20^h28^m00^s$ till $23^h06^m50^s$ UT.

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WGN, volume 16, nr 5, October 1988, pp. 143–176

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Useful Information

The December Issue *(WGN* 16:6)

This special (extra thick) issue will be sent out in the first week of December. Contributions for the *December issue* are due by *November 1* at the latest. They should be sent to *Marc Gyssens* or to any member of the editorial board (addresses on the inside of the back cover).

WGN Subscription/IMO Membership 1989

The subscription rate for volume 17 is 400 BEF (11 USD). Subscribers living outside receive *WGN* by airmail. IMO Founding Members renew their membership automically on renewing their subscription, unless explicitly required otherwise. Detailed information can be found on p. 143 of this issue. Additional gifts are of course welcome.

Please make sure that we retain the full amount due after deduction of bank and/or exchange charges. It is recommended to pay by international postal money order to Ann Schroyens (address on the inside of the back cover). Other "safe" ways of payment are suggested on p. 143 of this issue.

Administrative Correspondence

All payments should be addressed to Ann Schroyens. Complaints about not receiving *WGN* or changes of address should be sent to Paul Roggemans. Their addresses can be found on the inside of the back cover.

From the Editor-in-Chief

Marc Gyssens

Once more, we have to thank authors for the numerous contributions they sent us over the past couple of months. As a consequence, we have decided to make the December issue considerably thicker as well. So, if you mailed us an article and do not find it in this or previous issues, you will most likely see it in print two months from now. The two extra thick issues of 1988 were made possible thanks to the additional support we received from various subscribers. If the flow of contributions for WGN continues to increase — and we hope so — thicker issues will have to become ever more frequent. Therefore, we hope we may count on your continuing sympathy and support in the future as well. Detailed subscription and membership information for 1989 can be found on the next page; please know that you help us a lot by renewing early!

This is the second issue that is completely produced by computer text editing (TEX). Unfortunately, the improvement in the previous issue was spoiled by a bad printing quality, for which, once more, we ask you to accept our apologies. Many authors already sent contributions on floppy which saved me a tremendous amount of time, and this is crucial to make extra thick issues physically possible in the future. Unfortunately, a typo slipt in my explanation on p. 142 of the previous issue. If you can, send your article as an ASCII text file on a $5\frac{1}{4}''$ *360 (not 560) K MSDOS floppy. If you can only work on an Apple MacIntosh system, you may also send us an ASCII text file on a* $3\frac{1}{2}''$ *MacIntosh diskette. In all events, send along with your floppy or diskette a printed version of your article and, of course, the figures. To people that cannot use a personal computer, we guarantee that their contributions will be processed with the same priority as the other articles.*

The main contributions in this issue can be divided into three categories. First, we have an extensive study of Ralf Koschack and Jürgen Rendtel about spatial number densities in meteor streams. Next, we have two contribution of the Summer 1987 Aquarids. And finally, we are able to give you a first impression of this year's Perseids. Enjoy your reading!

1989 WGN Subscription/IMO Membership Info

Marc Gyssens

Traditionally, October is the month in which we ask you to renew your subscription. Since *WGN* is now the journal of the International Meteor Organization (IMO), we have set the subscription rate for volume 17 (1989) to 400 BEF, irrespective of where you live. Indeed, for a truly international organization, it would be unfair to let the subscription/membership fee depend on the distance between the reader's home and the site from which *WGN* is mailed. If you live outside Europe, *WGN* will automatically be shipped to you by airmail.

If you already sent us an application form for founding membership of IMO, then renewing your *WGN* subscription automatically yields renewal of your membership, unless explicitly required otherwise. If you have a subscription to *WGN* for 1988 and still wish to become a founding IMO member, just send us together with your renewal the application form which you can find on the back of the booklet enclosed in the previous issue of *WGN*, so that it reaches us *no later than December 31, 1988*. All other renewals will be considered as subscriptions by non-members.

If you did not subscribe to *WGN* in 1988, but wish to do so for 1989, you can also become an IMO-member, though not a founding one. More information about this possibility will be given in the December-issue.

Since it is our policy to keep the subscription rate for *WGN* as low as possible, it is most important to us that, after deduction of bank charges and/or exchange costs, we retain the full amount of 400 BEF. Therefore we please ask you not to deviate from the payment instructions given below.

- A first possibility of payment is using an *international postal money order*, made payable to *Ann Schroyens*, whose address can be found on the inside of the back cover (so, *not* to *WGN*, IMO, etc.). If you have a postal giro account yourself, you can transfer the subscription fee to the postal giro account of Ann.
- *European subscribers* can also pay by *Eurocheque*, *provided the following four conditions are met:*
  - the check must be made payable to *Ann Schroyens* (so, *not* to *WGN*, IMO etc.);
  - the check must be drawn in *Belgian francs*;
  - the check must mention a *Belgian city* (e.g. Brussels) as the place where the check was drawn;
  - your *Eurocheque card number* must figure on the back of the check.

  British subscribers can also pay through *George Spalding* (address on the inside of the back cover). Please contact George for further information.
- *North-American subscribers* (or persons owing a US or Canadian bank account) can pay by sending a *personal check for* 11 *USD* (or the equivalent in Canadian currency) to *Peter Brown* (address on the inside of the back cover).
- Of course you can pay *cash* to Ann by sending her bank notes for the required amount, or the equivalent in any freely convertible currency at the rate-of-the-day. We also accept *USD Traveller's Cheques*, *provided you add* 100 *BEF for exchange costs for each check you use*. It goes without saying that sending cash or Traveller's Cheques is done at the subscriber's risk.
- Finally, you can also go to your bank and ask them to make a *bank check* for you, drawn in *Belgian francs*. In that case, *specify explicitly that all charges must be at your own expense*. Again, the check has to be made payable to Ann.

Once again, please comply with these simple rules. Typically, bank charges for cashing a foreign check are in the same order of magnitude as the subscription rate for *WGN* itself. Therefore we will refuse all checks that do not meet the above requirements, simply because there might be hardly anything left for us after deduction of bank charges and exchange costs!

Finally, we wish to continue improving *WGN* as we have done for the past couple of years. This improvement has been made possible by subscribers having paid something extra in support of our activities. We expect to publish at least one but, more likely, two thicker issues in 1989 to keep pace with the ever increasing stream of incoming contributions. So, please continue to support us and pay something extra if you can!

Errata on *WGN* 16:4

p. 107 The first IMW took place in *June 1979* (instead of 1978) in *Königswinter* near Bonn.
p. 111 Line 5 of the Introduction: read 00^h57^m UT (instead of 10^h57^m).
p. 132 First and second line: read *December* (instead of April).
p. 135 Something went wrong with the table numbering. The tables on pages 135 to 137 should have been numbered 4 to 8.

Observer's Notes: November–December 1988

Paul Roggemans

1. Introduction

Long term history of meteor showers clearly shows that November is a famous month with many rich meteor storms, yes the most spectacular showers ever seen were all reported in November. In the 19th century the word November was synonymous to the exceptional Leonid and Andromedid showers. Today, November has lost this reputation somehow, but the current favorite month is December, with the rich Geminids.

Table 1 — Moonlight and observing conditions in November–December 1988.

Date	k	Date	k
Friday November 4	0.27−	Friday December 2	0.43−
Friday November 11	0.02+	Friday December 9	0.01+
Friday November 18	0.63+	Friday December 16	0.47+
Friday November 25	0.98−	Friday December 23	1.00+
		Friday December 30	0.61−

New Moon:	October 10, November 9, December 9, January 7, February 6
First Quarter:	October 18, November 16, December 16, January 14, February 12
Full Moon:	October 25, November 23, December 23, January 21, February 20
Last Quarter:	October 2, November 1, December 1, December 31, January 30

The illuminated part of the Moon is always given for 0^h UT on the date indicated.

2. The Taurid meteor complex

1988 will enable Northern and Southern hemisphere observers to watch the Taurid meteor stream during a period without moonlight. The hourly rates will not be spectacular at all, but each year some impressive Taurid fireballs are reported. The Southern Taurid radiant is expected to produce a weak maximum on November 3. The Moon will hamper only during the last hours of the night. The best nights for the northern branch of the Taurids will be November 12 and 13, when these slow moving meteors will radiate from near the Pleiades. Read about this stream in the Handbook Visual Meteor Observations, published and distributed by IMO.

3. The Leonid meteor stream

Eleven years from now this shower will become the most thrilling meteor event as it may repeat spectacular rates such as seen in 1833, 1866 and 1966. Also the years before 1999 are expected to be very rich Leonid years; 1997 and 1998 will be good anyway. If you have read the IMO Visual Handbook (everybody by now has a copy we hope, order your copy now if you do not have one!), you will be impressed by the historical record of the Leonids. Observations were available from 1955 till 1987 *without* interruption! We are well on the way to monitor the Leonids further without one year of disillusion until the next strong return. In 1988 the best Leonid rates may be expected during the night of November 17–18. The Moon will then be past First Quarter and hamper observing at least until midnight. However there is no reason to observe the shower then. Start your Leonid watch well after 1^h local time and go on until the morning. You will see the Leonid radiant rising in the sky and the number of Leonids increasing accordingly until the final observing hour, which will be the most favorable.

4. The Geminid meteor stream

New Moon on December 9 means perfect nights moonwise for the richest meteor shower currently active, the Geminids. The maximum is predicted for December 13, 1988 around $18^{h}.2$ UT. Observers in the Soviet Union may have the best location provided the temperatures allow any observing at all! The Handbook mentions the first Geminids to appear from about December 4 onwards. However rates are very low and we can rather say that only some Geminid-like meteors can already be reported. A notable Geminid activity starts around December 7 and becomes very rich from December 12 onwards. The top three for the Geminid nights are December 13–14, the maixmum, December 12–13 with very good rates and December 14–15 with a very rapidly decreasing Geminid activity. Very high rates were reported during a period of 5 hours before and after the maximum. For Europe the best display is awaited during the first part of the night, unfortunately with the radiant low near the horizon. The decrease in shower activity past maximum will be counterbalanced by the rising radiant position. After midnight and after the culmination of the radiant, rates will decrease rapidly as the Earth enters less dense areas in the Geminid stream while the radiant elevation decreases. American observers have "bad luck" being in night hours several hours before maximum and after the maximum .Japanese and Australian observer will be probably the only observers who are able to observe the best Geminid display of 1988.

5. Some less popular meteor showers

Gary Kronk mentions several other showers for this period in [1]. The first one are the Andromedids, almost non-existent today but assumed to produce still some meteors on November 14 from a radiant at $\alpha = 26°$ and $\delta = +37°$.

On November 21 ($\lambda_{\odot} = 238°.7$), the November Monocerotids may show some activity. However these meteors were reported in 1925, 1935 and 1985 only, so that we have to deal with a very narrow annual shower or with a periodic shower, not showing any activity in intermediate years. We suggest observers to use radio equipment as the moon will disturb too much in 1988 for visual observers.

Last year, observers in France reported a notable activity from a radiant in Coma Berenicis. According to Kronk this shower would be active from December 8 onwards; the best rates, however, would be seen between December 20 and 29 from a radiant at $\alpha = 165°$ and $\delta = +30°$. The Coma Berenicids' radiant moves from Leo Minor between December 12 and 17 to Coma Berenices in January.

Between December 4 and 15 with a maximum on December 11 , meteors will be seen radiating from near σ Hydri. The radiant position is $\alpha = 127°$ and $\delta = +2°$.The velocity of the σ-Hydrids is comparable to that of the Perseids.

During your Geminid observations you will see from time to time meteors that radiate from $\alpha = 101°$ and $\delta = +10°$, faster than the Geminids and comparable in speed to the δ-Aquarids in July. This shower is called the December Monocerotids which have no link with the November Monocerotids [2].

χ-Orionids can be seen from November 16 until December 16. There are two distinct radiant centers: $\alpha = 82°$, $\delta = +23°$ and an other on at $\alpha = 88°$, $\delta = +20°$. Both show a maximum on December 10. Southern observers should pay much attention to the Phoenicids between December 2 and 7 while northern observers may forget the Ursids visually due to the moonlight. However, radio observations should be conducted to monitor this shower in case there would be another sharp outburst such as seen in 1986.

6. Conclusions

The call to observers that you read on these pages was written in order to draw your attention to the observing circumstances for some showers. It is up to you now to decide how much time you are going to spend on the observing program. Whatever you plan , always provide yourself with a good preparation. Consult your literature, read the instructions, and remember that you need to be very careful when you identify a meteor as a shower member. Your reports are welcome for the various databases of IMO results from these joined efforts will be published in combined reports as soon as most reports are received from everywhere around the world. Meanwhile we invite you for a fast reporting of your results in an informal manuscript for immediate publication in WGN. *Good luck!*

References

[1] Kronk G.W., "Meteor Showers , a Descriptive Catalogue", Enslow Publisher, Hillside, NJ, 1988, pp. 211–271.

[2] Lindblad B.A., "Comet 1944 I and the November Monocerotids", *WGN* 15:5, 1987, pp. 154.

Astro-Mail and IMO

Christian Steyaert

The possibilities for using bulletin boards in connection with meteor work are discussed.

1. Introduction

In "visiting" various astronomy related bulletin board systems (BBS) around the world, I finally came across a European one: *Astro-Mail* (AM) in the north of the Federal Republic of Germany. The phone number was provided by Frank Thielen, who visited Belgium and gave a lecture during last year's VVS annual amateur meeting.

A bulletin board can be accessed by means of a personal computer of any brand, which can be equipped with a modem.

From the first contact, it was clear that some highly capable people are running this BBS. Quickly, I was in contact with Peter Bluhm, the system operator, and Jost Jahn (an IMO member). The latter proposed to create a special section ("Brett") for IMO. The proposal was discussed with the Temporary Administration of IMO, who agreed that any initiative in this field was welcome.

Still before last summer break of AM (August 6–20), a few first bulletins could be loaded. A typical part of a user session is given on the next page.

By the time this article is published, you might already find in AM the Photographic Meteor Database (PMDB), an astrometric star catalogue containing 14 000 stars up to magnitude 7, and some programs for the IBM PC and compatibles.

AM can be used for all kinds of communications regarding IMO:

- observations (photographic, radio and visual) giving to the IMO staff the big advantage of receiving *readable* forms;
- administration (ordering of publications);
- questions regarding IMO or meteor work;
- articles for publication in *WGN*, which will be passed on to the editor-in-chief.

Electronic mail exists side by side with the classical letter mail and gets an ever bigger share.

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================================================================================

(Persoenliches Fach) Befehl: BR *
ABBS                          ABBS-Netzsystembrett
ARC                         # ARC Info u. programm
ASTRONOMIE                >>> Weitere Bretter folgen!
BUECHER                       Alles was interessant ist...
HILFE                       # Hilfstexte der Box
IMO-BULLETIN-BOARD            International Meteor Organization
MAILBOX                   >>> Weitere Bretter folgen!
RAUMFAHRT                 >>> Weitere Bretter folgen!
THE-ASTRONOMER              # News from GB
USER                      >>> Weitere Bretter folgen!
WETTERSTUDIO                  Wetterstudio Traben-Trarbach
Z-NETZ                    >>> Weitere Bretter folgen!

(Persoenliches Fach) Befehl: BR IMO

Brett      : /IMO-BULLETIN-BOARD
Betreff    : International Meteor Organization
Vertreter  : CH.STEYAERT

Neue Nachrichten:

Nr. ST kB Typ Kost Datum Absender         Betreff
4       2   T  0.00 01.08 CH.STEYAERT     The 1988 Perseid display
3       2   T  0.0  29.07 J.JAHN          zenithal hourly rate ZHR
2       4   T  0.0  29.07 CH.STEYAERT     Contents WGN Feb - Apr - Jun 88
1       3   T  0.0  28.07 CH.STEYAERT     Introducing IMO

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2. The Future — a personal view

Gradually, more and more BBS are set up in various countries. They are already linked, and in future, the need for doing so will still grow. With the gradual breaking-up of the national mail-, phone-, and cable-companies, and the unified European market of 1992 ahead of us, there is a great future for AM and its program *Zerberus*.

Most alarming (e.g. fireball observations, potential stream associations with new comets, ...) is now already being distributed by electronic means.

In full development at the moment is the efficient storing and presentation of *image files*: it will also become possible to transmit scanned photographs and maps.

For more information about *Astro-Mail*, contact *Peter Bluhm, Ginsterweg 7, D-2121 Dahlenburg, FRG*. The AM phone mumber (1200 or 300 baud modem) is (49)58517896, between 19^h and 6^h, weekends 24 hours.

Do not forget to renew your WGN subscription and/or IMO membership! More information can be found on p. 143 of this issue of WGN.

Number Density in Meteor Streams

Ralf Koschack and Jürgen Rendtel

First, the spatial number density of particles causing meteoroids of magnitude 6.5 or brighter is computed from the observed ZHR of a shower. It is then observed that the brightness of a meteor does not only depend on the particle's mass but also on its geocentric velocity. Reducing the previously obtained quantity for the geocentric velocity yields the spatial number density of meteoroids with a mass $M \geq M_0$. The latter density allows to compare streams with different geocentric velocity; as an example, the α-Capricornids and the Perseids are compared.

1. Introduction

We all know a lot about meteor showers. Often, we divide them in *major* and *minor* showers, according to the hourly number of meteors we observe. Such a criterion however is very arbitrary; e.g. for an observer at average northern latitudes, the Orionids will surely be called a major shower whereas the η-Aquqarids will be missed almost entirely. Computing a ZHR obviously leads to a good solution for this problem. Observations carried out under different circumstances then become comparable. In particular this concerns:

- comparison of data from one shower at different times (ZHR profile); and
- comparison of data from different showers.

Furthermore, we as well as other groups analyze magnitude data and derive the population index r. To some extent, the population index gives information about the particle size distribution. The analysis can also reveal:

- temporal variations of r within one shower; or
- a certain r-value being characteristic for some shower.

Obviously, a shower is well characterized if both these features are known.

Looking at commonly used lists of meteor showers, we often find ecliptical showers with low ZHRs[1]. Meteoroids of ecliptical showers enter the Earth's atmosphere at rather low velocities (25–30 km/s). Although the theoretical lower bound for the geocentric velocity is about 11 km/s, we rarely see such meteors. The reason for this can be found in the way energy is transformed from kinetic energy into emission of radiation. According to e.g. [1,2,3], the absolute magnitude m of a meteor is a function of at least its geocentric velocity v and the initial entering mass M:

$$m = m(v, M, \ldots) \tag{1}$$

The lower the geocentric velocity of a given meteoroid is, the fainter the meteor it causes. In other words, for producing the same magnitude distribution, a shower with a low geocentric velocity has to contain a significantly larger number of heavier particles. Therefore, the ZHR underestimates the activity of showers with low geocentric velocities. In order to get a comparable measure for the dimensions and particle population of a stream, it is necessary to calculate the true spatial number density.

This article gives some basic ideas for the calculation of the number density of meteor streams. Finally, we illustrate the importance of such calculations by the 1986 July-August observations of the α-Capricornids and the Perseids.

2. Density of particles causing meteors of 6.5 and brighter

In an earlier article [4], we calculated the probabilities of perception $p(m)$ of meteors within a field with a radius of 52°5 from extensive double-count observations. Using the values of

[1] We exclude the Geminids from further conclusions, since this shower seems to be an exception in several ways.

$p(m)$, we can transform the observed ZHR_o into a true ZHR_t taking into account the real number of meteors of all magnitude classes up to the limiting magnitude:

$$ZHR_t = ZHR_o \times c(r) \tag{2}$$

This is the true number of meteors appearing within the field with a radius of 52°5. Herein, $c(r)$ is a correction depending on the population index r. The ratio of the cumulative true number φ of meteors with magnitude $m \leq 6.5$. (6.5 or brighter) to the cumulative observed number n with $m \leq 6.5$ is:

$$c(r) = \frac{\varphi}{n} \tag{3}$$

φ and n have to be calculated for all magnitude classes and then be summarized over the whole magnitude range:

$$c(r) = \frac{\sum \left(r^m - r^{m-dm}\right)}{\sum \left(r^m - r^{m-dm}\right) \times p(m)} \tag{4}$$

We calculated $c(r)$ for values $1.4 \leq r \leq 4.0$ and $-0.4 \leq m \leq 6.4$, with $dm = 0.2$. The results are given in Table 1.

Table 1 — Correction factors $c(r)$ for calculation of the true ZHR

r	$c(r)$	r	$c(r)$	r	$c(r)$	r	$c(r)$	r	$c(r)$
1.5	9.18	2.0	19.8	2.5	34.1	3.0	49.8	3.5	65.5
1.6	10.9	2.1	22.4	2.6	37.2	3.1	53.0	3.6	68.5
1.7	12.9	2.2	25.2	2.7	40.3	3.2	56.2	3.7	71.5
1.8	15.0	2.3	28.1	2.8	43.5	3.3	59.3	3.8	74.5
1.9	17.3	2.4	31.0	2.9	46.7	3.4	62.4	3.9	77.4
								4.0	80.2

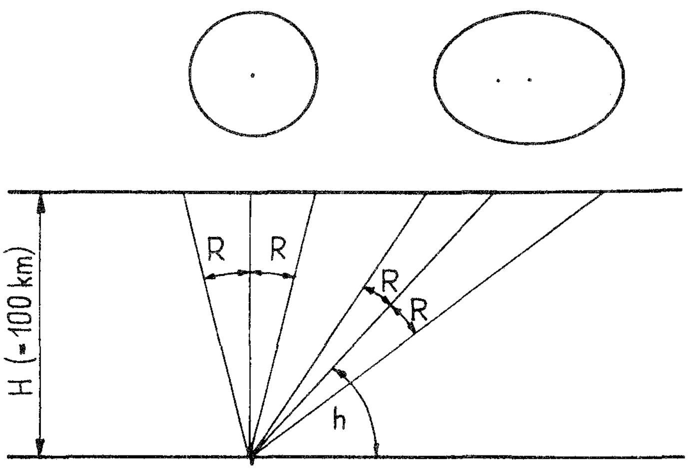

Figure 1 — Calculation of the number density

According to Figure 1, we find the number density of meteors with $m \leq 6.5$ (designated as $\varrho_{6.5}$) to be:

$$\varrho_{6.5} = ZHR_o \times c(r) \times \frac{r^{5 \log\left(\frac{H}{100\ \text{km}}\right)}}{\pi \times \text{tg}^2\, 52°5 \times H^2 \times v \times 3600\ \text{s}} \tag{5}$$

if the height of the luminous path is H and the observer looks in zenithal direction.

The volume looked through increases as the observing direction deviates from the zenith. Due to the increasing distance between the observer and the meteor, the observable brightness decreases. Additionally, the amount of extinction is increasing. A precise calculation of all factors is rather difficult and depends on the actual situation [5]. For group observations with observers looking into different directions, we did not find any systematic differences between the ZHRs they obtained and the ZHR of an individual zenith observer.

Moreover, for practical reasons we recommend an elevation of at least 50° for the center of the field of view. Therefore, we take the formulae valid for zenithal observations as a general basis.

Any deviation in the height H of the luminous path from $H_0 = 100$ km causes a change in the derived density $\varrho_{6.5}$ according to (5). We summarize the effect in the quantity d and write:

$$\varrho_{6.5} = \mathrm{ZHR}_o \times c(r) \times d \times \frac{1}{\pi \times \mathrm{tg}^2\, 52.^\circ5 \times 10^4\ \mathrm{km}^2 \times v \times 3600\ \mathrm{s}} \tag{6}$$

with:

$$d = \frac{r^{5\log\left(\frac{H}{H_0}\right)} \times 10^4\ \mathrm{km}^2}{H^2} \tag{6'}$$

The values of d are given in Table 2 for $H = 90$ km and $H = 110$ km, and for $2.0 \leq r \leq 3.5$.

Table 2 — Effect of the height H of the luminous path of a meteor on the density $\varrho_{6.5}$ according to (6')

r	$H = 90$ km	$H = 110$ km
2.0	$d = 1.05$	$d = 0.95$
2.5	$d = 1.00$	$d = 1.00$
3.0	$d = 0.96$	$d = 1.04$
3.5	$d = 0.93$	$d = 1.07$

As one can see, the variations with respect to $H_0 = 100$ km are small (maximally 7%, or, in the most common range $2.5 \leq r \leq 3.0$, only 4%). Because of the uncertainties in the values of ZHR_o, $p(m)$ and H, we use $H = 100$ km as a constant. Equation (6) for the number density of meteoroids causing meteors of at least magnitude 6.5 then becomes:

$$\varrho_{6.5} = \frac{\mathrm{ZHR}_o \times c(r)}{v} \times 0.521 \times 10^{-8}\ \mathrm{km}^2\mathrm{s} \tag{7}$$

with v in km/s and $\varrho_{6.5}$ in particles per cubic kilometer.

3. Comparison between different streams

As mentioned before, the brightness of a meteoroid depends on its entering velocity into the Earth's atmosphere. Hence, even if we assume that two streams have the same particle size distribution, we will in general still observe different magnitude distributions. Streams having a lower geocentric velocity are thus more difficult to observe, or are even suppressed under a detectable level. It seems necessary to reduce $\varrho_{6.5}$ to a "standard velocity" v_0 as well.

In general, the light intensity I of a meteor depends on its entering mass M and its geocentric velocity v:

$$\begin{aligned} I &\propto M^b \\ I &\propto v^a \end{aligned} \tag{8}$$

Now consider a given intensity I (e.g. the intensity of a meteor corresponding to a magnitude $m = 6.5$). We derive:

$$M^b \propto v^{-a} \tag{9}$$

If we consider two meteors, (9) can be written as:

$$\left(\frac{M_1}{M_2}\right)^b = \left(\frac{v_1}{v_2}\right)^{-a}$$

or, in logarithmic form:

$$b \log \frac{M_1}{M_2} = -a \log \frac{v_1}{v_2}$$

which leads to the equation:

$$r^{-2.5b \log \frac{M_1}{M_2}} = r^{2.5a \log \frac{v_1}{v_2}} \tag{10}$$

for I and m constant.

For meteors of one shower we have, according to equation (8):

$$\left(\frac{M_1}{M_2}\right)^b = \frac{I_1}{I_2}$$

Using the well-known relation:

$$-2.5 \log \frac{I_1}{I_2} = m_1 - m_2 \tag{11}$$

we obtain:

$$-2.5b \log \frac{M_1}{M_2} = m_1 - m_2$$

or:

$$r^{-2.5b \log \frac{M_1}{M_2}} = r^{m_1 - m_2}$$

According to the definition of the population index, we have the following relation for the true numbers of meteors φ:

$$\frac{\varphi_1}{\varphi_2} = r^{m_1 - m_2}$$

This leads to the equation:

$$r^{-2.5b \log \frac{M_1}{M_2}} = \frac{\varphi_1}{\varphi_2} \tag{12}$$

Equation (12) describes the mass distribution of the particles of a stream with some geocentric velocity v. Since we assumed I to be constant, a change in v merely implies another M in order to get the same I. The ratio φ_1/φ_2 will still be described by (12), because r remains unchanged. Thus we may equate (10) and (12) yielding:

$$\frac{\varphi_1}{\varphi_2} = \frac{\varrho^1_{6.5}}{\varrho^2_{6.5}} = r^{2.5a \log \frac{v_1}{v_2}} \tag{13}$$

Hence a spatial number density $\varrho^0_{6.5}$ reduced to the standard geocentric velocity v_0 has to be calculated according to:

$$\varrho^0_{6.5} = \varrho_{6.5} \times r^{2.5a \log \frac{v_0}{v}} \tag{14}$$

4. Density of particles with masses larger than 0.00025 gram

According to Verniani [2] and Hughes [3], the absolute magnitude m of a meteor depends on the mass M of the entering body and its preatmospheric velocity:

$$m = 40 - 2.5 \log \left(7.7 \times 10^{-15} \times M^{0.92} \times v^{3.91}\right) \tag{15}$$

with M in grams v in km/s. The exponents introduced in equation (8) are therefore equal to $a = 3.91$ and $b = 0.92$.

Alternatively, equation (15) can be written as:

$$M = 10^{27.30-0.435m} \times v^{-4.25} \tag{16}$$

A meteor with an absolute magnitude $m = 6.5$ can be caused by particles of different masses M, depending on their geocentric velocities v, as is shown in Table 3.

Table 3 — Mass M of a meteoroid causing a meteor of $m = 6.5$, given as a multiple of 10^{-4} gram, in function of the geocentric velocity v, given in km/s.

v	20	25	30	35	40	50	60	70
M	49.3	19.1	8.81	4.57	2.59	1.00	0.463	0.240

From the values given their we arbitrarily choose the mass $M_0 = 2.5 \times 10^{-4}$ g as a reference. From equation (15) we find the corresponding velocity (reference of standard velocity v_0) for a meteoroid of mass M_0 causing a meteor of magnitude $m = 6.5$ to be:

$$\begin{aligned} v_0 &= 10^{6.432-0.1023m} \times M^{-0.2353} \\ &= 10^{6.432-0.1023\times 6.5} \times 0.00025^{-0.2353} \text{ km/s} \\ &= 40.28 \text{ km/s} \approx 40 \text{ km/s} \end{aligned} \tag{17}$$

Combining (14) and (15) leads to the relation:

$$\varrho_{6.5}^{40} = \varrho_M = \varrho_{6.5} \times r^{9.775 \log \frac{40}{v}} \tag{18}$$

ϱ^{40} is the spatial number density of meteoroids causing meteors of at least $m = 6.5$ at $v_0 = 40$ km/s, which is equivalent to the spatial number density of meteoroids with a mass $M \geq M_0 = 2.5 \times 10^{-4}$ g, while $\varrho_{6.5}$ is the spatial number density of meteoroids causing meteors of at least 6.5 at a geocentric velocity v.

5. Comparison of α-Capricornids and Perseids

We chose these showers to illustrate the importance of the relationships derived above. All observers know both showers to be active at very different levels. Furthermore, ZHR-values for both showers can be calculated from the same observational material, gathered in July and August, thus excluding other possible effects.

Here, we do not give a complete analysis of observational results concerning these showers. We only want to prove the relations derived in the previous section. To this end, we use observational data from experienced observers of the *Arbeitskreis Meteore* from July and August 1986.

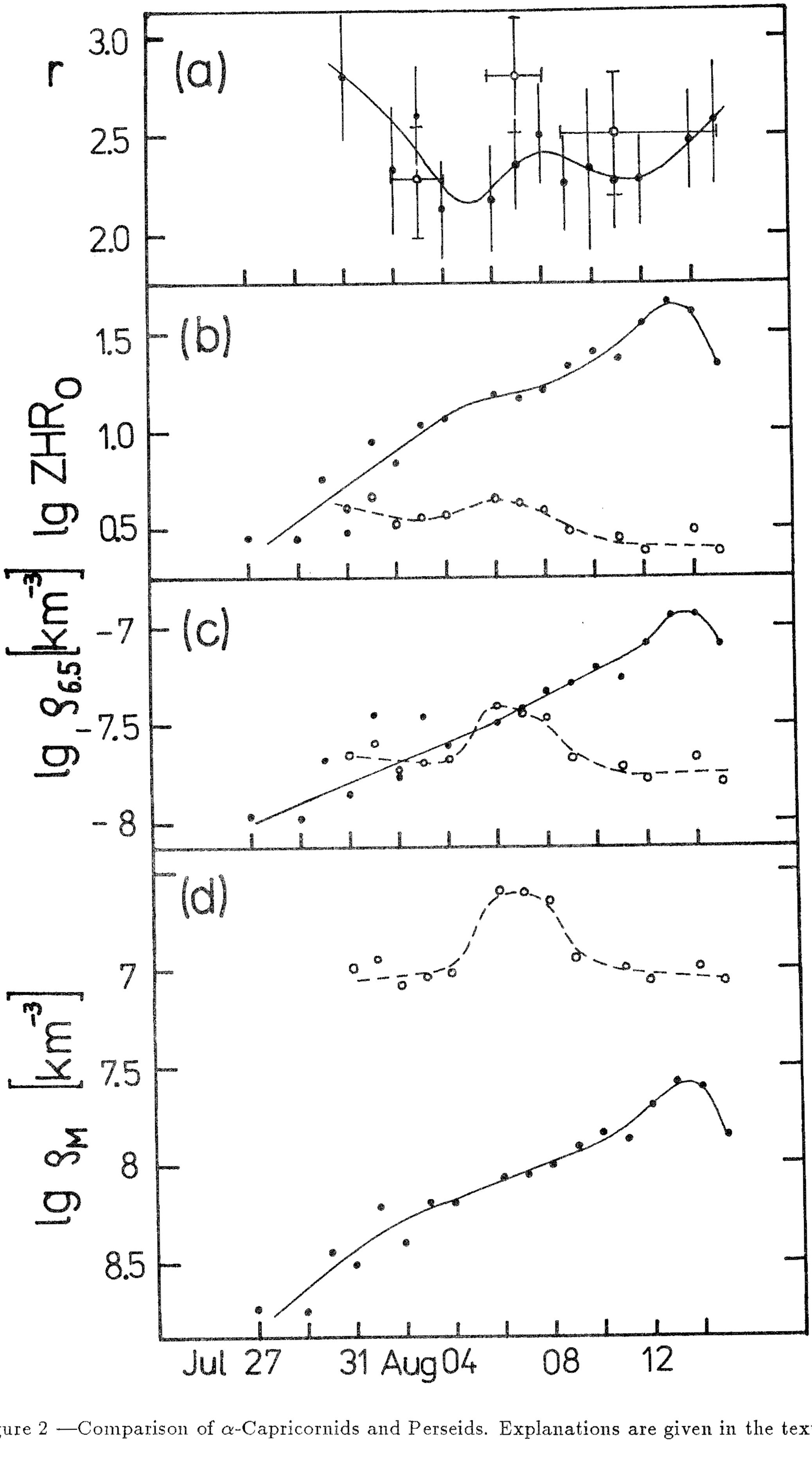

Figure 2 —Comparison of α-Capricornids and Perseids. Explanations are given in the text.

Table 4 — Observational data and derived quantities for the α-Capricornids in 1986. "Int" represents the magnitude range and n the number of shower meteors used to calculate the population index r. The spatial number densities are expressed as the number of particles per 10^9 km^3.

Date	Int	n	r	ZHR	$\varrho_{6.5}$	ϱ_M
Jul 31				4.0 ± 1.6	22	100
Aug 01				4.6 ± 3.3	26	120
02	$-1 - +5$	129	2.30 ± 0.30	3.3 ± 1.0	19	85
03				3.6 ± 2.5	20	93
04				3.7 ± 2.2	21	95
06				4.5 ± 2.6	39	260
07	$-1 - +5$	112	2.80 ± 0.31	4.3 ± 1.8	38	250
08				3.9 ± 1.6	34	220
09				3.1 ± 2.3	21	110
11				2.8 ± 1.1	19	100
12	$-1 - +5$	90	2.49 ± 0.33	2.4 ± 1.0	16	88
14				3.1 ± 0.9	21	110
15				2.4 ± 0.8	16	88

Table 5 — Observational data and derived quantities for the Perseids in 1986. "Int" represents the magnitude range and n the number of shower meteors used to calculate the population index r. The spatial number densities are expressed as the number of particles per 10^9 km^3.

Date	Int	n	r	ZHR	$\varrho_{6.5}$	ϱ_M
Jul 27				2.9 ± 2.6	11	1.9
29			2.8	2.8	11	1.8
30				5.6	21	3.6
31	$-1 - +5$	64	2.80 ± 0.37	3.8 ± 1.3	14	2.4
Aug 01				9.4 ± 0.2	35	6.0
02	$-1 - +5$	75	2.33 ± 0.34	6.8 ± 1.5	17	4.0
03	$0 - +5$	250	2.60 ± 0.26	10.7 ± 3.7	34	6.7
04	$-1 - +5$	317	2.13 ± 0.25	11.7 ± 2.7	24	6.5
06	$-2 - +5$	208	2.17 ± 0.27	15.3 ± 2.9	32	8.5
07	$-2 - +5$	364	2.36 ± 0.24	14.5 ± 2.5	38	8.6
08	$-2 - +5$	245	2.50 ± 0.26	15.9 ± 2.1	47	9.7
09	$0 - +5$	399	2.27 ± 0.24	21.6 ± 4.3	51	12
10	$0 - +5$	54	2.33 ± 0.39	24.5 ± 8.1	62	14
11	$0 - +5$	242	2.28 ± 0.26	22.9 ± 3.7	54	13
12	$-2 - +5$	426	2.27 ± 0.24	34.9 ± 4.4	82	20
13			2.3	46	112	27
14	$-1 - +5$	395	2.48 ± 0.25	40.1 ± 3.9	115	24
15	$-1 - +5$	136	2.79 ± 0.30	21.3 ± 0.9	80	14

As ZHR-values we took into account the average of the ZHR-values of the individual observers and calculated the standard deviation. During the observations different methods, such as plotting and counting, were used, depending on the number of observable meteors. The zenith correction includes zenith attraction of the radiant. We calculated the population index according to [6]. Meteor data obtained under almost identical limiting magnitudes were taken together. Also, because of the uncertainties in the probabilities of perception for the faintest meteors, only meteors of magnitude 5.0 or brighter were considered. In the case of the α-Capricornids, it was necessary to combine data of some consecutive nights in order to obtain a sufficiently large sample.

Tables 4 and 5 give all the observational data as well as derived quantities. Figure 2a shows the variation of the population index r according to our data. The calculated ZHRs are plotted in Figure 2b and confirm the commonly known profiles for the α-Capricornids and the Perseids.

The calculation of the spatial number density $\varrho_{6.5}$ for the meteors of 6.5 and brighter was done according to (7), using the values $c(r)$ given in Table 1 and the population indices r obtained from our observations (Tables 4 and 5). The result, visualized in Figure 2c, is remarkable. The α-Capricornid maximum is very distinct, whereas the maximum in the ZHR-profile (Figure 2b) is rather unpronounced. This is explained by the fact that the α-Capricornid maximum coincides with an increase of the population index. A larger r-value implies a larger number of faint meteors and hence a larger fraction of meteors remaining invisible.

From this example, we must conclude that the ZHR-profile is no measure for the true number density of meteoroids in a stream. $\varrho_{6.5}$ on the other hand does seem to be a suitable measure for variations in the number density of meteoroids in a shower. Moreover, $\varrho_{6.5}$ is computed using a minimum of corrections only.

In order to compare two different showers, it is essential to consider the same mass interval for the particles of both streams. In other words: the velocity of the meteoroids has to be taken into account. Calculating ϱ_M according to (18) leads to Figure 4d. This quantity allows to compare streams directly. In our example, the number density of the α-Capricornids exceeds that of the Perseids by a factor 10. Because of some uncertainties in the mass-magnitude relation and because of probable influences from the physical properties of the meteoroid material (mass density, consistence), we recommend ϱ_M only as a rough measure.

Anyhow, the so-called *"minor" showers* (mostly ecliptical and with low geocentric velocities) deserve as much attention as the *"major" showers* (often cometary and with higher geocentric velocities). Obviously, the Geminids are a case apart. Assuming an observed ZHR of 100, a geocentric velocity of 33 km/s and a population index of 2.9, one finds $\varrho_M = 1760 \times 10^{-9}$ particles/km^3!

6. Conclusions

The usual distinction between "major" and "minor" showers refers to the apparent impression on the observer. The true spatial number density demonstrates the importance of the so-called "minor" showers. Of course, there are practical limits to the observability of such showers. The radiant has to be determinable and has to "produce" at least a certain number of meteors in order to obtain a sufficiently large sample from which results can be derived that are statistically relevant. Essential to this end is the careful shower association taking into account all available data (direction, length of trail, angular velocity). Countings often turn out to be inaccurate with regard to minor showers.

In order to obtain a reliable spatial number density, it is of the greatest importance to use the correct r-value. In particular, we have to examine whether the variation in the population index found from the observations are real (i.e. caused by a variation in the particle size distribution of the stream) or apparent (i.e. caused by inaccuracies in the method used to calculate r). It has to be noticed that errors in magnitude estimations affect the calculated index r especially in the case of small samples (in particular, those obtained from minor showers). In the future, more and larger samples have to be obtained from minor showers. Also, it will be necessary to combine data from several years in order to obtain a reliable population index profile for the observed shower.

The theoretically best measure ϱ_M for the spatial number density is not ideal because of the uncertainties in the mass-magnitude relationship. Therefore, we recommend the use of $\varrho_{6.5}$ if one is only interested in the profile of one shower. However, ϱ_M is needed if different streams have to be compared. Nevertheless, ZHRs should also be mentioned as initial data, and for comparison with earlier observations. Consequently, the analysis of a shower should include:

- the population index r;
- the observed $\mathrm{ZHR_o}$;
- the most important spatial number density measure $\varrho_{6.5}$; and
- the true number density ϱ_M for comparison with other showers.

References

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[2] Verniani F., *Journal of Geophysical Research* 78, 1973.

[3] Hughes D.W., *Astronomy and Astrophysics* 187, 1987.

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[6] Steyaert C., "Populatie-index bepaling", *Technische nota 5*, 1981.

Erratum

Ralf Koschack

For the article "On the Determination of the Probability of Perception for Visual Meteors" in *WGN* 16:3, June 1988, pp. 77–84, the author forgot to submit a table in his manuscript. As a consequence, Table 4 on p. 83 should have been named Table 5. Table 4, which is referred to in the text, is shown below.

Table 4 — Probabilities of perception p of meteors in function of Δm and R. E.g.: $\Delta M = 3.0$ and $R = 20°$ gives $p = 0.380$.

	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0
05°	0.058	0.089	0.135	0.205	0.340	0.525	0.775	0.955	1.00	1.00	1.00	1.00
10°	0.040	0.063	0.107	0.174	0.288	0.435	0.617	0.795	0.89	0.95	0.98	1.00
15°		0.049	0.085	0.145	0.223	0.338	0.490	0.660	0.758	0.87	0.91	0.98
20°		0.034	0.066	0.115	0.178	0.263	0.380	0.525	0.660	0.775	0.87	0.95
25°			0.045	0.079	0.129	0.170	0.275	0.435	0.575	0.708	0.813	0.94
30°				0.032	0.063	0.100	0.182	0.316	0.457	0.602	0.760	0.93
35°					0.020	0.049	0.115	0.223	0.363	0.525	0.677	0.92
40°						0.020	0.060	0.144	0.240	0.372	0.550	0.91
45°								0.048	0.095	0.192	0.380	0.69
50°										0.073	0.190	0.40

Also, there was a typo in the aforementioned article. In (11), a prime was omitted. This equation should read:

$$\log p = \log p' - \Delta a.R + c \tag{11}$$

We apologize to the reader for the inconvenience.

1987 Aquarids

1987 Aquarids in Australia

Jeff Wood

Due to exceptionally good weather and favorable moon, it was possible to carry out an extensive Aquarid watch. Data about the δ- and ι-Aquarids as well minor showers active in the same period are given.

For the first time in several years, the moon and weather were favorable so that an extensive program could be carried out to monitor the δ-Aquarid and other meteor streams occurring during late July and early August. The 1987 δ-Aquarid watch covered 12 days from July 20–21 to August 01–02. Twenty people participated observing for a total of 106 man hours. The observers who took part were as follows:

> Darren Ferdinando, Louise Cockeram, Jeff Wood, Jenny Ball, Chris Beer, Michelle Treasure, Brian Macauley, Craig Hinton, Nicholas Harvey, Martin Coroneos, Michael Keating, Drew Taylor, John Liew, George Platt, Maurice Clark, Andrea Jahn, Darren Anthony, Brian Alexander, Cameron Reis, Andrew Anderson.

During the 1987 δ-Aquarid watch seven streams were monitored for their activity. They are listed in Table 1.

Table 1 — Showers observed during the Australian 1987 δ-Aquarid watch.

Shower	Abb.
δ-Aquarids South	SDA
δ-Aquarids North	NDA
υ-Pegasids	PEG
ι-Aquarids South	SIA
β-Aquarids	BAQ
α-Capricornids	ACP
Piscis Austrinids	PAS

Below are the ZHR data of the streams observed.

Table 2 — ZHR-values obtained during the 1987 δ-Aquarid observations in Australia

Date	Nr. Obs.	SDA	NDA	PEG	SIA	BAQ	ACP	PAS
Jul 20–21	6	4.2 ± 0.9	0.4 ± 0.4		0.6 ± 0.3	0.8 ± 0.4	1.9 ± 0.6	1.1 ± 0.3
21–22	4	5.0 0.2	0.5 0.3	0.4 ± 0.4	0.6 0.1	0.6 0.4	1.3 0.3	1.1 0.3
22–23	7	7.3 1.0	0.5 0.5	0.3 0.5	0.5 0.4	0.6 0.4	1.9 0.6	1.1 0.3
23–24	9	8.8 1.3	1.0 0.4		0.7 0.3	0.8 0.5	1.4 0.5	1.3 0.5
24–25	4	10.6 1.1	0.8 0.5	0.5 0.6	0.9 0.2	1.1 0.1	3.0 0.6	1.3 0.4
25–26	14	13.3 2.8	1.3 1.1	0.1 0.4	1.2 1.2	0.8 0.6	5.0 2.4	1.9 0.8
26–27	6	19.1 1.6	1.5 0.5	0.1 0.3	1.0 0.6	0.9 0.4	2.5 0.6	6.7 1.7
28–29	3	26.9 2.4	1.5 0.1		1.4 0.4	0.7 0.2	3.3 0.2	1.8 0.3
29–30	4	21.2 3.0	1.3 0.3		1.5 0.5	0.8 0.5	3.0 0.5	1.7 0.4
30–31	4	16.2 2.2	0.9 0.2		1.6 0.4	0.4 0.5	8.9 0.4	1.0 0.1
31–32	5	10.3 0.3	0.6 0.6		1.6 0.3	0.3 0.3	2.3 0.5	1.3 0.7
Aug 01–02	3	8.6 ± 0.9	0.6 ± 0.5	0.3 ± 0.4	1.9 ± 0.1	0.7 ± 0.5	2.0 ± 0.4	0.5 ± 0.4

The night of maximum for the δ-Aquarids was July 27–28, for the Piscis Austrinids July 26–27 and for the α-Capricornids July 25–26 and July 30–31. With all other meteor streams it was impossible to determine a date of maximum with the given data.

The magnitude distributions are given in Table 3.

Table 3 — Magnitude distributions obtained during the 1987 δ-Aquarid observations in Australia

Shower	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot	$\overline{m}$
SDA	0	0	0	1	5	14	54	149	331	382	212	48	1196	3.52
NDA	0	0	0	0	1	0	3	14	25	29	12	4	88	3.47
PEG	0	0	0	0	0	0	0	0	3	5	2	0	10	3.90
SIA	0	0	0	0	0	2	7	16	34	35	14	3	111	3.32
BAQ	0	0	0	0	0	0	2	10	24	25	9	0	70	3.41
ACP	1	1	5	6	10	17	41	53	59	51	22	8	274	2.34
PAS	0	0	0	0	2	5	12	32	58	47	24	7	187	3.20

The color distributions are given in Table 4.

Table 4 — Color distributions obtained during the 1987 δ-Aquarid observations in Australia

Color	SDA	NDA	PEG	SIA	BAQ	ACP	PAS
Red		5.5%				1.5%	
Orange	0.9%			4.3%		7.5%	
Yellow	18.4%	22.2%		39.1%	16.7%	35.8%	12.2%
Green	0.9%			4.3%		0.7%	
Blue	4.0%	5.5%				3.7%	6.1%
White	75.8%	66.8%	100.0%	52.3%	83.3%	50.8%	81.7%

Finally, in Table 5, the percentages of meteors having shown a train and the population indices as calculated from the observations, are given.

Table 5 — Train percentages and population indices obtained during the 1987 δ-Aquarid observations in Australia. "Int" represents the magnitude range used to compute the population index r.

Shower	Trains	Int	r
SDA	4.1%	$-1-+5$	3.60
NDA	3.4%		
PEG	0.0%		
SIA	3.6%	$0-+5$	3.25
BAQ	2.9%		
ACP	6.2%	$-4-+5$	2.14
PAS	8.6%	$-1-+5$	3.00

Call for Observational Results

Paul Roggemans

Mike Morrow communicated the request from Ruthi Moore to send to her address any remaining data that *WGN* readers may have on the η-Aquarids or Orionids for 1987 and 1988. Her address is: *Ruthi Moore, 3111 McGeorge Terrace, Alexandria, Virginia 22309, USA.*

An Analysis of the 1987 Aquarids

Glenn Ticket

This article deals with the results obtained from visual observations made between July 18 and August 5. Observations of Australian, European and American observers were used. In total, 29 observers gathered over 400 hours of effective observing time. The Aquarid shower was the main shower of interest (ι- and *delta*-Aquarid shower, North and South). α-Capricornids and Perseids were also observed.

The observers whose observations were used in this article are spread over three continents. They can be divided into four groups. The Australian group (AUS), which is led by Jeff Wood, counts 8 observers who watched 86 hours. The East German group (GDR), led by Jürgen Rendtel, has 5 observers who totalized 57 hours of effective observing time. The Haute Provence group (HP), led by Paul Roggemans, counts 5 observers who were able to observe 195 hours. The American group (AM) consists of 11 observers who monitored the skies during 85 hours. This "group" is composed of totally independent observers. The raw hourly rate data of 9 of them were taken from [1].

In Table 1, one can find the names of the observers, their number of observing nights, their effective observing time and to which group they belong.

Table 1 — Data about the observers considered in this 1987 Aquarid analysis.

Observer	Init.	Nr	T_{eff}	Group	Observer	Init.	Nr	T_{eff}	Group
Rainer Arlt	RA	5	10.2	GDR	Paul Martsching	PM	4	19.0	AM
Peter Brown	PB	11	45.4	HP	Michael Morrow	MM	5	9.5	AM
Maurice Clark	MC	1	2.0	AUS	Ina Rendtel	IR	8	14.0	GDR
Louise Cockeram	LC	2	3.0	AUS	Jürgen Rendtel	JR	9	23.7	GR
Phyllis Eide	PE	1	4.7	AM	Paul Roggemans	PR	12	52.0	HP
Darren Ferdinando	DF	8	22.0	AUS	Ann Schroyens	AS	1	3.8	HP
Nicholas Harvey	NH	3	5.0	AUS	Karl Simmons	KS	1	3.0	AM
Craig Hinton	CH	1	2.0	AUS	Wanda Simmons	WS	1	3.0	AM
Gregory Jones	GJ	3	8.0	AM	David Swann	DS	3	6.0	AM
André Knöfel	AK	2	5.0	GDR	Richard Sweetsir	RS	1	3.0	AM
Bernhand Koch	BK	5	6.0	AM	Richard Taibi	RT	1	3.0	AM
Ralf Koschack	RK	2	3.9	GDR	Glenn Ticket	GT	12	53.2	HP
Dirk Laurent	DL	10	41.3	HP	Michelle Treasure	MT	2	5.0	AUS
Robert Lunsford	RL	6	17.5	AM	Jeff Wood	JW	12	36.0	AUS
Brian Macauley	BM	6	11.0	AUS					

Most nights in July were very well covered. The nights in August were not so well covered. But not a single night was lost. There was always somebody who was observing. This allows us to get a good picture of the day by day variations in the different showers.

A first characteristic which might change in a shower is the population index r. To be able to investigate the day by day variations of r we need to have a magnitude distribution per shower per night. This was only provided by the HP group. The GDR group did this for the Perseid shower only. The AUS group gave one magnitude distribution per shower for the entire period (not for the sporadics). The AM group gave no magnitude data. The perception coefficients determined by H.J. Bekker [2] were used to obtain the real number of meteors per magnitude class. Then the cumulative distribution was made and the logarithmic values were calculated. Then r can be calculated using linear regression [3].

In Table 2, the r-values of the Aquarid showers and the α-Capricornids are given, as well as the average magnitude and the number of meteors on which the information is based. As one can see, there is a large variation in the values. In Table 3, the same information is given for the Perseids and the sporadics. All these data were obtained from the HP observations.

They will be discussed in detail in a later issue of *WGN*. From Tables 2 and 3 it is clear that the α-Capricornids have an r-value which is considerably lower than the r-values of the other showers.

Table 2 — Population index and average magnitude for the Aquarid showers and the α-Capricornids in 1987.

Date	Aquarids			α-Capricornids		
	N	r	$\overline{m}$	N	r	$\overline{m}$
Jul 19–20	15	2.88	3.43	21	2.39	2.84
20–21	19	2.99	2.91	28	2.28	2.86
21–22	39	4.08	3.71	40	2.49	2.88
23–24	38	3.07	3.48	32	2.58	3.27
24–25	55	3.75	3.73	36	2.70	3.27
25–26	50	2.77	3.05	22	1.95	2.11
26–27	101	4.48	3.91	50	2.88	3.19
27–28	162	3.89	3.59	49	2.88	3.20
28–29	213	3.19	3.64	47	2.21	2.67
29–30	33	3.13	3.41			
30–31	138	3.21	3.57	56	2.19	2.57

Table 3 — Population index and average magnitude for the 1987 early Perseids and the sporadic background.

Date	Perseids			Sporadics		
	N	r	$\overline{m}$	N	r	$\overline{m}$
Jul 18–19				44	3.46	3.37
19–20				137	3.96	3.75
20–21	33	4.86	4.08	121	3.50	3.65
21–22	55	3.93	3.89	192	4.03	3.92
23–24	61	2.67	3.33	122	3.00	3.74
24–25	65	3.30	3.62	206	3.91	3.78
25–26	58	2.83	3.32	105	4.10	3.76
26–27	89	3.93	3.78	271	3.40	3.83
27–28	114	3.85	3.28	236	3.65	3.54
28–29	127	3.49	3.57	341	3.16	3.49
29–30				74	3.71	3.81
30–31	61	3.55	3.69	154	4.19	3.74

In Table 4, the population index is given for each shower, determined from one magnitude distribution containing all magnitude data from the entire period. The AUS group considered the several Aquarid branches separately [4]. The magnitude data of these branches were added together to form one magnitude distribution, which would allow comparison with the other groups who did not distinguish between several branches.

Table 4 — Average population indices for the 1987 Aquarids, α-Capricornids, Perseids and the sporadic background.

Shower	AUS			GDR			HP		
	N	r	$\overline{m}$	N	r	$\overline{m}$	N	r	$\overline{m}$
Aqr	1465	3.69	3.50	230	2.81	3.54	870	3.60	3.62
Cap	274	2.14	2.34	158	2.58	3.27	394	2.52	2.93
Per				210	2.80	3.40	693	3.62	3.61
Spor				445	2.99	4.19	2003	3.60	3.71

From Table 4 it is clear that the AUS and HP group agree rather well when it comes to the r-value of the Aquarids. The GDR group obtained a value which is a lot lower. But when one looks at the average magnitude one sees that all the groups obtain a comparable value. Why then is the r-value so different? The GDR group saw a lot of magnitude 5 and 6 meteors. When corrected with the perception coefficients mentioned above, the resulting number was much to high so that the magnitudes 5 and 6 had to be dropped to calculate the r-value. This means that some of these meteors were actually brighter. If we were to bring this in consideration, the r-value would increase. But there would still be a considerable difference with the values of the other groups.

In this period, the δ-Aquarid South shower was the most active of all the Aquarid branches, as can be derived from the AUS observations [4]. The GDR group observed from a rather unfavorable latitude for this branch. Secondly they were not able to observe during the maximum of this branch and they did some observing closer to the maximum of another branch of the Aquarid complex (ι-Aquarids South). Therefore, they proportionally observed more meteors belonging to the other branches than the other groups. These branches are known to have lower r-values [5]. This might perhaps explain the difference. The r-value obtained by the other groups is slightly higher than the literature value of 3.4 [4].

If we look at the r-values for the α-Capricornid shower we see that the GDR and the HP group agree very well. Still, the average magnitude of the GDR group is fainter. Here we can make the same remark: the GDR group saw too many meteors of magnitudes 5 and 6. But this means that their actual r-value is even higher, making the difference with the AUS group still larger. Nevertheless we must consider the AUS value superior to those of the other groups, since their radiant position was the most favorable. Most likely, some sporadics were identified as α-Capricornids by the other groups. This hypothesis is supported by the fact that these groups obtained higher ZHR-values than the AUS group for this shower.

If we consider the Perseid shower, we notice a big difference between the r-values of the GDR group and the HP group. The difference in average magnitude on the other hand is not so large. For the same reason as above, we can say that the r-value of the GDR group is probably a bit to low, but this cannot explain the entire difference. Maybe some sporadics were counted as Perseids by the HP group (there is some indication in the ZHR values that this is the case). The GDR group did some observing in August, while the HP group did not. Most likely the r-value of the Perseid shower is lower in early August than in the second half of July. Since the activity is higher in early August, a considerable fraction of the Perseids seen by the GDR group were recorded during these nights. Thus the r-value was lowered by these "brighter" Perseids. Anyhow, the r-value obtained in the period under consideration is obviously higher than the r-value obtained around the Perseid maximum. This is consistent with the idea that the Earth encounters smaller particles as it enters the outer edges of the stream.

For the sporadic meteors we have yet again a large difference between the r-values of the GDR and the HP group. The average magnitude is very bright for the GDR group. Even if one takes into account the effect described above, it can not sufficiently reduce the average magnitude to a value compatible with a moderate r-value. The r-value of the sporadics has to be rather high. The value obtained by the HP group has to be considered superior to that obtained by the GDR group since it is based on approximately four times as many meteors. Thus we can say that the population index of the sporadic meteors is rather high.

In Table 5, the observational results are summarized. ZHR- and HR-values were calculated using the correction factors determined in [6]. The correction factor for the radiant elevation was calculated assuming that the zenith exponent $\gamma = 1.0$. These correction factors are nearly always used in *WGN* (see e.g. [3]). When the HR is not mentioned in Table 5, this means that the observer failed to provide the limiting magnitude. In these cases, the limiting magnitude was calculated assuming that the HR should be about 10. Hence the ZHR-value is not mentioned only if no meteors of that shower were seen.

Table 5 — Individual ZHR-values of the 1987 Aquarids, α-Capricornids and Perseids and HR-values of the sporadics.

Date	Obs	Aqr	Cap	Per	Spor
Jul 18–19	JR	7.8 ± 4.5	1.3 ± 1.3	3.7 ± 2.1	9.7 ± 2.4
	IR	7.1 4.1	4.8 2.4	1.7 1.2	6.5 1.9
	PR				13.2 3.2
	DL				11.2 3.4
	GT				21.4 5.4
Jul 19–20	JR	9.1 ± 4.6	2.0 ± 1.4	5.9 ± 2.4	6.8 ± 1.8
	IR	14.7 5.6	0.9 0.9	1.8 1.3	11.1 2.1
	PR	7.1 2.9	0.6 0.6	5.1 1.9	10.1 1.7
	DL	7.7 3.5	3.6 1.6	1.6 1.1	10.4 1.9
	GT	1.1 1.1	4.0 1.6	1.3 1.9	16.0 2.3
	PB	5.9 3.4	5.3 1.8	3.1 1.6	9.2 1.8
Jul 20–21	JW	8.2 ± 1.9	2.7 ± 1.1		19.7 ± 2.8
	DF	5.4 1.6	1.4 0.8		17.3 2.6
	BM	6.4 1.7	2.7 1.1		17.7 2.7
	JR	15.5 5.8	4.9 2.4	5.4 ± 2.4	8.2 2.2
	IR	14.9 5.3	4.1 2.1	1.8 1.3	11.0 2.3
	PR	9.0 3.7	8.9 2.6	14.0 3.7	14.9 2.3
	DL	3.7 2.6	8.9 3.2	8.9 3.2	7.4 2.1
	GT	5.3 2.4	3.9 1.5	8.0 2.3	13.8 2.0
	PB	8.7 2.9	4.6 1.7	7.3 2.3	12.4 2.0
Jul 21–22	JW	10.0 ± 2.1	1.8 ± 0.9		15.7 ± 2.5
	CH	7.7 1.9	1.4 0.8		14.4 2.4
	JR	6.9 2.8	6.4 2.2	3.7 ± 1.5	7.5 1.7
	IR	4.6 2.0	5.0 1.8	5.8 1.7	9.5 1.6
	RA	7.0 3.5	2.0 1.4	2.3 1.4	3.8 1.3
	PR	13.7 4.3	6.0 1.7	7.2 1.9	10.4 1.6
	DL	16.2 4.9	5.4 1.7	4.7 1.7	9.1 1.6
	GT	8.6 2.5	6.2 1.7	7.4 1.8	17.1 1.9
	PB	9.1 3.4	3.1 1.5	8.9 3.0	14.4 2.4
Jul 22–23	JW	15.4 ± 2.8	2.5 ± 1.1		29.6 ± 3.6
	DF	8.0 2.0	1.5 0.8		34.0 3.9
	NH	20.9 3.2	4.0 1.4		40.8 4.3
	LC	8.6 2.9	2.5 1.7		18.8 4.1
	JR	12.7 6.3	4.1 2.4	5.2 ± 2.6	7.1 2.2
	IR	5.0 5.0	2.7 2.7	7.1 4.1	6.7 3.0
	DS		2.8 1.6	2.7 1.9	6.3 2.1
Jul 23–24	JW	14.7 ± 1.7	1.8 ± 0.8		33.2 ± 2.3
	DF	11.3 2.3	0.9 0.6		18.9 ± 2.8
	BM	10.9 2.2	1.4 0.8		22.1 3.0
	NH	23.5 4.7	3.6 1.8		30.5 4.9
	MT	8.5 2.8	1.8 1.3		16.1 3.6
	RA	4.4 2.5	1.0 1.0	0.7 ± 0.7	8.3 1.9
	PR	9.6 3.4	4.2 2.1	7.2 1.4	7.9 2.0
	DL	7.1 2.5	3.7 1.6	8.5 2.2	8.1 1.8
	GT	9.9 2.7	4.4 1.7	7.8 2.0	15.4 2.2
	PB	6.5 2.3	6.7 2.1	11.0 2.4	13.3 2.2
	MM	3.9 2.2	1.2 1.2		
Jul 24–25	JW	14.1 ± 2.0	4.0 ± 1.3		33.8 ± 2.8
	DF	9.9 1.8	3.1 1.2		23.3 2.3
	JR	8.4 8.4	6.4 4.5	6.2 ± 4.4	5.9 2.9

Table 5 — continued.

Date	Obs	Aqr		Cap		Per		Spor	
Jul 24–25	IR					7.5 ±	4.3	10.3 ±	3.4
	PR	14.7 ±	3.7	4.3 ±	1.4	2.7	1.1	9.5	1.5
	DL	12.4	3.3	4.6	1.4	5.7	1.6	7.6	1.3
	GT	9.2	2.8	3.2	1.1	7.8	1.8	10.2	1.5
	PB	14.3	3.7	3.2	1.2	8.9	2.0	12.9	1.8
	AS	13.5	4.8	4.0	1.6	4.9	1.9	11.8	2.0
	BK	4.1	1.8	1.6	1.1			9.2	2.7
Jul 25–26	JW	23.9 ±	2.6	6.4 ±	1.3			19.5 ±	2.1
	BM	18.4	2.0	5.3	1.1			19.7	1.9
	MT	10.9	1.8	4.1	1.0			11.6	1.6
	MC	22.4	3.7	2.1	1.5			15.4	2.8
	RA	9.3	3.8	5.6	2.5	5.2	2.0	12.1	2.5
	RK	10.7	3.0	2.4	1.2	5.8	1.5	18.4	2.2
	AK	7.6	2.7	5.4	1.8	2.4	1.0	21.4	2.4
	PR	11.5	3.6	3.5	1.7	9.1	2.2	11.4	5.2
	DL	11.3	3.1	5.9	2.2	8.4	2.1	7.1	1.7
	GT	10.2	2.9	5.0	2.0	7.2	1.9	12.5	2.3
	PB	13.7	3.9	5.5	2.5	7.5	2.3	16.6	3.0
	BK	5.0	1.6	12.6	2.5			9.9	2.2
	GJ	5.8	2.9	1.4	1.4	2.0	1.4	16.5	3.8
Jul 26–27	JW	25.5 ±	2.6	3.7 ±	1.2			35.3 ±	2.7
	DF	16.4	2.1	2.1	0.9			25.9	2.3
	LC	19.1	2.9	2.3	1.0			16.5	2.6
	PR	15.0	3.1	5.4	1.5	10.4 ±	2.0	14.0	1.7
	DL	8.9	2.4	6.1	1.9	11.9	2.7	9.1	1.5
	GT	28.2	4.8	5.4	1.5	9.3	1.9	18.1	1.9
	PB	23.0	4.2	5.9	2.7	6.6	1.6	16.3	1.8
	BK	10.8	4.1	5.6	2.5			4.0	2.0
	RL	15.6	2.8	6.2	1.8	3.7	1.3	15.0	2.2
Jul 27–28	PR	36.2 ±	4.9	3.0 ±	1.1	6.6 ±	1.5	11.5 ±	1.5
	DL	24.4	3.9	3.6	1.3	10.0	1.9	8.4	1.4
	GT	23.1	3.6	7.1	1.6	13.0	2.1	15.7	1.7
	PB	17.9	3.5	6.8	1.8	13.5	2.4	16.2	2.1
	MM	1.7	0.8	1.9	1.0			9.5	1.5
	RL	17.3	2.8	2.2	1.0	3.4	1.2	9.6	1.7
	PE	7.7	2.3	2.8	1.2	0.7	0.7	6.9	1.2
Jul 28–29	JW	48.0 ±	4.5	5.1 ±	1.5			23.4 ±	2.9
	BM	37.1	5.5	3.5	1.7			19.4	3.7
	PR	38.4	4.6	3.5	1.1	9.9 ±	1.8	15.3	1.7
	DL	30.6	4.3	4.6	1.4	11.5	2.0	16.3	1.9
	GT	34.6	4.4	4.5	1.3	10.8	1.9	20.8	2.0
	PB	20.1	3.7	7.4	2.0	12.1	2.3	21.1	2.4
	MM	3.9	1.3	2.1	1.5				
	RL	17.9	2.9	1.1	0.8	1.8	0.8	12.5	1.9
	PM	27.4	3.4	7.5	1.6	6.2	1.4		
	RT	9.7	3.1	1.6	1.2				
	GJ	17.4	4.6			6.0	2.5	18.2	4.0
Jul 29–30	JW	26.5 ±	2.6	4.6 ±	1.3			38.7 ±	2.8
	DF	19.4	2.4	2.6	1.0			25.8	2.7
	PR	19.5	6.2	2.6	1.5	7.0 ±	2.7	10.6	2.2
	GT	14.6	5.2	3.0	1.8	5.9	2.7	15.0	2.9
	PB	27.9	8.8	4.2	2.1	2.4	1.7	14.3	2.9

Table 5 — continued.

Date	Obs	Aqr	Cap	Per	Spor
Jul 29–30	RL	17.4 ± 2.9	2.6 ± 1.2	1.8 ± 0.8	12.5 ± 1.9
	PM	27.4 3.4	7.5 1.6	6.2 1.4	
Jul 30–31	JW	22.4 ± 2.3	11.7 ± 2.0		34.9 ± 2.6
	DF	12.5 1.8	7.4 1.6		22.5 2.1
	JR	11.2 3.0	1.0 0.7	8.7 ± 1.9	6.1 1.3
	IR	24.7 17.4	3.1 3.1	11.8 5.9	5.2 2.6
	PR	42.2 5.6	8.4 1.9	7.3 1.8	10.3 1.6
	GT	33.3 4.9	9.9 2.1	7.8 1.8	15.6 2.0
	PB	29.9 5.4	8.6 2.2	14.4 2.8	14.9 2.2
	BK	10.6 2.7	9.6 2.6		21.3 3.8
	DS	6.5 2.0	3.3 1.4	2.2 1.1	11.5 2.0
	MM	9.7 4.0	2.8 2.0		
	RL	14.3 2.4	0.9 0.6	2.7 0.9	12.0 1.7
	PM	34.6 4.4	10.3 2.1	9.7 2.0	
Jul 31–32	JW	19.6 ± 3.3	3.4 ± 1.4		28.0 ± 3.7
	BM	13.6 3.9	3.3 1.9		17.0 4.0
	NH	30.5 4.1	5.0 1.7		36.5 4.3
	RL	14.5 2.9	2.7 1.3	3.9 ± 1.3	14.0 2.2
	PM	19.8 3.0	5.7 1.4	6.7 1.5	
Aug 01–02	JW	17.0 ± 4.2	3.3 ± 2.3		29.0 ± 5.0
	DF	13.8 3.8	1.2 1.2		24.0 5.0
	BM	13.8 3.8	3.3 2.3		21.0 5.0
	BK	23.8 4.7	5.3 2.2		23.1 4.4
	GJ	10.6 2.6	1.1 0.8		11.7 2.3
Aug 02–03	JR	7.5 ± 2.8	4.1 ± 1.7	8.4 ± 2.0	7.8 ± 1.6
	RA	9.1 3.7	2.3 1.6	9.0 2.5	7.7 2.1
Aug 03–04	DS	8.8 ± 3.1	1.2 ± 1.2	3.6 ± 1.8	8.5 ± 2.6
Aug 04–05	JR	8.6 ± 3.0	3.6 ± 1.6	9.5 ± 2.1	7.5 ± 1.6
	RA	8.6 3.3	5.0 2.0	10.9 2.4	7.8 1.8
	RK	12.2 5.5	8.2 3.7	8.7 3.1	16.2 3.5
	AK	3.7 3.7	5.0 3.5	8.3 3.7	14.9 4.3
	IR			14.8 3.7	21.5 3.6
	RS	7.5 2.4	0.7 0.7	13.4 3.2	11.5 2.6
	WS	6.0 2.1	2.2 1.3	14.9 3.3	7.5 2.1
	KS	6.8 3.9	0.7 0.7	11.1 2.9	7.5 2.1

The data mentioned in Table 5 have been plotted in Figures 1 to 4.

The high sporadic HR for the AUS observers is remarkable. One factor that certainly has to be taken into account is the fact that in this period, it is winter in Australia. This allows observations to be carried out when the sporadic activity reaches its highest daily rates. If one takes a look at the observation of JW from July 29–30, one notices that in the period 16–17^h UT, he sees 32 sporadics, the following hour 35, from 19^{h}30^m until 20^{h}30^m 59, and the next hour even 67 sporadics. Hence the HR in the morning is about twice as high as around midnight (16^h UT in West Australia is about midnight local time). Secondly, NH and JW probably have a very high perception, since they notice considerably more meteors than the other observers during the same period with the same limiting magnitude. Most likely the AUS observers benefit from superior sky conditions compared to the other groups, particularly implying a better limiting magnitude near the the horizon. If these last two comments are correct, they should be taken into account when calculating the ZHR. This has not been done in this report.

In Figures 1 to 4, the ordinary dots represent the data obtained by the individual observers as shown in Table 5 whereas the dots with the error bars represent the average group ZHRs with their average standard deviation as shown in Table 6. Just to the left of the marks for each date, the East German ZHRs can be found; to the left of these are the Australian data. To the right of the East German data are the ZHRs from the group in the Haute-Provence (France); to the right of these, finally, are the American ZHRs. The groups have been positioned according to their geographical longitude so that the times of the observations (in UT) correspond to local midnight.

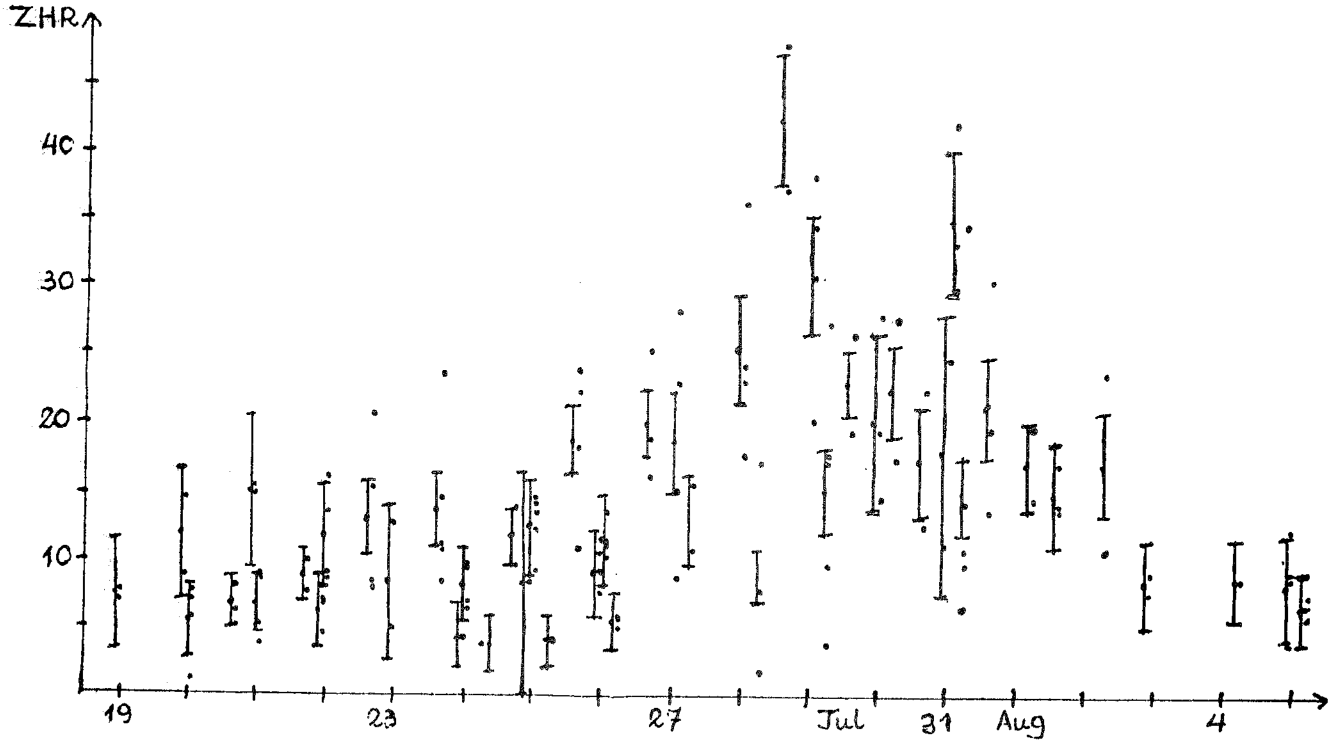

Figure 1 — The ZHR profile of the 1987 Aquarid shower.

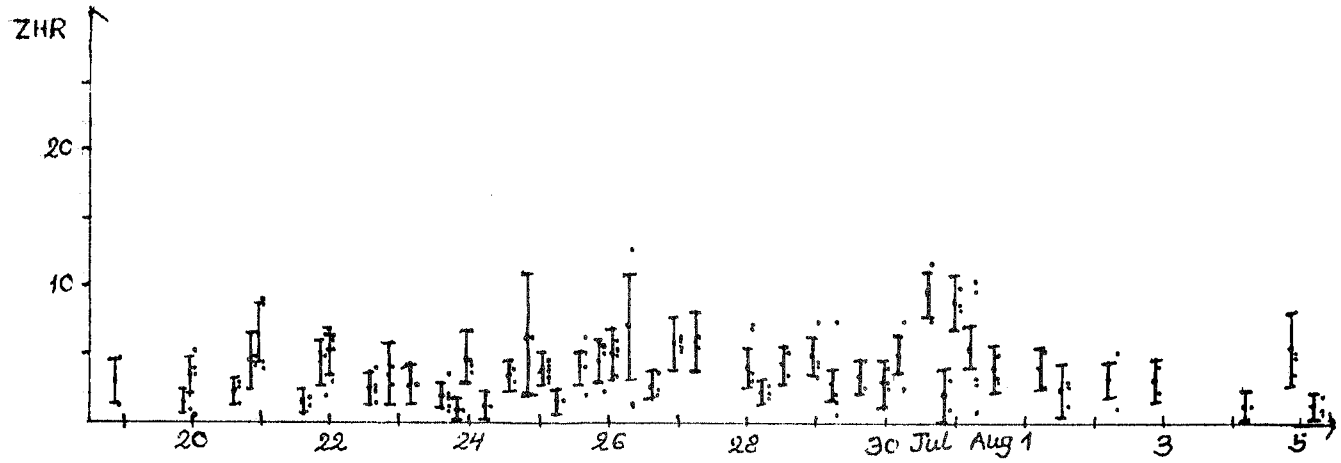

Figure 2 — The ZHR profile of the 1987 α-Capricornid shower.

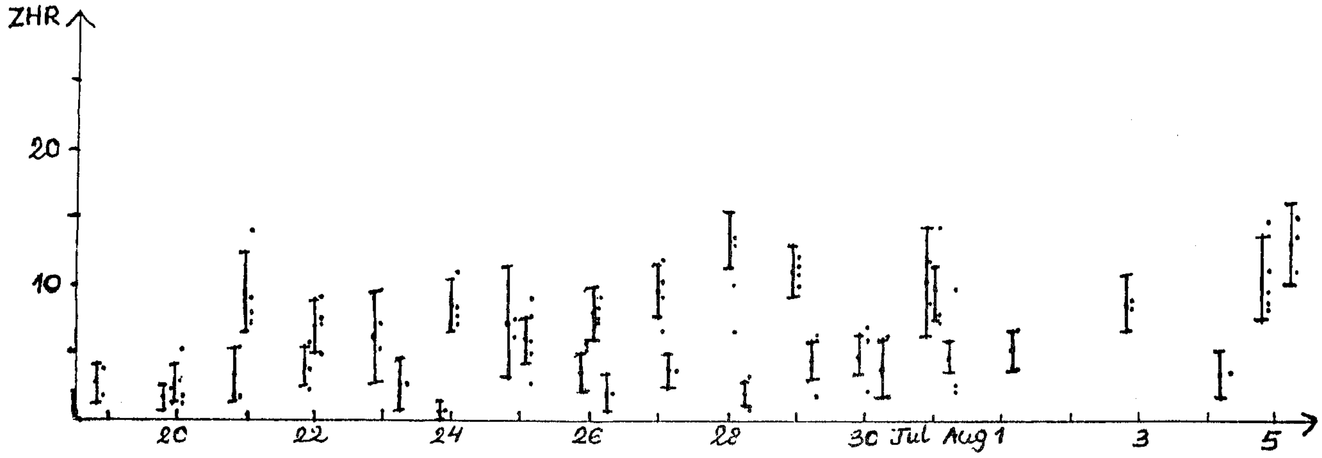

Figure 3 — The ZHR profile of the 1987 Perseid shower in late July and early August.

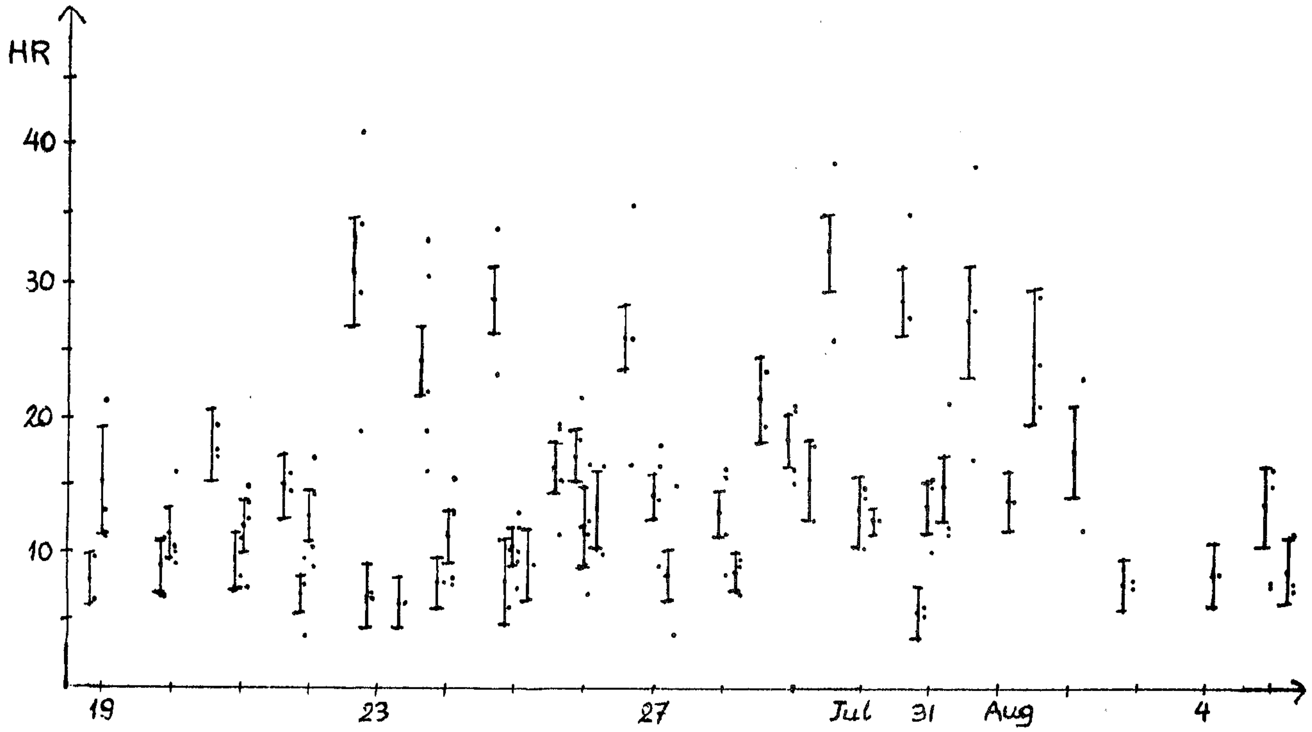

Figure 4 — The HR profile of the sporadics in late July and early August 1987.

The first two comments also explain why the average HR of the AUS group (see Table 6) varies that strongly from one day to the next: when some observations lasted till dawn or if one of the observers mentioned above were observing the HR is higher.)

Some variation is present in the AM observations. This is probably due to the fact that every American observer was located at a different site. The observers most probably dealt with different sky conditions (which were not entirely accounted for by the given limiting magnitude values).

The sky conditions in the Haute-Provence are, most likely, somewhat better than in in East Germany since the former group obtains HR-values which are a little higher than those obtained by the latter.

Table 6 — Average ZHR-values per group of the 1987 Aquarids, α-Capricornids and Perseids and HR-values of the sporadics.

Date	Group	Nr. Obs.	Aqr	Cap	Per	Spor
Jul 18–19	GDR	2	7.5 ± 4.3	3.0 ± 1.8	2.7 ± 1.6	8.1 ± 2.1
	HP	3				15.3 4.0
Jul 19–20	GDR	2	11.9 5.1	1.4 1.1	3.8 1.8	8.9 1.9
	HP	4	5.5 2.7	3.4 1.4	2.8 1.4	11.4 1.9
Jul 20–21	AUS	3	6.7 1.7	2.3 1.0		18.0 2.7
	GDR	2	15.2 5.6	4.5 2.3	3.6 1.9	9.6 2.3
	HP	4	6.7 2.3	6.6 2.3	9.6 2.9	12.1 2.1
Jul 21–22	AUS	2	8.9 2.0	1.6 0.9		15.1 2.5
	GDR	3	6.2 2.8	4.5 1.8	3.9 1.5	6.9 1.5
	HP	4	11.9 3.8	5.2 1.7	7.1 2.1	12.8 1.9
Jul 22–23	AUS	4	13.2 2.7	2.6 1.3		30.8 4.0
	GRD	2	8.5 5.7	3.4 2.6	6.2 3.4	6.9 2.6
	AM	1		2.8 1.6	2.7 1.9	6.3 2.1
Jul 23–24	AUS	5	13.8 2.7	1.9 1.1		24.2 2.6
	GDR	2	4.4 2.5	1.0 1.0	0.7 0.7	8.3 1.9
	HP	4	8.3 2.7	4.8 1.9	8.6 2.0	11.2 2.1
	AM	1	3.9 2.2	1.2 1.2		
Jul 24–25	AUS	2	12.0 1.9	3.6 1.3		28.7 2.6
	GDR	2	8.4 8.4	6.4 4.5	6.9 4.4	8.1 3.2
	HP	5	12.8 3.5	3.9 1.3	6.0 1.7	10.4 1.6
	AM	1	4.1 1.8	1.6 1.1		9.2 2.7
Jul 25–26	AUS	4	18.9 2.5	4.0 1.2		16.6 2.1
	GDR	3	9.2 3.2	4.5 1.8	3.5 1.5	17.3 2.0
	HP	4	11.7 3.4	5.0 2.1	8.1 2.1	11.9 3.1
	AM	2	5.4 2.3	7.0 3.9	2.0 1.4	13.2 3.0
Jul 26–27	AUS	3	20.3 2.5	2.7 1.0		25.9 2.5
	HP	4	18.8 3.8	5.7 1.9	9.6 2.1	14.2 1.7
	AM	2	13.2 3.5	5.9 2.2	3.7 1.3	8.5 2.1
Jul 27–28	HP	4	25.4 4.0	4.1 1.5	10.8 2.0	13.0 1.7
	AM	3	8.9 2.0	1.3 1.1	2.1 1.0	8.7 1.5
Jul 28–29	AUS	2	42.6 5.0	4.3 1.6		21.4 3.3
	HP	4	30.9 4.3	5.0 1.5	11.1 2.0	18.4 2.0
	AM	5	15.3 3.1	3.1 1.3	4.7 1.6	15.4 3.0
Jul 29–30	AUS	2	23.0 2.5	3.6 1.2		32.3 2.8
	HP	3	20.3 6.7	3.3 1.8	5.1 1.4	13.3 2.7
	AM	2	22.4 3.2	5.1 1.4	4.0 2.2	12.5 1.9
Jul 30–31	AUS	2	17.5 4.1	9.5 1.8		28.7 2.4
	GDR	2	18.0 10.2	2.1 1.9	10.3 3.9	5.7 2.0
	HP	3	35.1 5.3	9.0 2.1	9.8 2.1	13.6 1.9
	AM	5	15.1 3.1	5.4 1.7	4.8 1.3	14.9 2.5
Jul 31–32	AUS	3	21.2 3.8	3.9 1.7		27.2 4.0
	AM	2	17.2 3.0	4.2 1.4	5.2 1.4	14.0 2.2
Aug 01–02	AUS	3	14.9 ± 3.9	2.6 ± 1.9		24.7 ± 5.0
	AM	2	17.2 3.7	3.2 1.5		17.4 3.4
Aug 02–03	GDR	2	8.3 3.3	3.2 1.7	8.7 ± 2.3	7.8 1.9
Aug 03–04	AM	1	8.8 3.1	1.2 1.2	3.6 1.8	8.5 2.6
Aug 04–05	GDR	5	8.3 3.9	5.4 2.7	10.4 3.2	13.6 3.0
	AM	3	6.8 2.8	1.2 0.9	13.1 3.1	8.8 2.3

The average HR of all observers can be found in Table 7 and Figure 5. However one should not pay too much attention to these values because of the large difference in the HR between the AUS group and the other observers.

Table 7 — Average ZHR-values per date of the 1987 Aquarids, α-Capricornids and Perseids and HR-values of the sporadics.

Date	Aqr	Cap	Per	Spor
Jul 18–19	7.5 ± 4.3	3.0 ± 1.8	2.7 ± 1.6	12.4 ± 3.2
19–20	7.6 3.5	2.7 1.3	3.1 1.5	10.6 1.9
20–21	8.6 3.1	4.7 1.9	7.6 2.6	13.5 2.3
21–22	9.3 3.1	4.2 1.6	5.2 1.8	11.3 1.9
22–23	11.8 3.7	2.0 1.7	5.0 2.9	20.5 3.3
23–24	10.0 2.6	2.8 1.4	7.0 1.7	17.4 2.3
24–25	11.2 3.5	3.9 1.6	6.3 2.5	13.5 2.2
25–26	12.4 2.9	4.9 2.0	5.6 2.0	14.8 2.5
26–27	18.1 3.3	4.7 1.7	8.4 1.8	16.8 2.1
27–28	18.3 3.1	2.9 1.3	7.9 2.7	11.2 1.6
28–29	26.0 3.9	4.1 1.4	8.4 1.8	18.4 2.6
29–30	16.5 3.9	3.9 1.5	4.7 1.7	21.2 2.5
30–31	21.0 5.0	6.4 1.9	7.7 2.3	15.3 2.3
31–32	19.2 3.5	4.0 1.6	5.2 1.4	23.9 3.8
Aug 01–02	15.8 ± 3.8	2.8 ± 1.7		22.0 ± 2.4
02–03	8.3 3.3	3.2 1.7	8.7 ± 2.3	7.8 1.9
03–04	8.8 3.1	1.2 1.2	3.6 1.8	8.5 2.6
04–05	7.7 3.4	3.6 1.9	11.4 3.2	11.8 2.7

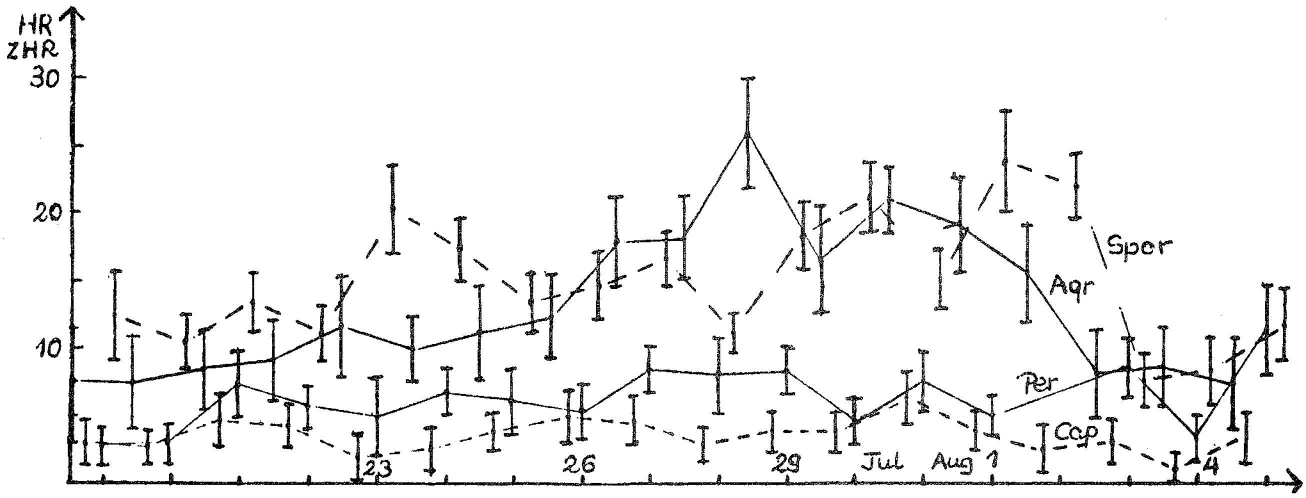

Figure 5 — ZHR-profile of the 1987 Aquarids, α-Capricornids and Perseids and HR-profile of the sporadics, based on the data in Table 7.

From Figure 1, it is clear that the Aquarid shower reaches its highest activity between July 27 and August 1. Looking at Figure 5, one can see that the highest average ZHR is obtained around July 28–29. During the preceding days, the activity gradually increases. Until July 23, the ZHR is somewhat lower than 10 (see also Table 7). It remains above 10 until August 2. However, it should be noted that the nights after this date are not very well covered.

A striking difference between the average ZHR profiles per group (Table 6) is the fact that each of them obtains the highest ZHR on a different date (AUS: July 28–29, HP: July 30–31, AM: July 29–30). With the exception of the AUS value, these highest values are not that much higher than those obtained one night earlier or later. This leaves open two alternatives. One possibility is that the maximum occurred when only the AUS group was able to observe. This means that the maximum could not have lasted longer than eight hours. Or else the

AUS group ZHR is not sufficiently representative for the true global activity (it is based on only three hours of observing by two people). In the latter case, the Aquarid maximum lasted about six days during which the activity does not change significantly and is clearly higher than in the previous and following nights. From July 26 until August 01, the Aquarid shower reaches a ZHR of 20, with a possible maximum on July 28–29 with a ZHR of 40.

From Figure 5 it appears that the α-Capricornid activity remains more or less the same over the entire period. There is no distinct maximum. The ZHR of this stream seems to be about 5. On looking at the different groups separately, we get a somewhat different picture. The AUS and HP observers obtain a ZHR of 10 around July 30–31, suggesting that a maximum occurs. The other groups however, do not obtain comparable values nor do they notice any increased activity. For the GDR group this might be attributed to their unfavorable latitude, which causes the effective number of observed α-Capricornids to be rather low. If some of these meteors were erroneously identified as sporadics, the ZHR would be too low. On examing the ZHR-values of the individual AM members, one notices that two observers, BK and PM, do obtain the value 10. The others give rather low values. Perhaps they did not pay enough attention to the α-Capricornid stream, or the maximum might have been over by then: BK and PM had already finished, when the others started observing.

In [4], a second maximum of the α-Capricornid shower is reported for July 25–26. This is not so obvious from the value given in Table 6 for the AUS group. That night, four observers were active in Australia. Two of them obtained a ZHR which is higher than the values they obtained during other nights (with the exception of July 30–31). The other two observers obtain low values, but they can hardly be compared with values of other nights: (MT made only one other observation and MC none. The HP and GDR group did not notice any increase in the activity. They probably missed it, since their ZHR was only 5 or 6 (considering the values obtained by JW and BM), which is a value often obtained by these observers (maybe due to a mixture of sporadic and shower meteors). In Bolivia, BK also derives a high ZHR. The other observer of the AM group did not notice anything unusual. Perhaps a second maximum occurred on July 25–26, which was only noticeable from the Southern Hemisphere due to the low ZHR, but only few observations support this hypothesis.

In Figure 3 the ZHR profile of the Perseids has been plotted. The ZHR appears to remain about the same througout the period covered. Using linear regression, one finds that the ZHR increases on average with 0.2 per day. The mean value over the entire period is 6.4.

Future observations are necessary to confirm or reject results found in this study. Special attention is needed for those possible stream characteristics that are still doubtful. For the Aquarid shower the main question is whether or not a maximum does occur with a ZHR of approximately 40. For the α-Capricornid shower, further attention needs to be paid to the maxima (especially the first, smaller one). Also, more magnitude data must be gathered for the early Perseids in order to check the high population index we found. The large variations in the HR among the different groups suggests that the sky condition is not always sufficiently represented by its limiting magnitude. A better description of the sky condition seems necessary. Finally, it would be preferable that observers provide magnitude data per per stream *and* per night.

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1988 Perseids

A New Telescopic Perseid Subradiant?

Mark Vints

During telescopic observations on August 12–13, a subradiant was noticed near the main Perseid radiant.

During the observing campaign in Lardiers, southern France, the Perseid activity was monitored on twelve different nights with 10×50 binoculars. On August 12–13, telescopic activity was noticed from a radiant about 2° west of the main Perseid radiant. Six meteors radiated from a point near $\alpha = 2^h54^m$ and $\delta = 57\overset{\circ}{.}5$. Five of them appeared between 0^h30^m and 1^h50^m UT; their average magnitude was 7.3. The star map below shows the directions of the six meteors, together with two "real" Perseids and the Perseid radiant.

Telescopic observers are requested to check their data for this subradiant and send the results to *WGN*.

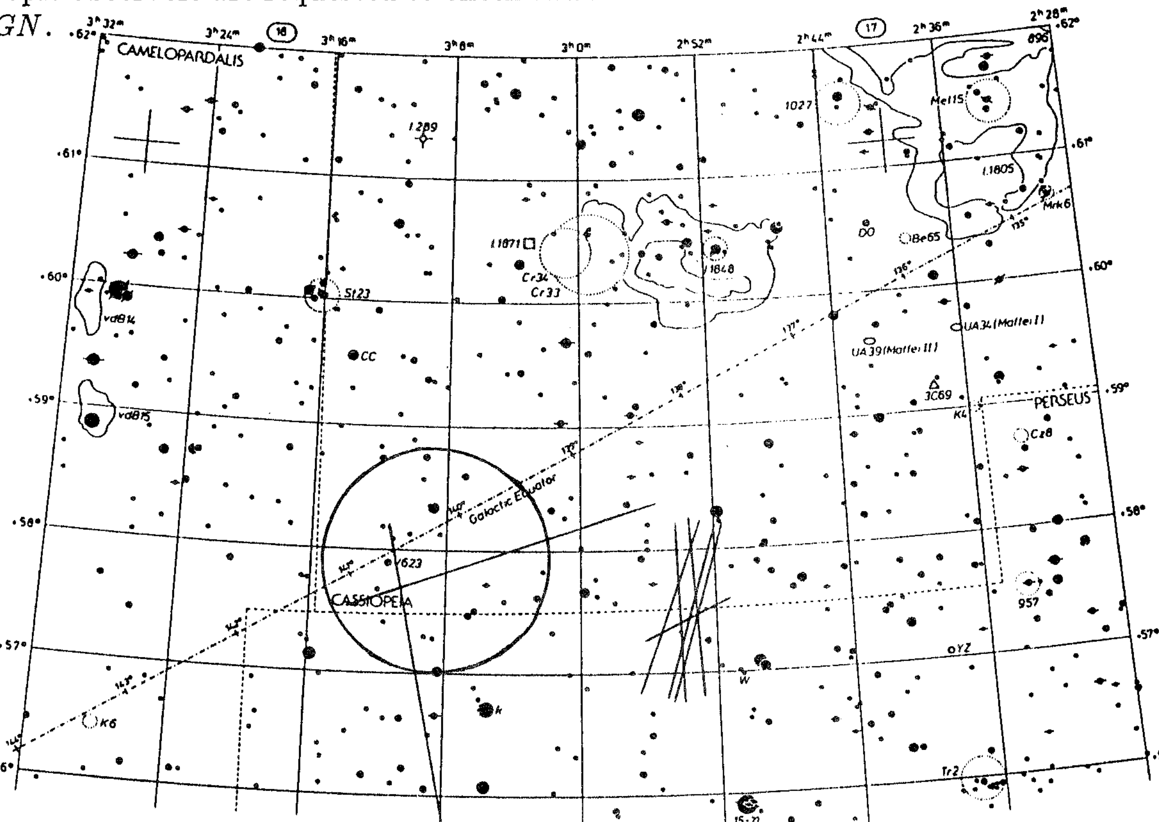

Figure 1 — Six meteors radiating from a point about 2° west of the main Perseid radiant. The other two meteors are "real" Perseids.

1988 Perseids in Maryland and Michigan

Richard Taibi

A brief summary is given of the author's 1988 Perseid observations.

In August, Washington DC is usually enveloped by a hot, humid, semi-opaque atmosphere. Anticipating this, I decided to drive 1300 km to northern Michigan. This is in the Great Lakes region where cool, clear, Canadian high pressure systems often enter the United States. The strategy was only partly successful because it met with some setbacks. Clouds threatened my northern Michigan sites on the crucial night of August 11–12 . So, on August 11, I drove 500 km southwest to near Battle Creek, where I had mediocre, but at least, cloudless conditions. My odyssey was 3100 km round trip but was worthwhile because my Washington DC site proved to have been too hazy to be useful. Below are my Maryland and Michigan observations for August 1988.

Table 1 — Observing sites for the 1988 Perseids in Maryland (MD) and Michigan (MI).

Location	Abb.	λ	φ	h
Mc Kendree, MD	MK	76°38′12″ W	38°46′50″ N	36 m
Rockport Quarry, MI	RQ	83°22′56″ W	45°12′07″ N	180 m
Long Lake, MI	LL	83°25′07″ W	45°11′05″ N	213 m
Assyria, MI	AS	85°05′58″ W	42°25′16″ N	286 m

Table 2 — The 1988 Perseids as observed in Maryland and Michigan, USA. Some Aquarids, α-Capricornids (C) and κ-Cygnids (K) were also noticed.

Date	Loc	Period (UT)	T_{eff}	Lm	F	Per	Aqr	Showers	Spor
Aug 04	MK	04^h20^m–05^h20^m	1.00	5.00	1.00	3	0	2C	6
04	MK	05^h20^m–06^h20^m	1.00	5.00	1.09	1	1		5
04	MK	06^h20^m–07^h20^m	1.00	5.00	1.32	4	1		3
04	MK	07^h20^m–08^h20^m	0.93	5.00	1.39	4	1		3
06	MK	05^h16^m–06^h16^m	1.00	5.20	1.00	4	1	1C	6
06	MK	06^h16^m–07^h16^m	0.97	5.20	1.00	6	6	1C	2
06	MK	07^h16^m–08^h16^m	1.00	5.20	1.00	4	5		4
06	MK	08^h16^m–08^h43^m	0.40	5.20	1.00	0	0		2
10	RQ	06^h00^m–07^h00^m	1.00	6.00	1.00	10	0	1K	11
10	RQ	07^h00^m–08^h00^m	1.00	6.00	1.00	13	0		10
10	RQ	08^h00^m–09^h00^m	1.00	5.00	1.00	14	0		5
11	LL	04^h42^m–05^h42^m	1.00	6.00	1.00	7	1	1K	9
12	AS	05^h20^m–06^h20^m	1.00	5.00	1.00	20	1		7
12	AS	06^h20^m–07^h20^m	1.00	5.00	1.00	22	1		9
12	AS	07^h26^m–08^h26^m	1.00	5.00	1.00	30	0		6
12	AS	08^h27^m–09^h02^m	0.60	5.00	1.00	8	0		2
22	MK	05^h00^m–06^h00^m	1.00	5.70	1.00	0	2		5
22	MK	06^h00^m–07^h00^m	1.00	5.70	1.00	0	2		4
22	MK	07^h00^m–07^h30^m	0.50	5.70	1.00	3	1		3

1988 Perseids in Hawaii

Mike Morrow

An account is given of the 1988 Perseid observations conducted by the Meteor Group Hawaii.

The year 1988 was supposed to be ideal for observing the Perseids. The Moon was new on August 12 and would not interfere. Those meteor observers who could manage to flee the lights of nearby towns and cities could observe under nearly perfect conditions. Those of us in Hawaii had the same idea and had planned for some time to go to the island of Lanai and observe, however the Perseids are a summer time shower and the summer brings it own problems. Lanai suffered clouds and showers as a result of the remnants of three hurricanes.

The Meteor Group Hawaii managed to observe some time under not so perfect skies on the island of Oahu. Between the remnants of Gilma, Fabio, and Hector, the sky was pleasantly nice, but not nearly as fine as we would have had, had we been able to observe under the clear clean skies of Lanai. One of our group was on a boat one mile offshore of the island of Maui and had better results than those of us on the island of Oahu.

Despite the adverse conditions we did see meteors and managed a fine time of it. The impression we had was that the Perseids were a bit weaker than usual in our location and somewhat brighter than average. However, this is only an impression based on what we were able to see between clouds. The lighted portion of our sky is to the East and Southeast and so we no doubt lost many dim Perseids, not only to the clouds but to the light. For our observer offshore near Maui, conditions were much better, but he too, seems to have seen the Perseids brighter than usual.

It should prove interesting when all the observations from round the world are put together to see what variations in Perseid strength show up.

1988 Perseids in Bulgaria

Jürgen Rendtel

During the summer of 1988, East German observers of the *Arbeitskreis Meteore* were able to observe over 20 000 Perseids in southern Bulgaria under excellent conditions.

From 1974 to 1987 we continuously tried to carry out Perseid observations from a site near Potsdam. During the 14 periods chosen (depending on the Moon's phase) we always suffered to some extent from unfortunate weather conditions. There were only few "maximum nights" with clear skies during at least a considerable time interval. The coincidence of New Moon and the Perseid maximum in 1988 led us to the conclusion that we had to observe from a site with more stable weather conditions. Looking at a map of Europe, we chose southern Bulgaria. We contacted the Bulgarian National Observatory of the Academy of Sciences situated at Mount Roshen ($\varphi = 41.^\circ 7$ N, $h = 1750$ m), not far from Smolyan. We started our expedition on July 31, 1988. First, we had a nice flight to Sofia — but not all our luggage arrived with us! Therefore we had to divide the eight participants into two groups: both of them arrived safely at the observatory by Plovdiv and the Roshen pass. At the observatory, we were accommodated in a comfortable flat. The staff of the observatory helped us in every respect, especially Dr. Vesselina Koleva. We had a good observing site, electricity for our photographic equipment, and also the possibility to get a savory meal at a reasonable price. Of course, we not only observed meteors; we also walked through the beautiful surroundings to the nearest towns, looked at the instruments of the observatory and watched Jupiter's clouds, the moon's surface and Mars' polar cap and surface details through the 2 m RC-telescope — an impressive event for everybody.

Our own observing program began on the first evening and ended in the morning of our last night at Mount Roshen. Except for one night, we had good or even excellent conditions. While the first observing nights ended early due to the rising of the decreasing crescent of the Moon, the remaining ones allowed us to observe 8 hours per night! To survive this situation during 16 consecutive nights required much perseverance. All together we noted 20 645 meteors in 95 man hours!

Our visual program consisted of six items:

1. a complete ZHR profile of the Perseids;
2. more detailed data on southern radiants than available from our northern latitudes;
3. reasonable magnitude data concerning all showers active;
4. derivation of personal probabilities of perception from modified double-count observations [1];
5. computation of the population index of showers using the personal probabilities of perception; and
6. calculation of spatial number densities of all showers observed [2].

All observational goals were accomplished. The analysis, of course, is not ready yet.

Photographic work was also carried out. We used two fish eye lenses $f/3.5$, $f = 30$mm (Zodiak, USSR) which is able to catch a 180° field through a diameter of 80 mm on a 9 cm × 12 cm plate. One camera was equipped with a rotating shutter between lens and film and worked without any filter. The other lens was used in combination with a blue filter for derivation of the color index of meteors in connection with a 6 × 6 camera (Pentacon six). 37 different meteors were photographed, some even by more than the two cameras mentioned above.

During our stay at the observatory, we also had a meeting with Bulgarian meteor observers from Sofia, Varna and Kardyaly, having their camp some 30 km southeast from Roshen. Beside an exchange of experiences, an exchange of data was arranged. Our way back home led us to Smolyan where we visited the planetarium (we also stayed one night there). In the early morning of August 19 we took a bus crossing the Rhodope mountains to Sofia. We still had some hours to do some sightseeing in the capital of Bulgaria before our plane brought us back to Berlin in the evening.

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[2] Koschack R., Rendtel J., "Number Density of Meteor Streams", *WGN* 16:5, October 1988, pp. 149–157.

1988 Perseids from Heuvelland, Belgium

Ghislain Plesier

An account is given of the 1988 Perseid observations from Heuvelland, Belgium.

Unstable weather conditions and personal occupations made the 1988 Perseid 1988 into one of our less successful meteor observation sessions for years. The fact that the Perseids would not be hampered by any moonlight at all, gave high expectations. From long before everything was arranged so that I did not have to work during the week of the maximum. Conditions seemed to be at their best. But it would have been to beautiful to be true...

The night of Friday August 5 was the first night with open sky. Some fog made good observations impossible. Saturday 6 was even worse, and Sunday 7 was completely spoiled by heavy fog (limiting magnitude of 2.5). Monday August 8 was good, but activity was rather low especially for the sporadic background. August 9 was good too but only for a short period. In the night of August 10 some hours of clear sky were missed because of bad previsions by the weather forecast. Then, the maximum night would be clear in the second part of the night according to them but only from 00^h55^m to 01^h35^m the clouds showed some gaps going from 10% to 40% of the sky. Nevertheless this was enough to witness a spectacular show with 20 to 25 meteors one of which was a Perseid of -4, just before 01^h00^m UT. And then came Friday... This was what I needed to feel better again after all this bad luck. A total of 226 meteors in 5.83 hours of observing under a perfect sky, already from 20^h45^m onwards (usually only from 21^h30^m). Saturday was almost as good but activity had already declined severely. The following nights were very clear again but were missed because of exams. August 16 and 19 were the last nights whith acceptable conditions, although (sporadic) activity was low.

Table 1 — 1988 Perseid observations from Heuvelland, Belgium, by Ghislain Plesier

Date	T_{eff}	Lm	F	Pers	ZHR	Spor	HR	Tot
Aug 05–06	2.83	6.5	1.00	8	5 ± 2	12	5 ± 1	23
06–07	2.75	6.0	1.00	1	1 1	2	1 1	3
08–09	4.70	6.6	1.00	24	7 1	17	3 1	48
09–10	2.90	6.5	1.00	7	3 1	7	3 1	17
12–13	5.83	6.9	1.00	163	30 2	52	5 1	226
13–14	3.50	6.7	1.00	34	11 2	20	5 1	57
16–17	5.00	6.6	1.00	5	1 1	19	3 1	31
19–20	2.23	6.9	1.00	3	2 1	12	3 1	16
Total	29.74			245		141		421

Apart from the Perseids, 13 α-Capricornids, 18 Aquarids and 4 κ-Cygnids were seen. In Table 2, the magnitude distributions of the Perseids and the sporadics can be found. The other showers were not included as their number of meteors was too small to allow relevant conclusions.

Table 2 — Magnitude distribution of the 1988 Perseids and sporadics, as observed from Heuvelland, Belgium

Date	Shower	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot	$\overline{m}$
Aug 05–06	Per	0	0	0	0	0	0	0.5	3	1.5	2	1	0	8	3.00
	Spor	0	0	0	0	0	1	0	0	4	4	2.5	0.5	12	3.63
06–07	Per	0	0	0	0	0	0	0	0	1	0	0	0	1	
	Spor	0	0	0	0	0	0	0	0	0.5	1.5	0	0	2	
08–09	Per	0	0	0	0	0	1.5	4.5	3.5	10.5	3	1	0	24	2.50
	Spor	0	0	0	0	0	0	0	2	3.5	4	5	2.5	17	4.15
09–10	Per	0	0	0	0	0	1	2	1.5	1.5	0	1	0	7	2.07
	Spor	0	0	0	0	0	0	0.5	2.5	0	0.5	3	0.5	7	3.64
12–13	Per	0	0	1	1	6	9.5	16	33.5	40.5	30	22	3.5	163	2.76
	Spor	0	0	0	0	0	0	1.5	6.5	6.5	19.5	17	1	52	3.90
13–14	Per	0	0	1	0	0	3	3	4	10.5	9.5	2.5	0.5	34	2.74
	Spor	1	0	0	0	0	0	2	1.5	5.5	4	6	0	20	3.13
16–17	Per	0	0	0	0	0	0	1	1	0.5	2	0.5	0	5	
	Spor	0	0	0	0	0	1	0	4	3	7	4	0	19	3.42
19–20	Per	0	0	0	0	0	0	0	1	1	1	0	0	3	
	Spor	0	0	0	0	0	0	1.5	2.5	1.5	5	1.5	0	12	3.33
Total	Per	0	0	2	1	6	15	27	47.5	67	47.5	27	4	245	2.69
	Spor	1	0	0	0	0	2	5.5	19	24.5	45.5	39	4.5	141	3.66

As conclusion of these Perseid observation, one can say that weather conditions could have been better. Nevertheless, a total of 421 meteors in 29.74 hours can be called a reasonable result.

Summary of Early 1988 Perseid Observations

Glenn Ticket

An overview is given of the 1988 Perseid observations made between July 23 and August 21 which were received before September 25.

The 1988 Perseid return was announced to be the most favorable one since 1980. Presented here is a short overview of the observations already received. Beyond any doubt, more reports are yet to come. Up to now, 117 persons supplied observations to IMO:

Peter Aneca, Rainer Arlt, Sandra Baroni, Dirk Bernaerts, Lieve Bresseleers, Peter Brown, Dominique Caris, Sven Claeys, Koen Clement, Sabine Clement, Pascal Cornelis, Tim Daniëls, Luigi D'Argliano, Jan De Bil, Frederic De Cock, Bernard De Grote, Jurgen De Herdt, Stefano Del Dotto, Marc Delignie, Kris Deman, P. De Pauw, Bart de Pontieu, Carl De Pooter, Jean Deweerdt, Anne De Weert, Kurt Dequick, Patrick De Wispelare, Ivo Dielen, Filip Dierckx, Maurizio Eltri, Irina Gaus, Koen Geukens, Roberto Gorelli, Peter Goris, Roberto Haver, Golis Hodeses, Kurt Jonckheere, Becky Kirkwood, John Kirkwood, Robert Kirkwood, André Knöfel, Bernhard Koch, Ralf Koschack, Detlef Koschny, Patrick Laenen, Iris Lafaille, Alberto Latini, Dirk Laurent, Kris Lavrijsen, Stefan Lobet, Robert Lunsford, Ann Martaux, Massiso Martini, Alastair McBeath, Dina Moro, Kristiaan Neyts, Michael Nolle, Kurt Oscar, Dirk Pauwels, Francis Plesier, Ghislain Plesier, Giacono Polischi, Edoardo Radici, Stefano Raffaelli, Ina Rendtel, Jürgen Rendtel, José Trigo-Campoy Rodriguez, Paul Roggemans, Wim Rogiest, Maarten Roos, Christian Rutges, Napoleone Scarpa, Ren Scurbecq, Steve Sillis, Brian Simmons, Karl Simmons, Stephen Simmons, Wanda Simmons, Wendy Simmons, Lieven Smits, Paul Smits, George Spalding, Peter Spony, Enrico Stomeo, Stefano Stomeo, Jan Strobbe, Dominique Suys, David Swann, Richard Sweetsir, Richard Taibi, Emanuelle Thieupont, Glenn Ticket, Emiliano Trizio, Toon Van Borm, Marc Van Den Broeck, Hendrik Vandenbruaene, Jan Vandenbruaene, Peter Van den Eijnde, Griet Van de Steene, Tom Van de Vreken, Karin Van Genegen, Filip Van Gorp, Mireille Vanheerentals, Didier Van Hellemont, Anik Vanhuysse, Pierre Van Mechelen, Tonny Vanmunster, Ward Van Nuffelen, Frank Van Reeth, Jonas Vanreusel, Cis Verbeeck, Sam Vereecke, Ivo Verlaeckt, Ivo Verstraelen, Jean-Marc Wislez, Steffen Witzschel, Sylvia ?.

In Table 1 below, a summary is given of the observations received thusfar.

Table 1 — Overview of the 1988 Perseid observations carried out between July 23 and August 21 received by IMO before September 25. E.g. Aug 7 stands for the period between August 6, 20^h UT and August 7, 20^h UT.

Date	Nr. Obs.	$T_{\rm eff}$	Date	Nr. Obs.	$T_{\rm eff}$
Jul 23	2	3.00	Aug 10	44	95.67
24	5	15.90	11	42	107.78
25	2	5.82	12	65	174.88
26	5	16.00	13	57	157.02
27	8	13.20	14	18	65.4
30	1	1.00	15	14	32.93
Aug 03	6	3.63	16	5	15.17
04	8	10.46	17	8	23.82
05	2	2.09	18	15	32.13
06	9	20.62	19	10	20.18
07	36	74.84	20	3	5.25
08	24	63.89	21	1	1.00
09	22	44.53			

As one can see, five days of the considered period are as yet without observations. This is of course due to the presence of the Full Moon during those nights. Dispite the disturbing moon some observers were, nevertheless, active during the last days of July and the first days of August.

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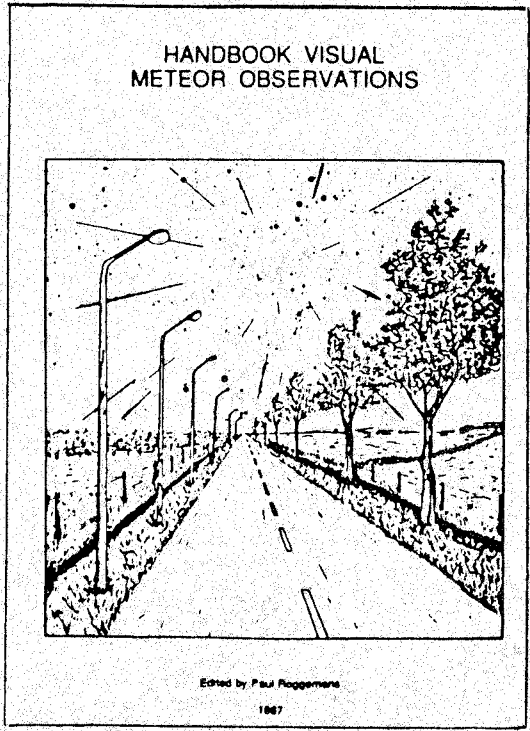

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