wgn

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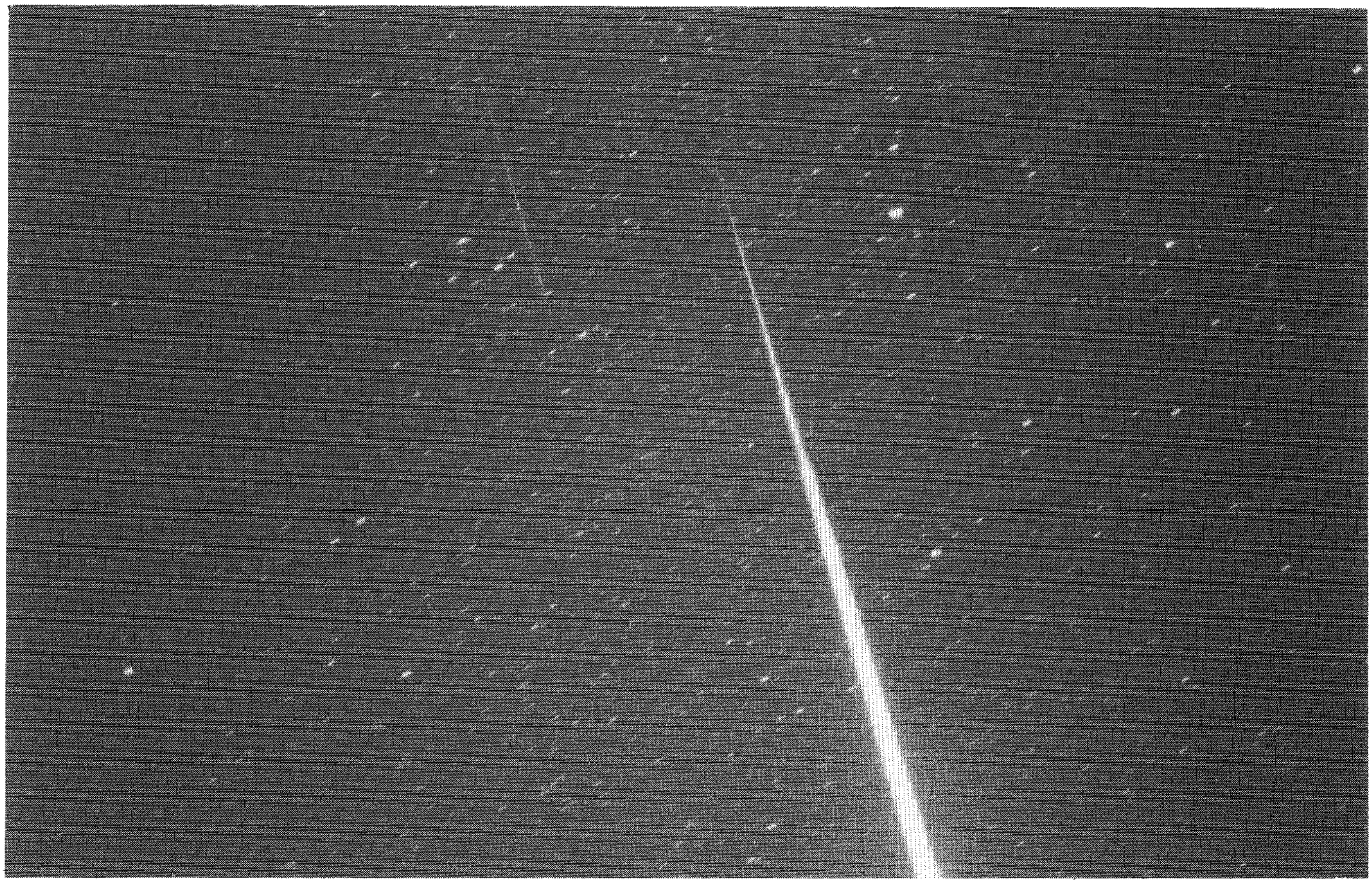


This double meteor was photographed on August 8, 1989, between $10^h55^m25^s$ and $10^h56^m45^s$ UT by Lance A.M. Benner of St. Louis, Missouri, USA. The fainter meteor may be of magnitude −1 or so, while the bright fireball has a magnitude of −6–−8. The photograph was made with a Minolta SR-T 200 45 mm $f/2$ and the film was developed in D-76 undiluted for 13.5 minutes at 24° C.

In case of non-delivery, return postage guaranteed. Please return to:

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

Afgiftekantoor: 2540 Hove

WGN, volume 18, nr 2, April 1990, pp. 29–70

Contents

Useful Information

The June Issue *(WGN 18:3)*

The *June issue* is expected to be mailed during the first week of June. Contributions are due *May 4*. 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 1990

The subscription rate for volume 18 is 400 BEF or 12 USD for six issues. It is anticipated that volume 18 will contain over 240 pages. Subscriptions should be paid to Ann Schroyens or, for the USA and Canada, to Peter Brown, or, for Japan, to Masahiro Koseki (all addresses on the inside of back cover). Please make sure we retain the full amount due after deduction of bank and/or exchange charges. Therefore it is recommended to pay by international postal money order. Additional gifts are of course welcome.

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

Some issues ago, we announced a comprehensive report on the observations of 1988. The compilation of this report suffered from some delays of various kinds, mainly the amount of work that was involved in writing conversion programs that, so to speak, "generate" the report directly from the VMDB data, with a minimum of human interference. Also, the first tries of the programs revealed a number of errors in the data input of the VMDB which of course had to be corrected first before the report could be finally processed. This is all done now and the entire report contains 148 pages of visual and fireball data. More information on ordering this report can be found in the next article.

Rather than calling the publication an "annual report", which might erroneously suggest a document of an administrative nature instead of an observational nature, we chose to print it as the first issue of a report series of WGN. This report series is intended to contain data on all kinds of meteor observations. Issues will appear at irregular intervals, but, of course, at least once a year.

Personally, I feel a lot of satisfaction now that this new series has started. What struck me most during the years immediately preceding the foundation of IMO was how easily valuable observational data could get lost for posterity. Indeed, several very active groups in the past produced vast quantities of data during several years, sometimes even more than a decade. Unfortunately, these groups faded away eventually, and, with them, the awareness of the existence of the work they produced. If it were not for the extensive literature search that Paul Roggemans conducted a few years ago, many old observational records would probably never have been rediscovered. Therefore, preserving observational data gathered from all over the world and making them available in a uniform format, thereby establishing a badly needed continuity, seemed to me the primary goal of an international organization.

Although computerized data are most handy for analyses purposes, as the VMDB has already proved so clearly in its short time of existence, we feel that the data should also be available in print. In this way, everybody can see which data IMO has to offer, in a universally accessible format, both now and in the future, without having to depend on (a) particular computer system(s). Persons or groups wishing to use some of the observational results for further analysis can then request to IMO the relevant data on a diskette.

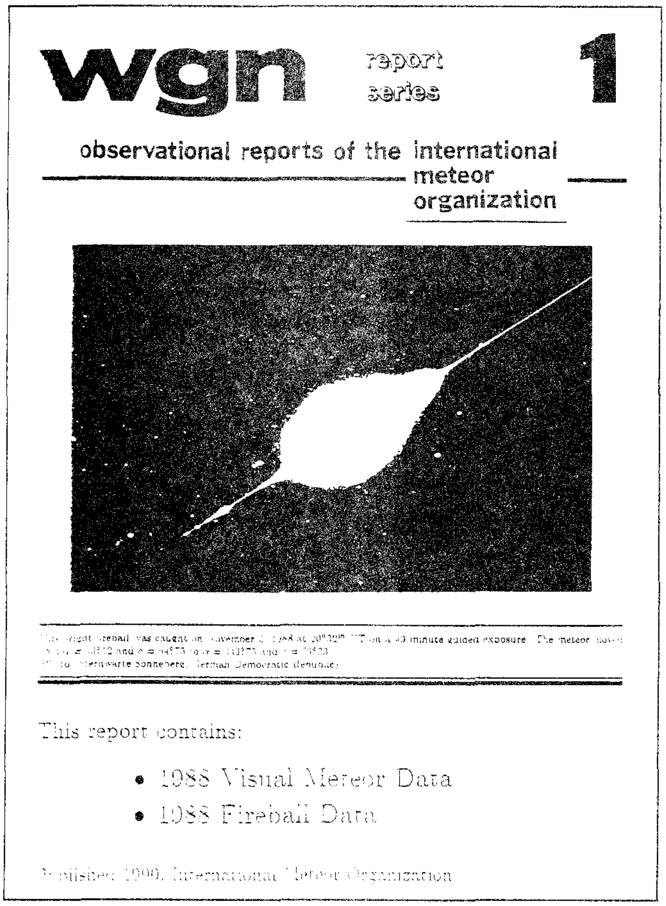
The first issue of the report series only contains visual and fireball data. So will also the second issue, containing the observational results of 1989. (Since most of the work in compiling the 1988 report was spent in writing the conversion programs, the 1989 will require only minimal preparations.) It should be clear, however, that in the future, also photographic, telescopic, radio and video data must be published in the report series.

The unfortunate but undeniable fact that compiling such reports is presently impossible, shows once more that a well run Photographic Commission is urgently needed within IMO. It also shows that telescopic, radio and video data should be organized in such a manner that they can be disseminated to the meteor community in a meaningful way.

Taking into account the realistic expectation that the amount of data collected by IMO will sharply increase over the years to come, all of this means of course a lot of work. Provided it is executed properly, this work will prove to be very rewarding. Maybe this is a good place and time to remind you that IMO is not an institute created on top of the meteor community, but the meteor community itself. Whatever IMO is to accomplish in the future will depend on the willingness of meteor workers to invest time and to commit themselves to persevere. Please take a few moments to think this over and if you think you can help, do not hesitate to step forward!

New Observational Report Series of WGN!

edited by Marc Gyssens


wgn report series 1

observational reports of the international meteor organization

This report contains:

- 1988 Visual Meteor Data
- 1988 Fireball Data

In my editorial message on the previous page, you could already read about the philosophy behind *WGN*'s new observational report series.

The first issue in this series contains all visual and fireball data of 1988. In total, you will find in it 100 408 visual meteors seen during 4867 hours in 256 calendar dates by 264 observers from 16 different countries, as well as 197 entries on fireballs. It goes without saying that this work is invaluable for those wishing to use observational material in their analysis. Also, observers can see how their work fits in a world-wide effort to gather information on meteor phenomena.

Do not miss this first issue of a new series and order now! For 148 pages of dense observational data, it only costs *300 BEF* (including surface mail delivery). Please pay as for your subscription to the *WGN* bimonthly journal, and, in particular make sure that we retain the full amount after deduction of possible transfer costs!

About Foreign Payments

Marc Gyssens, Paul Roggemans and Ann Schroyens

In spite of the very careful instructions for paying *WGN* or other publications of *IMO*, we still encounter many problems in receiving payments from abroad in that we often loose a considerable fraction of the paid amount due to various kinds of transfer costs. Since it is *IMO*'s policy to compute its prices as sharply as possible, your cooperation is essential. Below, we list the most frequent problems that occur together with some suggestions to avoid them in the future.

First we recall that using an *International Postal Money Order* is the cheapest way for a foreign payment. Although less popular in Anglosaxon countries such as the United Kingdom or the United States, it does exist in these countries. If you experience problems at your post office to obtain such a postal money order, please insist! Second, payments by *Eurocheque* to Ann Schroyens are safe, provided you mention the amount in Belgian francs (BEF), mention a Belgian city as the place where the check was drawn, make the check payable to Ann (*not* to *IMO*), and, very important, mention your Eurocheque card number on the back!

Recently, we especially experienced problems with payments from the United Kingdom. If, for some reason, you cannot use one of the two methods mentioned above, we urge you to choose between one of the two following alternatives:

- Pay from a postal giro account of your own to the postal giro account of Ann Schroyens, *mentioning the amount in Belgian francs (BEF)*! In that case, postal services will charge the transfer costs (about 5 GBP) to your account; if you would mention the amount in pounds sterling, then these cost are simply deduced from the amount that is transferred, whence we receive 5 GBP less!
- If you have to pay by a check other than a Eurocheque, pay in dollar to Peter Brown in Canada instead of to Ann, allowing for about 2 dollars of bank charges.

This last remark generalizes to everybody: if you have to pay by a check other than a Eurocheque, pay to Peter Brown instead of to Ann. In that case, calculate the amount due from the price in Belgian francs using the exchange rate of the day, adding about 2 dollars for bank charges. Bank charges in Belgium for foreign checks are really to high (up to 10 USD!) for paying small amounts. Therefore, we simply have to refuse all checks (other than Eurocheques) sent to Ann.

Please note ...

Marc Gyssens and Paul Roggemans

- ... that you can order the *Gnomonický Atlas Brno 2000.0* by Vladimír Znojil from *IMO* at a price of 100 BEF (to be paid in the same way as for *WGN*). Order this excellent gnomonic star atlas for your summer observations! Do note, however, that incoming orders are sent to Czechoslovakia for further processing in bunches once a month. Taking this into account as well as the time required for mailing, you should allow for about three months delivery time.
- ... *if you are an IMO member* you should find four enclosures in this issue:
  - An introduction to *IMO* (IMO_INFO(1));
  - A meteor calendar (IMO_INFO(2));
  - Who is who in *IMO* (IMO_INFO(3));
  - Voting document nr. 6.

If you should not have received one of this documents, please let us know. It goes without saying that the first booklet is not addressed to you, since you already are an *IMO* member. However, you can use it (by making copies of it) to propagate *IMO* among interested friends and colleagues.

Letters to WGN

compiled by Marc Gyssens

Aurora-like displays

The aurora-like rays reported in WGN 17:4, pp. 115–116 continue to produce reactions. In this issue, Philip Bagnall and Alastair McBeath comment on earlier reactions to the original note. Both disagree with the opinions expressed by Pekka Parviainen and Trond Erik Hillestad in WGN 18:1, pp. 2–3. Also Bill Katz suggests auroral rays as the explanation for the phenomenon. As we assume that all viewpoints on this issue are presented by now, we propose to close the discussion on this matter.

I believe that nor the explanation of Parviainen nor that of Hillestad are correct, and maintain that what Kristensen saw was rayform aurorae. Referring first to Parviainen's note, it is simply not true that his photograph and those of Kristensen are "strikingly similar". At first glance they do look the same, but a more detailed examination reveals major differences. For example, the orientation is different, so is the apparent size and distribution, the ratio of the length to the width does not agree, nor does the intensity. I have checked the meteorological records for April 27–28 which show a low pressure area centered on Stockholm and moving Northwards, and a second low pressure area in the English Channel moving Eastwards across central Europe. These conditions are not conductive to the formation of polygonal ice crystals in sufficient quantities to produce the observed effect. I therefore must reject Parviainen's explanation.

Hillestad remarks that individual rays are rarely seen—and indeed he is right for someone observing from his latitudes (59°7–68°2 N), but in more southerly latitudes individual rays are quite common, though they are often mistaken for floodlights and other artificial light spillage. However, there is one other reason why I reject Hillestad's comments. On April 25–26, only two days before Kristensen's observations, a major auroral storm occurred and was well-photographed from the U.K. This "storm" came only one month after a similar event, and it seems highly probable that some minor auroral activity continued for several days. I reiterate that what Kristensen saw was simply aurorae.

Philip M. Bagnall, February 23, 1990

It seems that Pekka's photograph in *WGN 18:1, pp. 2–3* has been taken in a twilit sky, which is not surprising, since any clouds would have to be lit by sunlight (or some form of ground lights) to be seen, such as noctilucent clouds in the summer months. Any twilight would naturally render aurorae invisible, though as Gotfred Kristensen's original photographs were taken long after sunset, I do not think his "trains" were cloud features of this type. Despite Trond Erik Hillestad's comments, I still feel auroral rays to be the most probable cause of the phenomenon, having seen similar things myself on several occasions. From 14 aurorae seen during the past two years (a better than average period for my site at about 55°5 N) five have shown at least some part of their displays as individual or multiple solitary rays, apparently connected neither to one another nor to any other auroral features. For sites with more southerly latitudes, rays on their own are even commoner features, since they can extend hundreds of kilometers away from the area of the main auroral event, though of course, the number of such auroral sightings is far fewer than even at my own site! In this case, the main part of the displays is actually taking place beyond the observer's horizon.

Alastair McBeath, February 17, 1990

Next, some insight, I hope, into the Denmark train reports. The duration, green-white color and convergence on the zenith are characteristics of an auroral form called a corona. Many, if not most, aurorae are not in active motion. While most aurorae begin on the northern horizon, sometimes an isolated corona or ray can be seen. Coronae are usually at the zenith, but individual rays may not be, though they will point to the zenith. Many times these rays may seem to drift over time.

Coronal aurorae are relative rare in southern latitudes and often not recognized. As we approach solar maximum, more auroral activity will be visible. Three coronal examples I have seen:

- A cloud in the form of a lambda (λ) formed at the zenith in evening twilight. Its color and other faint rays converging on the zenith were only noticeable after dark.
- An isolated ray grew from the horizon in the due west. It looked like a beacon at first but continued to lengthen until it stretched to the zenith.
- A series of thin, faint green and yellow rays arranged in two rows, one above the other in the due east. It looked like a diffraction grating pattern.

In each of these examples, no auroral arc or rays were visible in the north.

Bill Katz, February 1, 1990

Forward scatter data and the population index

Dr. M. Šimek of the Astronomical Institute of Ondřejov in Czechoslovakia has some comments on the article of Jeroen Van Wassenhove "Forward Scatter Data and the Population Index" in WGN 17:6, pp. 265–266.

Equation $\log N$ versus $\log D$ in its presented form is valid for underdense echoes only, where D is the signal amplitude (intensity). Duration of an underdense echo does not depend on particle mass. For overdense echoes, when amplitudes are considered, the multiplication factor is at least three times higher than presented in the article. It is not clear what amplitude in Figure 1 corresponds with the underdense/overdense region—it could be placed maybe around $\log A = 1.8$. I would recommend the author to reanalyze the r-values from this point of view.

When durations of meteor echoes are considered (for overdense reflections), the formula:

$$\log N = C - \frac{15}{8} \log r \log T$$

should be used.

Dr. M. Šimek, Astr. Inst. Ondřejov, January 30, 1990

The 1989 Quadrantids

Ralf Koschack comments on Paul Roggemans's contribution on the 1989 Quadrantids in WGN 18:1, pp. 12–18. A reaction from the author follows.

In this report Paul Roggemans asks whether a more reliable analysis can be made from many observations rather than a few good ones. The answer at the end favors the first alternative. As long as we have to take into consideration only random errors his conclusion would be correct, but also systematic errors act here, and one cannot cope with this kind of errors by means of statistics. Let us have a look at the main points we have to consider. A first factor is the correction for the limiting magnitude. The formula used:

$$c_m = r^{6.5-\mathrm{lm}} \qquad (1)$$

is valid only if the difference $6.5 - \mathrm{lm}$ is caused by extinction (dust, haze). If it is caused by an illumination of the sky (moon, city lights) equation (1) is an approximation only. Normally, the certainty of this approximation decreases with increasing difference $6.5 - \mathrm{lm}$. Furthermore, the population index r can be determined with a certainty of about 0.2-0.3 (cfr. [1]). For a limiting magnitude of 5.5, this uncertainty can result in a *systematic* error of about 10% which can still be accepted. For larger differences, this error increases rapidly. In the program of the Visual Commission [2], the limit for the calculation of reliable ZHRs was therefore set at $\mathrm{lm} = 5.5$.

Secondly, we use a correction factor for the elevation of the radiant:

$$z = \sin^{\gamma} h_R \qquad (2)$$

with $\gamma = -1$ and h_R the elevation of the apparent radiant (zenith attraction included). Equation (2) is only a geometrical correction valid for $90° \geq h_R > 10°$. It may be taken for granted, however, that the angle under which a meteoroid enters the Earth's atmosphere (corresponds to h_R) influences the brightness of a meteor. The amount of this may depend on meteoroid material, entry velocity, particle mass, ..., it can differ from observer to observer, and it seems to be impossible to determine it. The uncertainties increase rapidly with decreasing h_R. In order to take into account the effect mentioned it was proposed to use $\gamma = -1.3$ [3]. Experience shows that $\gamma = -1.5$ is too strong and that γ probably depends on h_R. To give an idea about the order of the possible error we assume that $\gamma = -1.2$. If we use $\gamma = -1$, this results in a systematic undercorrection of the ZHR of 23% for $h_R = 20°$, and of 42% for $h_R = 10°$. Therefore only ZHRs calculated from observations with $h_R \geq 20°$ are reliable. For $20° \geq h_R > 10°$, the ZHR becomes a rather poor estimate with a possible systematic error of up to 50%. A ZHR obtained from an observation with $h_R < 10°$ is of no use.

In the case of a weighing factor $1/C_{tot}$, not the value C_{tot} is really the selection criterion, but lm and h_R are. The limits set in the program of the Visual Commission should not prevent people to observe under poorer conditions. Although ZHRs are of low value, it is possible to determine the time of a maximum or of outburst from such data.

So far the theory. What does it mean for the Quadrantid activity profile presented? The *VMDB* currently uses $r = 2.5$ as a standard for all showers. This simplification cannot be accepted any longer. The first step of a shower analysis has to be the calculation of the population index r. But this can only be done if all observers report their magnitude distributions each night.

The Quadrantids are known to have a low value of r. From a personal observation of January 3, 1989 in the morning, we obtained $r = 2.18 \pm 0.25$ (134 Quadrantids with magnitudes between -2 and $+5$) according the method described in [1]. Using $r = 2.5$ and lm $= 5.0$ leads to an overcorrection of the ZHR of about 23%. Bearing in mind a further uncertainty due to sky illumination (equation [1])), such a result should not be used for a detailed analysis. Since most of the observations were carried out under poor sky conditions the average ZHR includes a systematic error, too. The elevation of the Quadrantid radiant is low for many hours. At 14^h30^m UT, the radiant was about 10° above the horizon in central Japan. Probably this causes a considerable undercorrection of the maximum ZHR. Fortunately, the ZHR was at the same time overcorrected due to poor limiting magnitudes. Therefore the final ZHR of 89 seems to be not unlikely, possibly a little too low as mentioned by Paul Roggemans. But a precise value cannot be given mainly due to the indeterminate zenith correction factor. We must conclude that the only reliable results obtained are the time of the maximum and the activity period ($\lambda_\odot = 282.^\circ0$–$283.^\circ5$). All ZHR values averaged are of restricted value.

Finally, some remarks concerning the style of the analysis. Paul Roggemans writes: "Since quite a lot of the observations required a rather strong combined correction for zenith distance and limiting magnitude, the ZHRs were accepted when the correction factor was not larger than 10". Using the same argument it would be possible to accept factors of 20 or even 30. Since a lot of observations were carried out under such poor circumstances the weighing factor does not abolish the systematic errors. What is the correct way?

First one has to look to what data are available. Then one can decide what results can be extracted, and how one should proceed. This is men's work which cannot be done by a computer. It is not possible to give a certain fixed criterion for all data sets and all showers. If the quantity meeting the selection criterion (lm and h_R) is not sufficient, a ZHR analysis cannot be carried out. Therefore one must clearly say that no result is better than a questionable result. It is frightening to know that after some years the result $ZHR_{max} = 89$ will be used to analyze long term variations of the Quadrantid activity. One will find considerable differences in ZHR_{max} from year to year and wonder what periodicity might be derived. Therefore uncertain results must not be published, or they have to be marked as such explicitly.

The statement that "the result shown in Figure 1 is very acceptable" needs arguments. Yes, it looks good. But that is all. The procedure used produces good looking graphs if the sampling period is not too short and the number of ZHR is large enough. Due to systematic errors the shape of the activity profile cannot be a criterion for the reliability. The analyzing procedure must be adapted to the data to be analyzed. A small quantity of observations requires another procedure. If this is not considered, a bad result for $C_{tot} \leq 2$ shown in Figures 4 and 7 can be foreseen. It does not prove that many ZHRs are better than fewer good ZHRs.

As it can be seen from other showers [4,5] the method developed by Paul Roggemans produces precious results if there is a large quantity of data without considerable systematic errors. Having the 1989 Quadrantid report in mind we see a danger and we warn for it. People tend to accept all results put out by a computer if they look nice. Often the reader is unable to value the reliability of the published results. The report may be impressive for people not so familiar with problems of visual meteor observations, but it does not serve the first target of the Visual Commission: the increase of the reliability of visual meteor observations.

[1] C. Steyaert, "Populatie-index bepaling", Technische nota 5, 1982.

[2] R. Koschack, "Program of the Visual Commission", *WGN* 17:6, December 1989, pp. 204–206.

[3] J. Zvolánková, "Dependence of the Observed Rate of Meteors on the Zenith Distance of the Radiant", *Bull. Astron. Inst. Czechosl.* 34, 1983, pp. 122–128.

[4] P. Roggemans, "The 1988 Perseid Meteor Stream and Observer's Perception Coefficients", *WGN* 17:5, October 1989, pp. 189–193.

[5] P. Roggemans, "The Geminid Meteor Stream in 1988", *WGN* 17:6, December 1989, pp. 229–239.

Ralf Koschack and Jürgen Rendtel

Below is the answer of the author:

The Quadrantid article was compiled in a very short time on special request of the editor-in-chief, who noticed there were not enough contributions for the February issue. Therefore, it was not the primary goal of the article to make an elaborated analysis, but rather to give some feedback to the observers to encourage them to provide data to the *VMDB* to produce better analysis in the future.

If one has a very large number of ZHRs, one can check all the conclusions using only the very good ZHRs. But in case there are too few ZHRs obtained under very favorable conditions, the question is whether one tries to get some idea about the activity profile from the unsignificantly small number of ZHRs with a small correction factor, or based on the significant number of stronger corrected ZHRs? In the Quadrantid paper, the different combinations all lead to the same result: a maximum of 88 ± 7 at $\lambda_\odot = 282\overset{\circ}{.}64 \pm 0\overset{\circ}{.}03$. I also tried to produce profiles taking into account some of Ralf and Jürgen's criteria and, still, this produces the same basic features. Very recently, I received a letter from Dr. B. McIntosh in which he says that the results in *WGN* are in line with his results.

The time interval of maximum did not contain many data points, but most were obtained by observations at the United States' West Coast where the radiant was high in the morning sky. In the period 14^h–15^h UT only a few Japanese observations are available. Most Japanese observations started in the morning (local time) after 16^h UT. This means that there is a gap of about 3 hours without much data by the low radiant position. The ZHR could have been underestimated during this period. Not a single observation indicates that! M. Simek concluded already before that the level of ZHR_{max} and the position of $\lambda_\odot$ varies from year to year.

We now come to the criticism of people who want to replace all tables in *WGN* by graphs. As a consequence of this policy, it is impossible to judge the weight of the data, since numerical data are missing. The data are kept only in the *VMDB* and only the author has then a good view on their reliability.

As a general conclusion, I can announce that the new version of the *VMDB* will be a sophisticated program, that will cope with most shortcomings of the first version. We have learned a lot over the past two years by trial and error method.

There is point in the criticism I do not agree with: the data evaluation can be done by a computer, even if the criteria are complex and require iterative procedures. If it is so that there is no rational methodology in the human made criteria, then it means that the criteria depend upon what the analyzers want to obtain and this could lead towards biased results.

Paul Roggemans

Did Heaven know about it?

Under this title, we received a humorous note from the Czechoslovakian telescopic meteor observer Petr Pravec about recent events, both in the sky as on Earth...

In last year's summer and autumn, the Czechoslovakian sky was really wonderful. This was maybe a "firework" for the celebration of the changes in Eastern Europe. One comet heeled another, two aurorae boreales were spotted an other successive phenomena occured too.

In June, Solidarity won parliamentary elections in Poland and that was the final end of the Stalinistic regime there. From July till September, the shining of the comet Brorsen-Metcalf (1989 *o*) celebrated this event.

At the beginning of October, a process of democratization in Hungary culminated with the disintegration of the Hungarian Labour Party. In October and the first half of November, ice started to move in the G.D.R., too. Okazaki-Levy-Rudenko (1989 *r*) watched all this with a smile at its head (from September to November). At the 20th of October an aurora borealis occurred—it was seen in Hungary. The Czechoslovakian people did not merit it yet, and that is why it was cloudy in their country.

On the 17th of November, however, just at the time of the massacre of the students on the Place of the Nation in Prague, a red aurora borealis flared over the whole Czechoslovakian country. In December comet Aarseth-Brewington (1989 *a*), brighter than all comets the past six years, shined in honor of a "tender" revolution. That comet put on the most beautiful look as well as a weeper, when the Rumanian people won the bloody fight for liberty.

Watching evolution, ideas of successive actions cross my mind. What is in store for us? Will it be "The Great Celestial Festival"? Let us take pains, so that it will be.

Petr Pravec, February 6, 1990

New Reporting Forms for Visual Observations

Ralf Koschack

In order to derive more reliable results from visual observations, more data than in recent years have to be reported and stored in the *VMDB* [1]. Therefore, new observing report forms have been established. You can find them on the following pages. Observers are asked to copy these forms and to use them for reporting their visual observations in the future.

The data needed for filling out the *Summary Report Form* are obtained by successively filling out a copy of the *Interval Analysis Form* for *each* observing interval. An observing interval should last 1.5 to 3 hours. Only around the time of maximum of a major shower, the interval length should be reduced to 1 hour. All times have to be given in UT.

We recall some details about the data requested additionally:

- To avoid shortcomings in future work, the radiant position and size assumed for shower association should be reported for every shower analyzed. If you do not assume a circular radiant area, mention diameter in right ascension followed by diameter in declination (e.g. $10^\circ \times 5^\circ$).
- Also for every shower analyzed, the observing method used has to be reported, i.e. plotting (P) or counting (C) of all possible shower members. Note that it is possible to plot e.g. all possible Aquarids and to count all other meteors.
- The center of the field of view should be reported for the middle of every interval (right ascension and declination with a precision of about 10° to 15°).

Please, send in only completely filled observing reports. For you, this is only a minor effort, but for us, this saves a lot of time. Moreover, you will guarantee that your observations can be used for serious analysis.

Reference

[1] R. Koschack, "Program of the Visual Commission of IMO", *WGN* 17:6, 1989, pp. 204–206.

International Meteor Organization

VISUAL OBSERVING FORM

Summary Report

Date: _____ (year), _____ (month), _____ (day). Begin: _____^{h}_____^{m}. End: _____^{h}_____^{m}. (UT)

Location: $\lambda =$ ___° ___′ ___″ E/W, $\varphi =$ ___° ___′ ___″ N/S, $h =$ ___ m. IMO Code: _________

Place: ______________________________ Country: ______________

Observer: ______________________________ IMO Code: _________

Observed showers *please use IMO three-letter code:*

Shower	α	δ	Diam.	Shower	α	δ	Diam.	Shower	α	δ	Diam.
________	___°	___°	____	________	___°	___°	____	________	___°	___°	____
________	___°	___°	____	________	___°	___°	____	________	___°	___°	____

Observed numbers of meteors per period and per shower:
(M: observing method (*C(ounting)*, *P(lotting)* or *R (meteor coordinates estimated directly)*)
(N: number of meteors observed; distinguish between "0" (no meteors seen) and
"/" (shower not observed during the period))

Period (UT)	Field		T_{eff}	F	Lm	______		______		______		______		______		______		Spor.	
($^{h\,m}$–$^{h\,m}$)	α (°)	δ (°)				M	N	M	N	M	N	M	N	M	N	M	N	M	N
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Fill out one copy of an Interval Analysis Form for each period mentioned above.

Magnitude distributions (for the entire observation):

Shower	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	+7	Tot
________															
________															
________															
________															
________															
________															
Spor.															

I.M.O. VISUAL OBSERVING FORM – Interval Analysis

Complete one copy of this form for each interval mentioned under "Period (UT)" on the Summary Report Form.

Date: ______ (year), ______ (month), ______ (day), interval from: ______h______m to ______h______m UT

Observer: ______________________________ IMO Code: __________

Time	Nr	N	Lm	Time	Nr	N	Lm	Time	Nr	N	Lm
__h__m				__h__m				__h__m			
__h__m				__h__m				__h__m			
__h__m				__h__m				__h__m			

Mean limiting magnitude Lm: __________ *(same as on Summary Report Form)*

Clouds, sky obscured	%	Clouds, sky obscured	%
__h__m–__h__m		__h__m–__h__m	
__h__m–__h__m		__h__m–__h__m	
__h__m–__h__m		__h__m–__h__m	
__h__m–__h__m		__h__m–__h__m	
__h__m–__h__m		__h__m–__h__m	

Breaks
__h__m–__h__m
__h__m–__h__m
__h__m–__h__m
__h__m–__h__m
__h__m–__h__m

$K =$ ______, $F = 1/(1-K) =$ ______ *(same as on Summary Report Form)*

Time for plotting: ______s/meteor, ______m total. Breaks: ______m total.

Netto observed time $T_{\text{eff}} =$ ______m= ______h *(same as on Summary Report Form)*

I.M.O. VISUAL OBSERVING FORM – Interval Analysis

Complete one copy of this form for each interval mentioned under "Period (UT)" on the Summary Report Form.

Date: _____ (year), _____ (month), _____ (day), interval from: _____h_____m_____s to _____h_____m_____s UT

Observer: ______________________________ IMO Code: __________

Time	Nr	N	Lm	Time	Nr	N	Lm	Time	Nr	N	Lm
__h__m				__h__m				__h__m			
__h__m				__h__m				__h__m			
__h__m				__h__m				__h__m			

Mean limiting magnitude Lm: __________ *(same as on Summary Report Form)*

Clouds, sky obscured	%	Clouds, sky obscured	%
__h__m–__h__m		__h__m–__h__m	
__h__m–__h__m		__h__m–__h__m	
__h__m–__h__m		__h__m–__h__m	
__h__m–__h__m		__h__m–__h__m	
__h__m–__h__m		__h__m–__h__m	

Breaks
__h__m–__h__m
__h__m–__h__m
__h__m–__h__m
__h__m–__h__m
__h__m–__h__m

$K =$ ______, $F = 1/(1-K) =$ ______ *(same as on Summary Report Form)*

Time for plotting: ______s/meteor, ______m total. Breaks: ______m total.

Netto observed time $T_{\text{eff}} =$ ______m= ______h *(same as on Summary Report Form)*

Observers' Notes: May–June 1990

Jeff Wood

1. Introduction

May and June sees the seasons changing from Spring to Summer in the northern hemisphere and from Fall to Winter in the southern hemisphere. Thus observing conditions tend to be more favorable in the northern hemisphere with warm clear nights than in the southern hemisphere where the temperatures approach freezing point when it is clear. Although there is only one really major shower active during this period, the η-Aquarids, there are a large number of minor streams active especially in the Scorpius-Sagittarius region that makes for good viewing. Table 1 below lists 20 of the more important showers that occur during May and June.

Table 1 – A list of some of the meteor showers to be seen in May-June 1990.

Shower	α	δ	Period	Max
α-Scorpids	246°	−23°	Mar 26–Jun 4	Several
η-Aquarids	337°	−01°	Apr 18–May 29	May 5
Corona Australids	284°	−40°	May 8–27	May 18
May Ophiuchids N	254°	−13°	Apr 25–Jun 2	May 18
May Ophiuchids S	256°	−24°	Apr 21–Jun 4	May 19
κ-Scorpids	267°	−39°	May 5–28	May 20
o-Cetids	27°	−04°	May 5–Jun 2	May 20
χ-Scorpids	247°	−13°	May 20–June 17	Jun 2
ω-Scorpids	243°	−22°	May 21–June 15	Jun 3
τ-Herculids	228°	+39°	May 19–Jun 14	Jun 3
Daytime Arietids	44°	+23°	May 29–Jun 19	Jun 7
ι-Scorpids	265°	−40°	May 30–Jun 18	Jun 8
γ-Sagittarids	272°	−28°	May 23–Jun 16	Jun 8
λ-Sagittarids	276°	−25°	Jun 5–Jul 21	Several
θ-Ophiuchids	264°	−20°	Jun 4–Jul 15	Several
June Lyrids	278°	+35°	Jun 11–21	Jun 16
June Bootids	219°	+49°	Jun 20–Jul 6	Jun 28
τ-Cetids	24°	−12°	Jun 18–Jul 5	Jun 28
ρ-Sagittarids	293°	−17°	Jun 15–Jul 8	Jun 29
τ-Aquarids	342°	−12°	Jun 19–Jul 8	Jun 30

Table 2 – Moonlight and observing conditions in May-June 1989.

Date	k	Date	k
Friday April 27	0.05+	Friday June 1	0.57+
Friday May 4	0.72+	Friday June 8	1.00+
Friday May 11	0.99−	Friday June 15	0.63−
Friday May 18	0.48−	Friday June 22	0.01−
Friday May 25	0.01+	Friday June 29	0.41+

New Moon:	April 25, May 24, June 22
First Quarter:	May 1, May 31, June 29
Full Moon:	May 9, June 8, July 8
Last Quarter:	May 17, June 16, July 15

The illuminated part of the Moon is always given for 0^h UT on the date indicated. The dates of the phases of the Moon are also given in UT.

2. The η-Aquarids

The η-Aquarids which were produced by debris from Halley's Comet are a very spectacular stream especially for southern hemisphere observers. Unfortunately, because the radiant reaches culmination during daylight hours, the η-Aquarids cannot be viewed in all their glory. Although the radiant is equatorial with a declination of $-1°$, the seasons are such that it is daylight in much of the northern hemisphere before the radiant can rise more than 20° above the horizon. The southern hemisphere is more favorably placed and the radiant is able to rise above 50° before sunrise.

The η-Aquarids are best viewed the last couple of hours before sunrise approximately from 3^h45^m to 5^h45^m am local time. Moreover, since it is about halfway between First Quarter and Full Moon around maximum, only this short period before daybreak will be moon-free. η-Aquarids are characteristically fast, yellow in color and have a train. It is not unusual for these trains to be very persistent lasting more than 30 seconds. Also, the η-Aquarids produce many brilliant fireballs.

3. Scorpius-Sagittarius complex

This name is given to the large number of ecliptic streams that are active in the constellations of Scorpius and Sagittarius from March to July. Although many of these streams produce only a handful of meteors per night, they have been known for unusually high rates on odd occasions. The Scorpius-Sagittarids are noted for the brilliant fireballs they produce. Although their parent body is not known, various authors have connected them with Comet Lexell (1770 I) and the Apollo Asteroids Adonis and 1983 LC.

In Table 1, I have listed some 12 components of the complex. Of these, the most active are the α-Scorpids, the ω-Scorpids, the Corona Australids and the λ-Sagittarids, which in most years produce over 4 meteors per hour at maximum. Because of their long period of activity and the fact that their radiants are visible virtually the whole night, these streams are not unduly hindered by the Moon.

4. Daytime showers

Since the southern hemisphere is approaching the winter solstice, the long nights mean that the radiants of several of the major daytime streams can rise substantially above the horizon before daylight. The two best candidates for viewing are the May *o-Cetids* and the June *Arietids*. Past observations of these streams indicate that during the last hour of darkness before dawn visual rates can rise up to 5 meteors per hour. Both the *o*-Cetids and the Arietids produce fast blue-white colored meteors which often have a train.

5. Minor northern hemisphere showers

Observations have shown that the *June Lyrids* produce irregular activity from year to year ranging from ZHRs of 1 to 10 meteors per hour. Since there is a Last Quarter on June 16, moon-free observations are only possible before midnight. However, an enhanced display of June Lyrids will not be unduly affected due to their overall brilliance if indeed one does occur. The June Lyrids are noted for being blue-white in color and having a train. The average magnitude of their 1969 display was 2.0 making them easily visible in all but the poorest of skies.

The *June Bootids* were produced by debris from Comet Pons-Winnecke and provided a great display on June 28, 1916. Since this time further good displays, but nowhere near as strong, were noted in 1921 and 1927. However, after the 1920s the shower produced 2 or 3 meteors per hour at best. Even though calculations show that Jupiter has perturbed the orbit of the meteors away from the Earth, another good display could come at any time like the surprise 1966 great Leonid storm. Thus observers should continue to monitor the June Bootids on a regular basis. These meteors were characteristically very slow and very faint. Observers of the 1921 and 1927 displays said that the majority of the meteors seen were magnitude +4 or fainter meaning that a dark sky is a must to detect them.

A First Quarter Moon will affect observations to some extent in the first part of the night, which is when then radiant has its highest elevation in the sky.

6. Minor southern hemisphere showers

The τ-*Cetids* were first observed by Jack Bennett, the discoverer of the great comet of 1970–71, during the late 1970s when rates of 5 to 10 meteors per hour were recorded. The τ-Cetids are best viewed the last couple of hours before dawn. They produce often bright, fast, blue-white meteors that frequently have a train.

The τ-*Aquarids* produce variable rates from year to year. At best they can reach 15 meteors per hour and at worst almost zero at maximum. Observers are encouraged to keep an eye out for these meteors. The τ-Aquarids are similar in speed to the δ-Aquarids and like their late July counterparts produce many meteors in the magnitude +2 to +4 category. Few τ-Aquarids produce trains.

Both streams can be observed with a favorable Moon.

We look forward to seeing the results of your observations. Clear skies and good viewing!

Call to Radio Observers

Dirk Artoos

On *April 25*, 1988 ($\lambda_\odot = 34\overset{\circ}{.}88$), I received a high number of reflections at 10^h UT. Observers are asked to listen around this date.

Also, there is a possibility for daylight meteor activity at *June 11*, due to the Earth-grazing asteroid 1989 UR. According to Christian Steyaert's calculations, the coordinates of the possible radiant are $\alpha = 80°$ and $\delta = -06°$.

Below the observability function is given for 50° N, 0° and 50° S. The value (a percentage) is given for each hour local time for the directions South, West, East and North. 100% corresponds to the best observability, 0% with the radiant under the horizon. For the calculations, a four element antenna at an elevation of 45°, a transmitter distance of 1000 km and a transmitter power of 30 kW were assumed.

Table 1 – Observability function for a four-element antenna elevated at 45° for each hour of the day (local time), four cardinal directions and three latitudes (100 = best observability, 0 = radiant below the horizon). For the calculations a transmitter distance of 1000 km and a transmitter power of 30 kW was assumed.

Lat.	Dir.	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
+50°	S	0	0	0	0	0	0	0	14	44	70	90	100	98	99	91	71	45	16	0	0	0	0	0	0
+50°	W	0	0	0	0	0	0	0	26	67	92	92	99	100	97	89	78	60	25	0	0	0	0	0	0
+50°	E	0	0	0	0	0	0	0	23	59	78	89	97	100	99	92	92	68	28	0	0	0	0	0	0
+50°	N	0	0	0	0	0	0	0	11	35	57	87	99	93	100	87	57	35	12	0	0	0	0	0	0
00°	S	0	0	0	0	0	0	0	37	71	95	100	70	0	70	100	95	72	39	0	0	0	0	0	0
00°	W	0	0	0	0	0	0	0	42	71	91	100	97	16	14	34	56	60	40	0	0	0	0	0	0
00°	E	0	0	0	0	0	0	0	39	60	57	35	15	14	96	100	90	72	43	0	0	0	0	0	0
00°	N	0	0	0	0	0	0	0	37	70	93	99	83	60	82	100	93	70	38	0	0	0	0	0	0
−50°	S	0	0	0	0	0	0	9	30	50	67	92	100	88	100	93	68	51	31	10	0	0	0	0	0
−50°	W	0	0	0	0	0	0	17	54	83	100	94	97	97	94	89	82	74	52	17	0	0	0	0	0
−50°	E	0	0	0	0	0	0	15	50	73	82	88	94	97	97	94	100	83	55	18	0	0	0	0	0
−50°	N	0	0	0	0	0	0	12	42	69	90	100	92	83	91	99	91	70	43	14	0	0	0	0	0

An Early Observation of Virginid Activity

Donald W. Olson, Southwest Texas State University

An observer at Vidalia, Louisiana, USA, on April 18, 1841, noted an unexpectedly intense shower from a radiant in Virgo. This may be first record of activity from the Virginid meteor complex and may also be the strongest Virginid activity ever recorded.

By the late 1830s, both the November Leonid and August Perseid meteor showers were well-recognized, and attention began to be directed to other times of the year, including the month of April. In a series of articles [1,2,3,4] in 1938 and 1939, Edward C. Herrick of Yale collected and published accounts of Lyrid meteor storm of April 20, 1803, and asked that "diligent observation should be made at this season of the year" to determine whether "evidence of its return might be detected" [3]. On April 19–20, 1839, Herrick himself observed a shower with a radiant near α Lyrae [4].

One of those who answered the call for additional April meteor observations was Caleb G. Forshey, then an engineer on hydrological projects along the Mississippi River and later an educator in Texas [5]. Forshey was a frequent contributor to scientific journals of the 1840s and 1850s on such naked-eye astronomical phenomena as aurorae, the zodiacal light and zodiacal band, and meteor showers, including the Leonids of 1833–1840 and the Perseids of 1837–1840 [5,6,7].

Forshey was unsuccessful in detecting a return of the Lyrid storm, but he did serendipitously discover something else quite interesting on the evening of April 18, 1841:

> *At about 8 o'clock on the same night, the 18th, at Vidalia, in Louisiana, Prof. Forshey noticed an unusual number of meteors in different parts of the heavens, and on tracing their paths backwards, found that they traversed the Constellation Virgo. Having commenced precise observations at half past 8, and continued them for three hours, he saw in two hours and a quarter, forty-five minutes being lost in recording, sixty meteors, of which, all but five, passed within 10° from the common radiant point. These meteors were very unlike those of the August shower; being chiefly without trains, and of a reddish colour, few of them of the first magnitude, and the greater number of the third and inferior magnitudes. Their velocities were remarkably equal and gentle; their paths short; and their light first increasing, then waning, as if they were moving on a chord to the circle of visibility. Professor Forshey determined their radiant point to be in a line drawn from Spica to Theta Virginis, somewhat nearer to Spica, say in R.A. 198°, S. Decl. 8°.* [6]

Forshey's description of slow reddish meteors from a diffuse radiant near the ecliptic in Virgo suggests an identification with the modern Virginid complex of radiants [8,9,10]. If so, this account from 1841 may have historic significance as both the first record of a meteor shower from the Virginid complex and the strongest Virginid activity ever reported. Forshey recorded 55 shower members during this watch (April 19, 1841, 2^h36^m to 5^h36^m UT; $T_{\rm eff} = 2^h\!.25$) at Vidalia (longitude 91°26′ W, latitude 31°34′ N), for an estimated ZHR of 34 meteors per hour.

Sears C. Walker, then at the Philadelphia High School Observatory, conducted a survey and found that the meteors on April 18–19, 1841, had gone generally unnoticed in the eastern USA except for the following brief report, which, if accurate, implies an even higher hourly rate:

> *In the morning of the 19th, however, a gentleman of Philadelphia, Mr. William F. Kintzing, counted eight in the course of ten minutes, shortly after mignight.*[6]

In modern times, activity from the Virginid complex is generally weak, with reported ZHRs often remaining below 1 or 2 meteors per hour and only occasionally reaching 5 to 10 meteors per hour [8,9,10]. However, modern observers are strongly urged to devote at least some attention to the March-April-May period, so that records might be made if strong unpredictable activity should occur, as it did on the night of April 18–19, 1841.

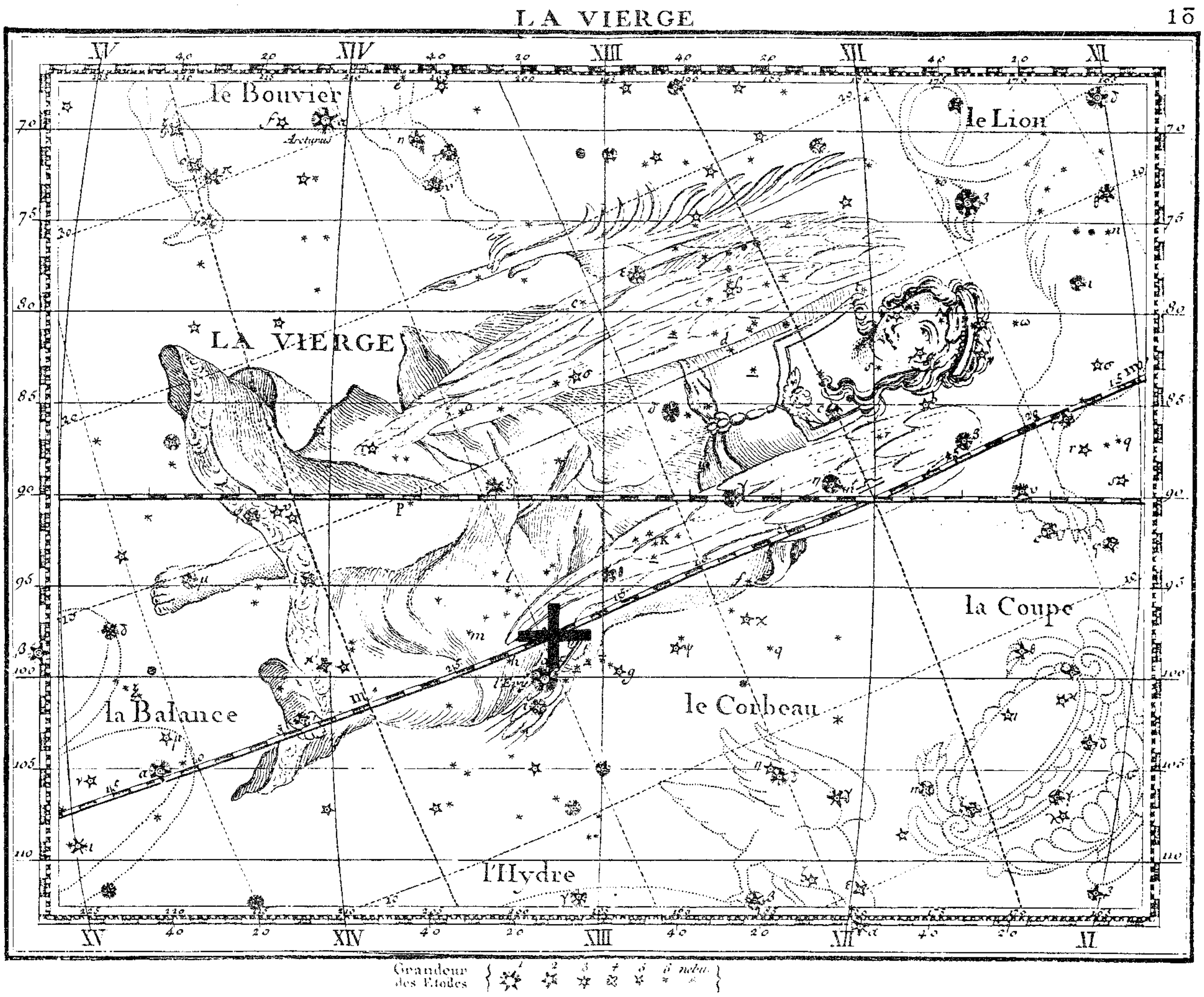

Figure 1 – The radiant (+) of the shower observed on April 18, 1841, fell near the ecliptic, as do modern Virginid radiants. This illustration of the Virgo region is from *Atlas Céleste*, a nineteenth-century French edition of John Flamsteed's *Atlas Coelestis*.

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[3] E.C. Herrick, "Report on the Shooting Stars of December 7, 1838, with remarks on Shooting Stars in general", *Am. Journ. of Sci.* 35, January 1839, pp. 361–368.

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Determination of Spatial Number Density and Mass Index from Visual Meteor Observations (I)

Ralf Koschack and Jürgen Rendtel

Some basic ideas concerning the calculation of spatial number densities and mass index of meteor showers were already described in previous papers. Here we present results derived from a larger sample of meteors observed in modified double count observations. Furthermore, the influence of some effects on the derived values are analyzed in detail. These double count observations allow the determination of certain probabilities of perception for a group of experienced observers. The formulae for the calculation of the mass index and the spatial number density of meteoroids with masses greater than 10^{-3} g in a shower are derived.

1. Introduction

From a visual meteor observation we may obtain two results: a ZHR and a population index r. These values should not be the final ones, since the parameters requested are the mass index s and the number density ρ of a given shower. The standard observing technique used in *IMO* worldwide requires an unrestricted field of view. Such observations are available for many years and periods. Therefore it is useful and necessary to develop methods to derive the requested parameters from such observations.

Alternatively, there are existing observing techniques, such as group observations using a restricted field of view centered at the zenith. At a first glance these seem to be more suitable for the purpose. But they contain disadvantages, too. They require some more effort and cannot be applied anywhere, they are not very effective concerning the sample, and they cause problems in connection with a reliable association of meteors to minor shower radiants. Finally, it seems impracticable to change the observing technique after a few years in an organization like *IMO*.

Thus we refer all analyzing procedures to the valid *IMO* standard. First attempts were published in previous papers [1,2].

In the present article we improve the method and are able to include much more observational data. Because of the huge amount of problems and their detailed approach we divide the work into two parts. Part I deals with the derivation of the method. We take into consideration a lot of influences. To this end we present observational material of one group. Data derived from visual observations, such as ZHR and r, contain uncertainties. We think that it is not very clever to consider all influences in an extensive and complicated method, rather than to find out the amount of possible errors. From this we decide which effects have to be considered and which do not. It is senseless to introduce a dozen of correcting factors if the basic material (e.g. already the number of meteors observed) is uncertain. Part II will present personal data concerning perception and conclusions from these. Furthermore we introduce an applicable procedure to all observers taking into consideration the perception of an individual observer.

To restrict the extent of the article we refer to the earlier publications in *WGN* and add an appendix containing some derivations and secondary results (not necessary for the immediate understanding but useful to trace back the procedure). This appendix will follow part II, to be published in the *August issue* of *WGN*.

2. The observed field

The effective radius of the field of view

In order to calculate the spatial number density of a meteor stream it is necessary to know the area surveyed by an observer at the meteor level. This field of view depends on the meteor's magnitude. It is rather small for a meteor of e.g. +6 while a −6 fireball will be visible ("detectable") even behind the observer. Since such bright meteors are rare events (about one meteor of at least −3 within 5 hours observing time as an annual average was found [3]) we can neglect them in the sample used for the calculation of the number density ρ.

For the determination of the effective size of the field of view for "ordinary" meteors we divide the field into radial distance classes of 5° width each, starting from the center.

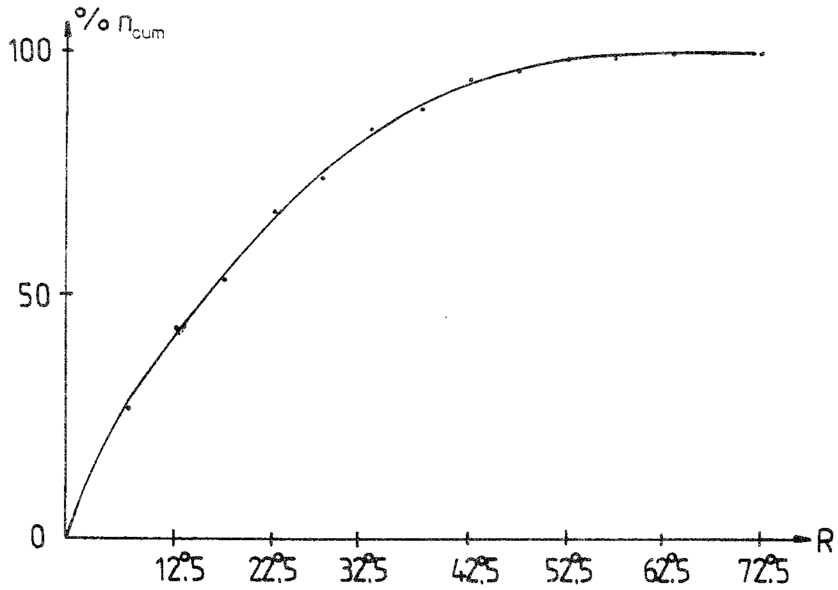

Figure 1 – Relative cumulative number of meteors observed in the distance classes R from the center of the field of view.

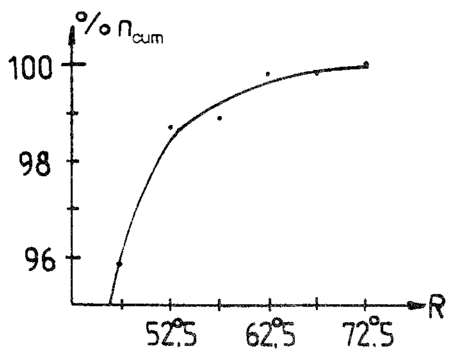

Figure 2 — Detail of Figure 1 for the outer region of the field.

The class $R = 10°$ includes the interval [7°5, 12°5]. The innermost class $R = 5°$ includes the interval [0°, 7°5]. The distance of a meteor seen (its brightest part) from the center of the field is classified to its class R.

Figure 1 shows the observed cumulative number of meteors inside the given distance R (2822 meteors registered in double count observations in August 1988 by an *AKM* group in the Bulgarian Rhodope mountains). At great distances from the field's center only few meteors were seen. Figure 2 demonstrates the reasonability of an effective field radius of 52°5. The slope of the cumulative distribution in Figure 1 strongly decreases at that point. About 98.7% of the meteors seen appear inside this field with $R = 52°5$ (class 50°). The remaining 1.3% are distributed over the classes $R = 55°–70°$ and can thus be neglected.

The effective radius of the field of view of a visual observer amounts to 52°5. It is regarded to be circular. The number of meteors with distances $R > 50°$ can be neglected (very few meteors; shower association at such a distance is very uncertain, and the meteors have to be regarded as sporadics, normally).

The corresponding area at the meteor level

Figure 3 shows the projections of the field boundaries ($R = 52°5$) for a field centered at the zenith ($h_f = 90°$) and another one centered at $h_f = 50°$ onto the meteor level (height $H = 100$ km) at the right scale. In the first case the projections of the isohypses appear as circles around the zenith. A field centered at $h_f = 50°$ corresponds to a larger area at the meteor level. Thus a higher number of meteors should be expected. On the other hand practical experience gives no hints towards systematical and significant differences between observers looking to the zenith or to a point of smaller elevation. Consequently, the area of projected field of view cannot be regarded as a measure of the number of meteors.

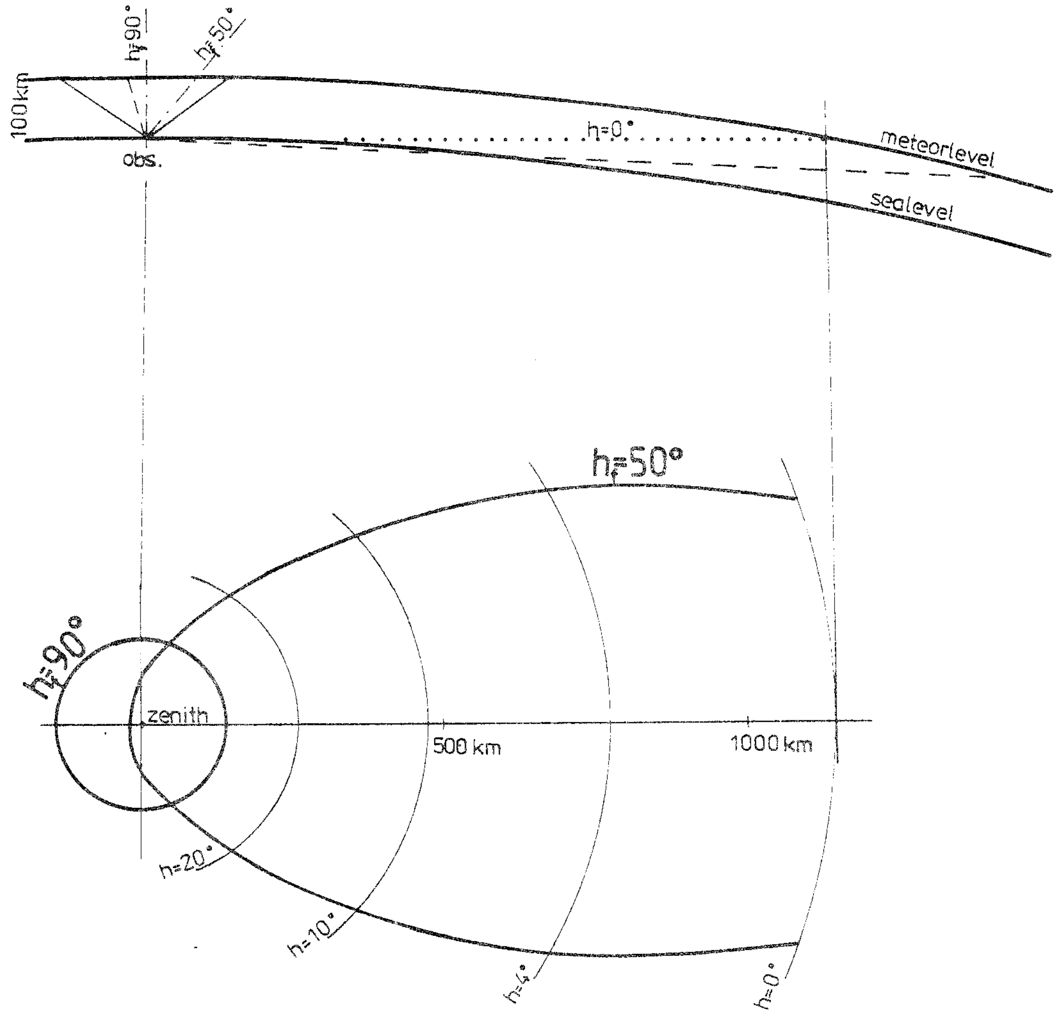

Figure 3 – Projection of a zenith-centered field of view $h_f = 90°$ and a field of view elevated at $h_f = 50°$ into the meteor level ($H = 100$ km) at the right scale.

The largest portion of the area at the meteor level in the case of $h_f = 50°$ is situated near the horizon. Therefore effects as the shape of the natural horizon, extinction, and diminishing of the meteor's apparent magnitude due to enhanced distance are important. As a consequence, the observable number of meteors per area unit decreases toward lower elevation angles.

In order to derive a particle flux or a number density it is necessary to reduce data on a standard area A_{red} (distance to the observer of 100 km, and no extinction ε). We calculate the areas A_i for small elevation zones centered at h_i and add them:

$$A_{\text{red}} = \sum_i A_i \, r^{5 \log \frac{100 \text{ km}}{d} - \varepsilon_i} \qquad (1)$$

For the calculation of the probabilities of perception it is necessary to know the ratio of the area (and hence the contribution of meteors) for each distance class R from the center of the observed field relative to the total field A'_R. The exact calculation of the areas is quite involved in the case of a field not centered at the zenith ($h_f < 90°$). We use the following method:

1. computation of the boundary lines for each distance class at the meteor level (cfr. appendix);
2. the isohypses in Figure 3 are circles at the meteor level surrounding the zenith (for the calculation of certain lines, see appendix);

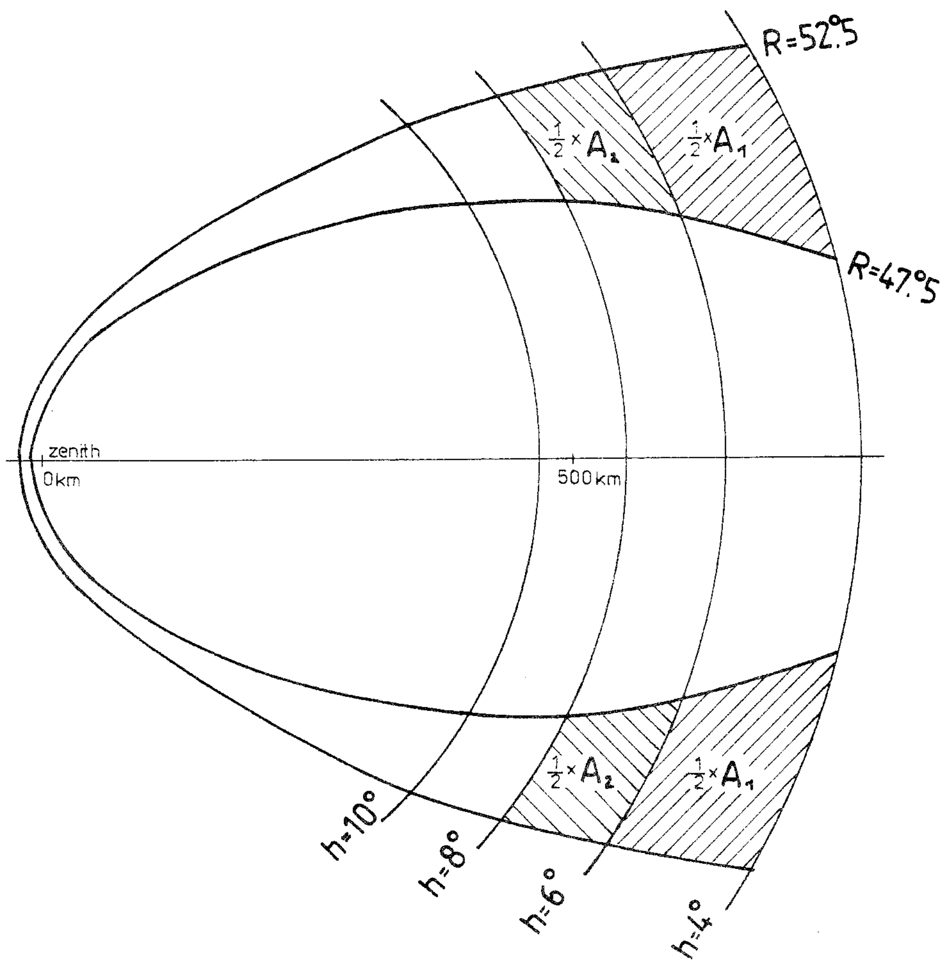

Figure 4 – Principle of the determination of the reduced areas A_R for a given distance class. As an example the outer parts of a field of view at $h_f = 50°$ are represented (hatched areas).

3. graphic determination of the areas A_i for each distance class and for each range of elevation h_i choosing a suitable scale. Because of the skyline of the horizon, only elevations $h > 4°$ were taken into account (for a detailed description, see appendix);
4. determination of A_R for each distance class;
5. summing up the values of A_R according to equation (1) in order to get A_{red}; and
6. calculation of the ratio of the areas of the distance classes to the total field of view:

$$A'_R = \frac{A_R}{A_{\text{red}}} \qquad (2)$$

For all computations of A_R and A_{red} a height $H = 100$ km was assumed. The procedure was carried out for $h_f = 40°$, $h_f = 50°$, and $h_f = 65°$. Furthermore we estimate the influence of the altitude H relative to the "standard" value $H = 100$ km. We take into consideration the calculated areas A_{red} and A'_R for $h_f = 90°$ as well as different values of the population index r (Table 1).

Table 1 – Influence of the altitude H and the population index r on the area A_{red}, for $h_f = 90°$ (zenith).

	$r = 2.0$			$r = 2.7$			$r = 3.5$		
H (km)	90	100	110	90	100	110	90	100	110
A_{red} (km²)	31 800	33 500	35 100	28 700	28 200	27 700	26 400	24 400	22 800

Within the range $2.0 \leq r \leq 3.5$ covering the common showers as well as the sporadic meteors the deviations of A_{red} for altitudes between $H = 90$ km and $H = 110$ km do not exceed 10%. The largest differences appear for $r = 3.5$. In Table 2 we summarize the values of A'_R for $r = 3.5$ demonstrating that the deviation for the altitudes other than 100 km are less than 5%.

Table 2 – Area A'_R for zenith field ($h_f = 90°$) and $r = 3.5$.

R	$H = 90$ km	$H = 100$ km	$H = 110$ km
05°	0.0226	0.0216	0.0221
10°	0.0379	0.0394	0.0388
15°	0.0590	0.0591	0.0592
20°	0.0772	0.0767	0.0770
25°	0.0958	0.0952	0.0954
30°	0.1127	0.1128	0.1128
35°	0.1294	0.1290	0.1288
40°	0.1433	0.1445	0.1441
45°	0.1556	0.1553	0.1558
50°	0.1666	0.1664	0.1660

From these calculations it is obvious that we can neglect different heights of the luminous meteor path and that we can consider $H = 100$ km as a constant.

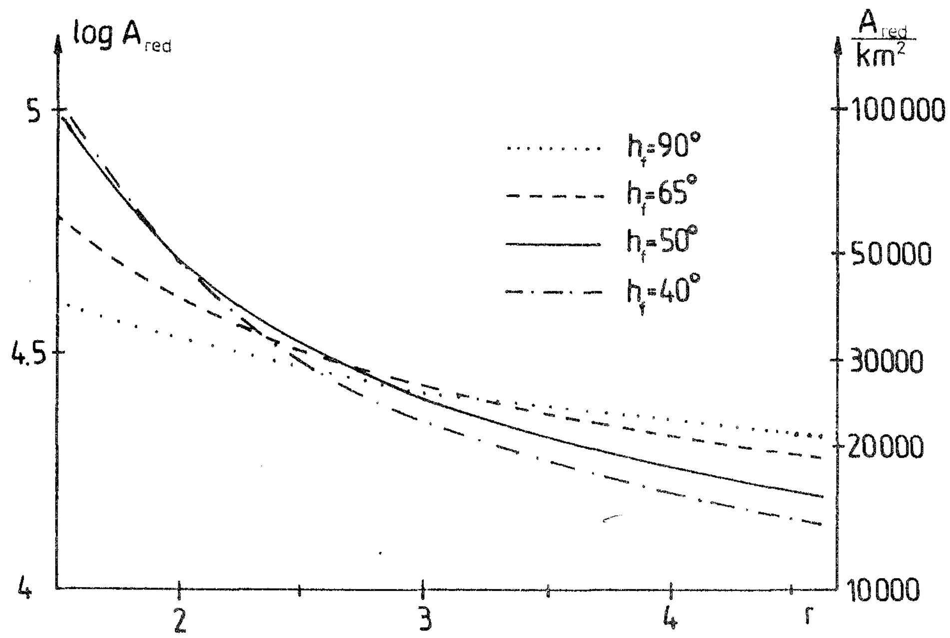

Figure 5 – Dependence of the reduced area A_{red} of an observer on the population index r for different fields of view (elevations of the centers h_f).

In Figure 5 we demonstrate the dependence of A_{red} on the population index r. In the case of a larger value of r near zenith areas should be preferred, while towards lower r-values the favorable elevation of the center of the observing field is about $h_f = 50°$. Within the usual limits of r one should not find significant deviations caused by different h_f. This also agrees with the practical experience. In most cases the observer chooses $h_f \approx 50°$. Furthermore we should keep in mind that we take into account average extinction values [4]. They may differ from the actual situation. Therefore a detailed consideration of elevations of the field of view differing from $h_f = 50°$ does not make much sense. We may use the values of A_{red} given in Table 3 calculated for $h_f = 50°$ and $H = 100$ km. The values can be approximated sufficiently for the given interval by:

$$A_{\text{red}}(r) = 178\,700 r^{-1.82} \tag{3}$$

Table 3 – Area A_{red} in dependence on r for $h_f = 50°$ and $H = 100$ km.

r	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6
A_{red} (km^2)	62 120	54 750	48 940	44 260	40 450	37 290	34 630	32 390	30 460
r	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5
A_{red} (km^2)	28 790	27 330	26 050	24 920	23 910	23 000	22 190	21 450	20 770

3. The probabilities of perception

The probability of perception p of a meteor can be calculated from the true number φ of meteors appearing and the number of observed meteors n by $p = n/\varphi$. The probability p depends on the magnitude, or more precisely on the difference between the (meteor) limiting magnitude and the magnitude of the meteor:

$$\Delta m = \text{lm} - m \tag{4}$$

as well as from the distance R from the center of the field of view. Furthermore the probability of perception is influenced by the angular velocity, the trail length and the train of a meteor. We try to find a value of the probability $p(\Delta m)$ for each magnitude class averaged over the entire field of view.

The double count method

The method and the accompanying problems were already described in detail in [1]. We describe the procedure of observation and analysis also in the appendix (to appear in part II, in the August issue). Here we add some remarks concerning the restrictions of the method. In the case of double count observations with identical field centers, $p_1 \approx p_2$ for a given meteor. The effects described in [1] do not allow determinations of $p \leq 0.5$ from such observations with sufficient certainty. In the other case (field centers 20° apart) the probability of perception of a meteor in the center of the field of observer 1 (p_1) is about 2–3 times higher as for the observer 2 at 20° distance (p_2). From these observations with field centers 20° apart we can derive probabilities to $p \geq 0.1$ without strong selection effects. We obtain values of the probability p for $R = 20°$–$40°$ with good certainty. If we enlarge the distance between the centers of the fields of view of the two observers to 35° the already mentioned factor increases to 5–7 and allows a calculation of the probability to $p \geq 0.05$ for $R = 35°$–$60°$. Towards brighter magnitudes the probabilities of perception p of both observers tend to become equal, and the value itself increases. Thus the calculated probabilities for such meteors are certain.

Determination of the probabilities of perception from double count observations

For our analysis we have at hand a sample of about 5000 meteors noted during the double count observations of ARLRA, BALPE, KNOAN, KOSRA, RENIN, RENJU, and SEIHO in 1985–1989.[1] The major part was done in 1988. The material includes observations of all three versions mentioned (field centers of both observers identical, 20° apart, and 35° apart). In part II of our article we present results concerning the observers separately. Here we restrict ourselves to an average.

At the beginning we determined systematic deviations of the perception of SEIHO from the average. Therefore we combined only the other observers to calculate average probabilities of perception. Furthermore we treated the data of the three sets (0°, 20°, 35° distance respectively) seperately. Observations carried out under different limiting magnitudes were combined into two sets for an interval of half a magnitude width in limiting magnitude.

[1] The abbreviations refer to the *IMO* observer codes in the *Visual Meteor Data Base (VMDB)* and can be found e.g. in the report announced on p. 30 and the back cover. (Ed.)

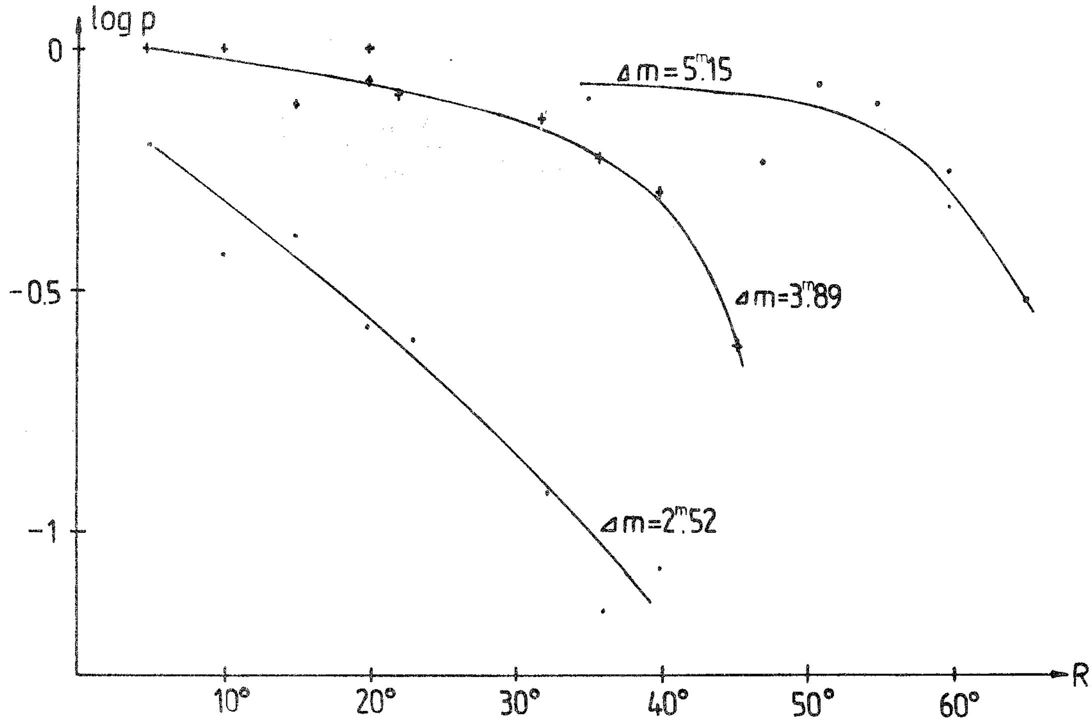

Figure 6 – Raw data of $p(\Delta m, R)$ for some Δm before any smoothing and graph used for the further evaluation.

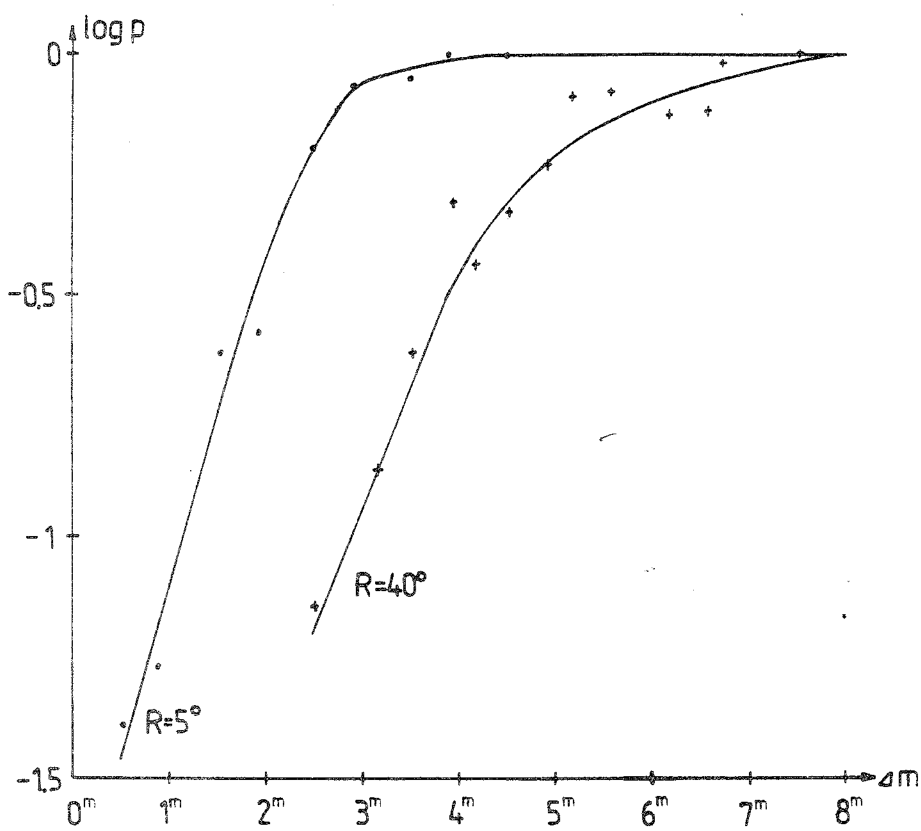

Figure 7 – Graphs of $p(\Delta m, R)$ after the first smoothing for some distance classes R.

These groups are:

1. $5.75 \leq \text{lm} < 6.25$, and $6.75 \leq \text{lm} < 7.25$; and
2. $6.25 \leq \text{lm} < 6.75$, and $\text{lm} \geq 7.25$.

Meteors of a magnitude class are put into one group. An average magnitude difference Δm, weighed with the number n of meteors seen, was calculated. For example, we put together the meteors of the class $m = +3$ seen under $6.75 \leq \text{lm} < 7.25$ and of the class $m = +4$ seen under $6.75 \leq \text{lm} < 7.25$. Weighed with their number n we obtain an average $\Delta m = 2.89$.

For the calculation of the probabilities of perception p, see [1]. The values of p calculated are then smoothed graphically over R for each smoothed Δm. After that, values of p were smoothed graphically for each distance class R. All graphical smoothings were carried out using a logarithmic scale on the ordinate. Identical relative errors appear then in the same size.

Figure 6 shows the values of p calculated before any smoothing. It demonstrates the amount of scatter in these values derived from the observations. In Figure 7, we show the result after the first smoothing.

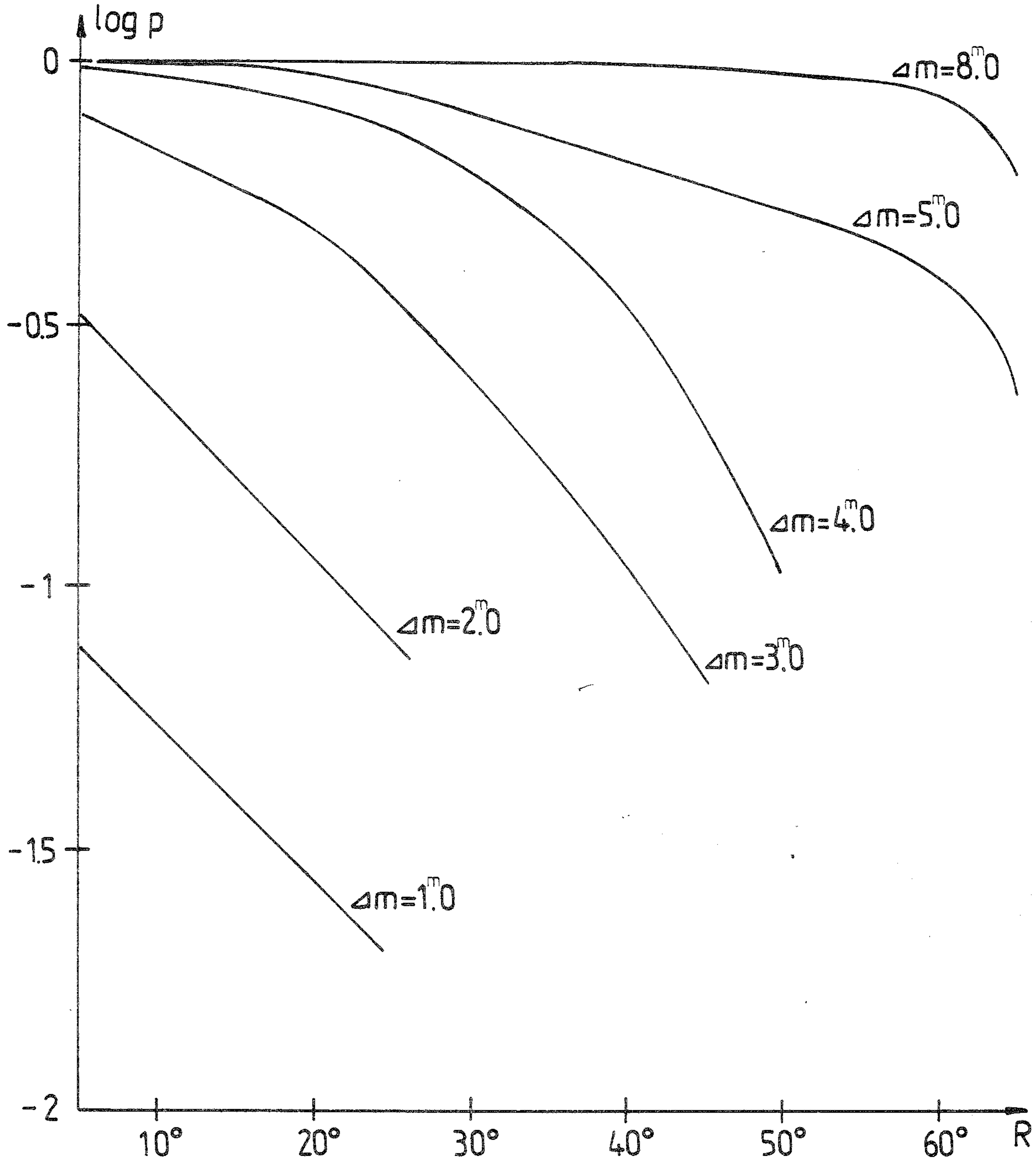

Figure 8 – Probabilities of perception $p(\Delta m, R)$ for some magnitude differences Δm in dependence on R.

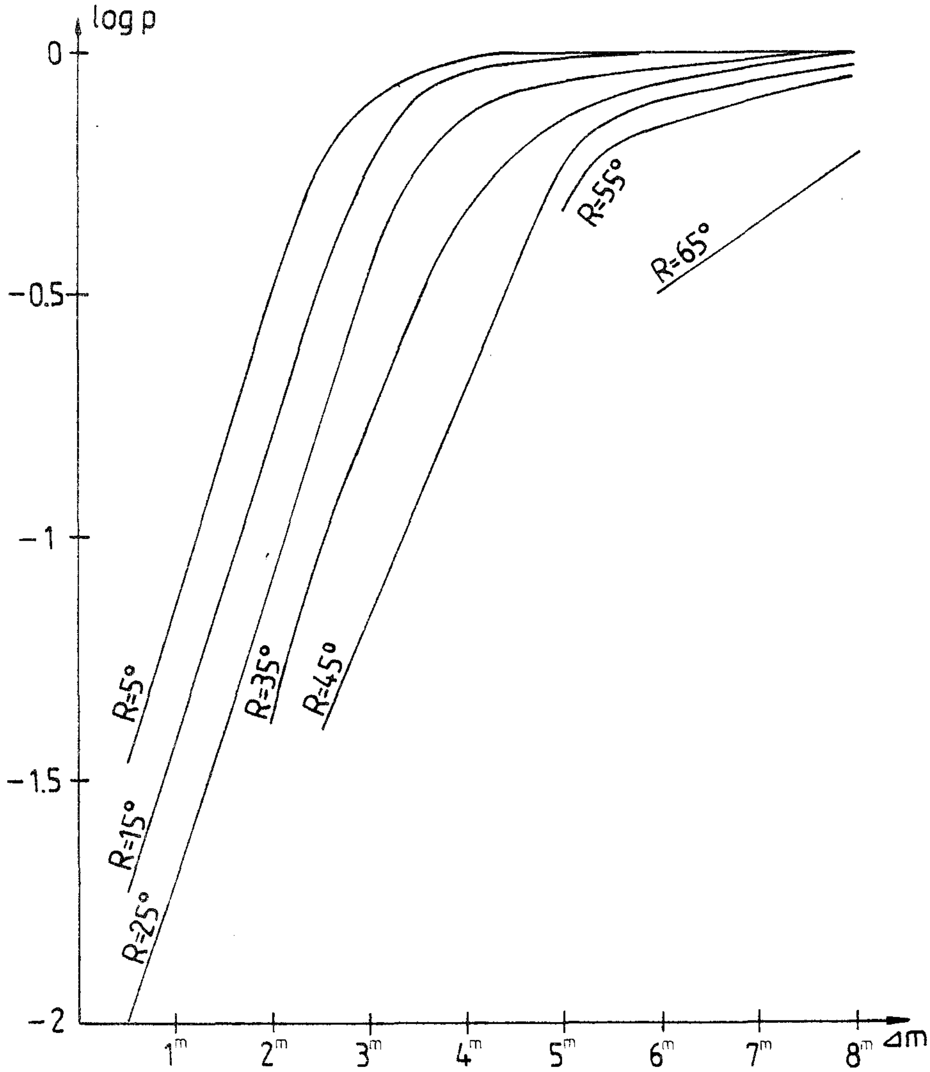

Figure 9 – Probabilities of perception $p(\Delta m, R)$ in dependence on Δm for some distance classes R.

In order to get smooth graphs for the further analysis we smoothed again over the distance R and the magnitude difference Δm. The result is shown in Figures 8 and 9 and also given in Table 4.

Table 4 – Probability of perception p in dependence on Δm (horizontal scale) and R (vertical scale) as found from the double count observations.

	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0
05°	0.0347	0.0777	0.158	0.330	0.600	0.794	0.912	0.98	1	1	1	1	1
10°	0.0252	0.0550	0.112	0.230	0.445	0.677	0.850	0.95	0.98	0.98	1	1	1
15°	0.0186	0.0390	0.0775	0.162	0.322	0.575	0.813	0.91	0.95	0.98	0.98	1	1
20°	0.0135	0.0275	0.0550	0.115	0.245	0.490	0.723	0.85	0.91	0.93	0.95	1	1
25°	0.0100	0.0195	0.0380	0.079	0.178	0.355	0.575	0.74	0.83	0.87	0.91	0.98	1
30°				0.059	0.135	0.245	0.416	0.617	0.723	0.81	0.89	0.98	1
35°				0.0415	0.0954	0.170	0.302	0.478	0.616	0.723	0.85	0.93	1
40°				0.0295	0.0645	0.118	0.214	0.346	0.500	0.645	0.83	0.93	0.98
45°					0.0397	0.066	0.114	0.200	0.362	0.588	0.79	0.89	0.95
50°							0.0724	0.112	0.208	0.524	0.76	0.85	0.93

Remembering the limits of the double count method mentioned earlier we have to consider the values of p for $\Delta m < 2$ to be uncertain. Further calculations are based only on the values for $\Delta m \geq 2$.

The values of p given in Table 4 are not usable for analysis of observations in this form. We rather need an average probability of perception $p(\Delta m)$ over the effective field of view of an observer. This can be calculated by averaging all $p(\Delta m, R)$ for each magnitude class Δm weighed with the area A'_R:

$$p(\Delta m) = \sum_R p(\Delta m, R) A'_R \tag{5}$$

The area A'_R depends on the population index r and the elevation of the field of view h_f. Thus also $p(\Delta m)$ depends on these quantities.

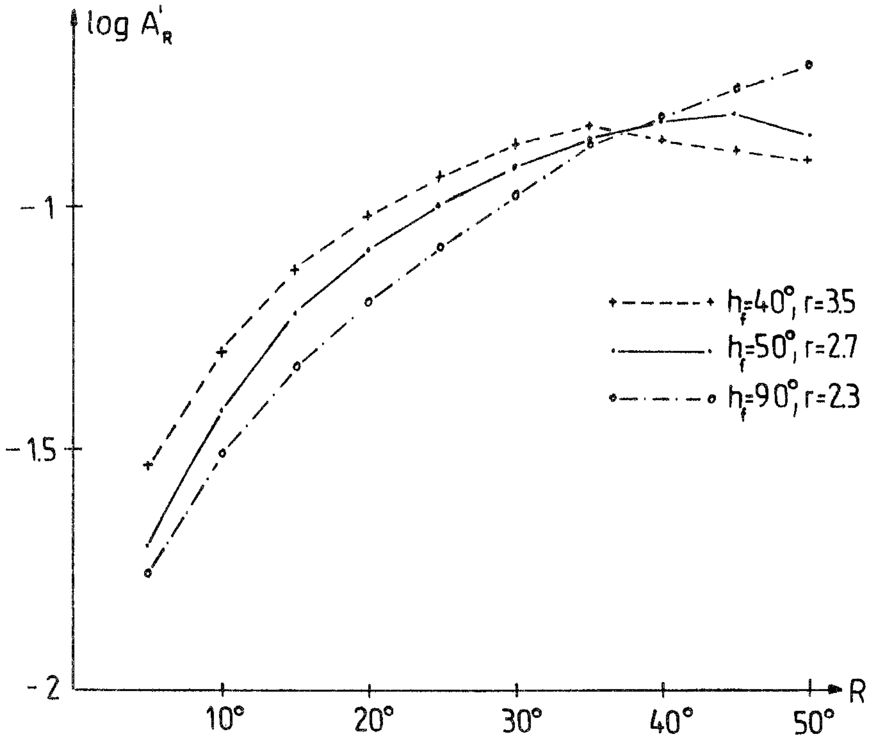

Figure 10 –Most extreme functions for $A'_R(h_f, r)$ and a curve which can be regarded as standard ($h_f = 50°$, $r = 2.7$).

In Figure 10, we illustrate these effects on the probability of perception $p(\Delta m)$. The figure shows the graphs of A'_R for the limits of the parameters to be considered ($2.3 \le r \le 3.5$, $40° \le h_f \le 90°$) for $H = 100$ km as well as an averaged graph for $r = 2.7$, $h_f = 50°$. In order to find out the effects on $p(\Delta m)$ caused by A'_R differing from the average mentioned we give the extreme values in Table 5 including the relative deviations.

Table 5 – Probabilities of perception $p(\Delta m)$ for the extreme values of A'_R.

Parameters		$\Delta m = 0.5$		$\Delta m = 2$		$\Delta m = 3.5$		$\Delta m = 6$	
h_f	r	p	diff.	p	diff.	p	diff.	p	diff.
50°	2.7	0.00482	–	0.0593	–	0.365	–	0.860	–
90°	2.3	0.00400	−17%	0.0504	−15%	0.323	−12%	0.847	−2%
40°	3.5	0.00602	+25%	0.0689	+16%	0.402	+10%	0.870	+1%

As already mentioned, the values for $p(\Delta m = 0.5)$ are uncertain. But for the further procedure the knowledge of the fainter magnitude classes is of some importance. The differences given in Table 5 are the highest to be expected. The effort to introduce the complete dependence on the population index r and the elevation of the observer's field of view h_f is not appropriate.

Practically, the error reduces, since most observers prefer to observe a field centered at $h_f = 50°$. Table 6 summarizes the portions of the field A'_R for the "standard" data set.

Table 6 – Portions of the field A'_R for the "standard" data $H = 100$ km, $h_f = 50°$, $r = 2.7$, $A_{\text{red}} = 28\,790$ km^2.

R	A'_R	R	A'_R
05°	0.0202	30°	0.1210
10°	0.0381	35°	0.1379
15°	0.0598	40°	0.1506
20°	0.0804	45°	0.1540
25°	0.0963	50°	0.1415

Assuming these values and taking the probabilities given in Table 4, we may use equation (5) to calculate the probabilities of perception $p(\Delta m)$ for the magnitude range $\Delta m \geq 2$.

Calculating probabilities of perception for fainter meteors

The uncertainties of the probabilities of perception for fainter meteors derived from double count observations near the limiting magnitude ($\Delta m < 2$) are too large. Therefore we calculate these from the magnitude distributions of the sporadic meteors gathered by the same observers during the August 1988 campaign.

Data of the nights of the Perseid maximum (August 10–11 to 12–13) have been omitted because of a probable change in the perception in such nights with high rates and frequent appearance of bright meteors.

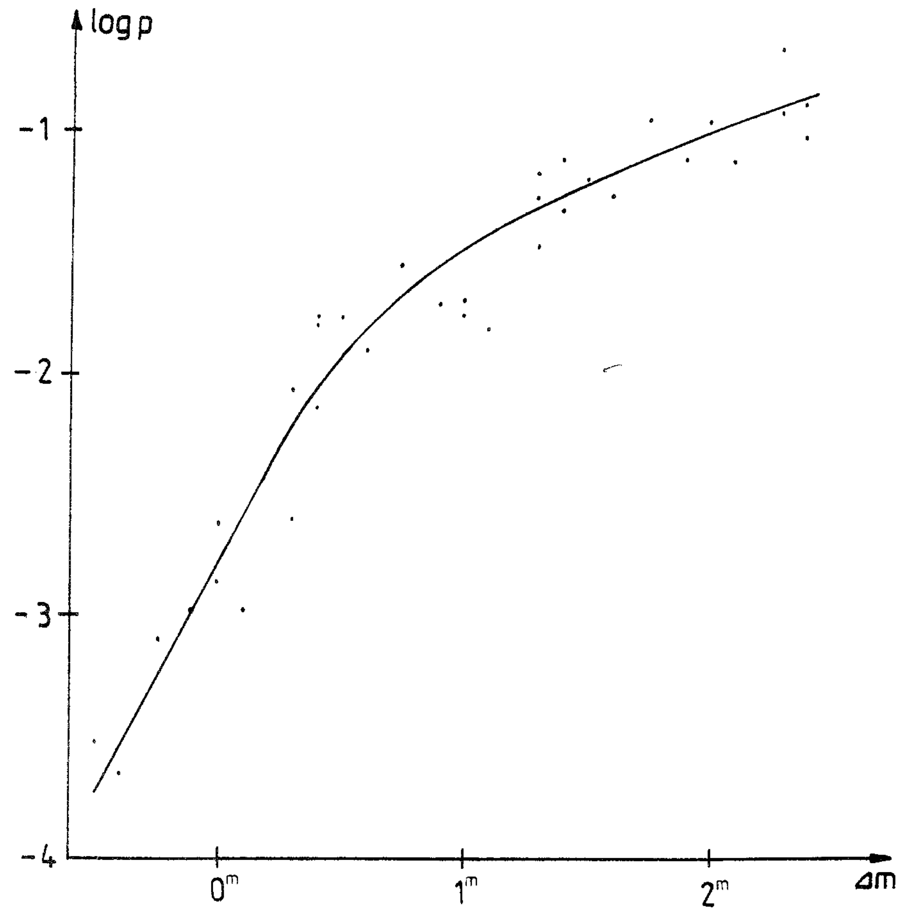

Figure 11 –Raw data of the probabilities of perception $p(\Delta m)$ calculated from the magnitude distributions for fainter meteors and smoothed graph.

First, the population index r was calculated for each observer and for each night according to the method described by Steyaert [5]. This calculation was restricted to the magnitude range $\Delta m \geq 2$. We used the probabilities of perception $p(\Delta m)$ calculated in the previous paragraph. For the magnitudes $\Delta m \geq 2$ we get the linear expression:

$$\log \Phi(m) = am + b \qquad \text{with } r = 10^a \tag{6}$$

From (6), we can derive the true number of meteors φ in the magnitude class m:

$$\log \varphi(m) = am + b + \log(1 - 10^{-a}) \tag{7}$$

For the magnitude range covered by the visual observations (at best to about 7.5) we may assume the population index r to be constant. Thus we may extrapolate the regression line towards the fainter magnitude classes. The probability of perception then follows from:

$$\log p(m) = \log n(m) - \log \varphi(m) \tag{8}$$

Equation (4) allows the conversion from m into Δm. Figure 11 shows the values of $p(m)$ found through this procedure and a graphically estimated curve.

The function $p(\Delta m)$

Now we have found values of the probabilities of perception $p(\Delta m)$

1. using the double count observations; and
2. using the magnitude distribution.

Both fit well in the transition range. Figure 12 shows the result of our effort.

We also tried to fit this graph with the analytic expression which should be of the type:

$$\log p = ar^b + cr \tag{9}$$

We did not find a satisfying solution. Since we consider classes of 1 magnitude width for the calculation of the probabilities of perception $p(\Delta m)$, the values are averaged over such intervals. For instance, $p(\Delta m = 3.5)$ is not the probability of perception of a meteor for which $\Delta m = 3.5$ but is the average probability of perception for meteors in the range $3.0 \leq \Delta m \leq 4.0$. Therefore, the probability for negative values of Δm is not necessarily zero. Of course the probability to see a meteor for which exactly $\Delta m = -0.2$ is zero, but with a limiting magnitude of e.g. 6.8, meteors for which $m = +7$ (which means $+6.5 \leq m \leq +7.5$) might be spotted. Hence we find $p(\Delta m = -0.2) = 7 \times 10^{-4} > 0$.

4. Calculation of the spatial number density

Spatial number density of meteoroids causing meteors of at least +6.5

First, it is necessary to calculate the true zenithal hourly rate ZHR_t from the observed ZHR_o, corrected for a field of view with a radius of 52°5:

$$\text{ZHR}_t = \text{ZHR}_o \, c(r) \tag{10}$$

with:

$$c(r) = \frac{\Phi(m = 6)}{n_{\text{cum}}(m = 6)} \tag{11}$$

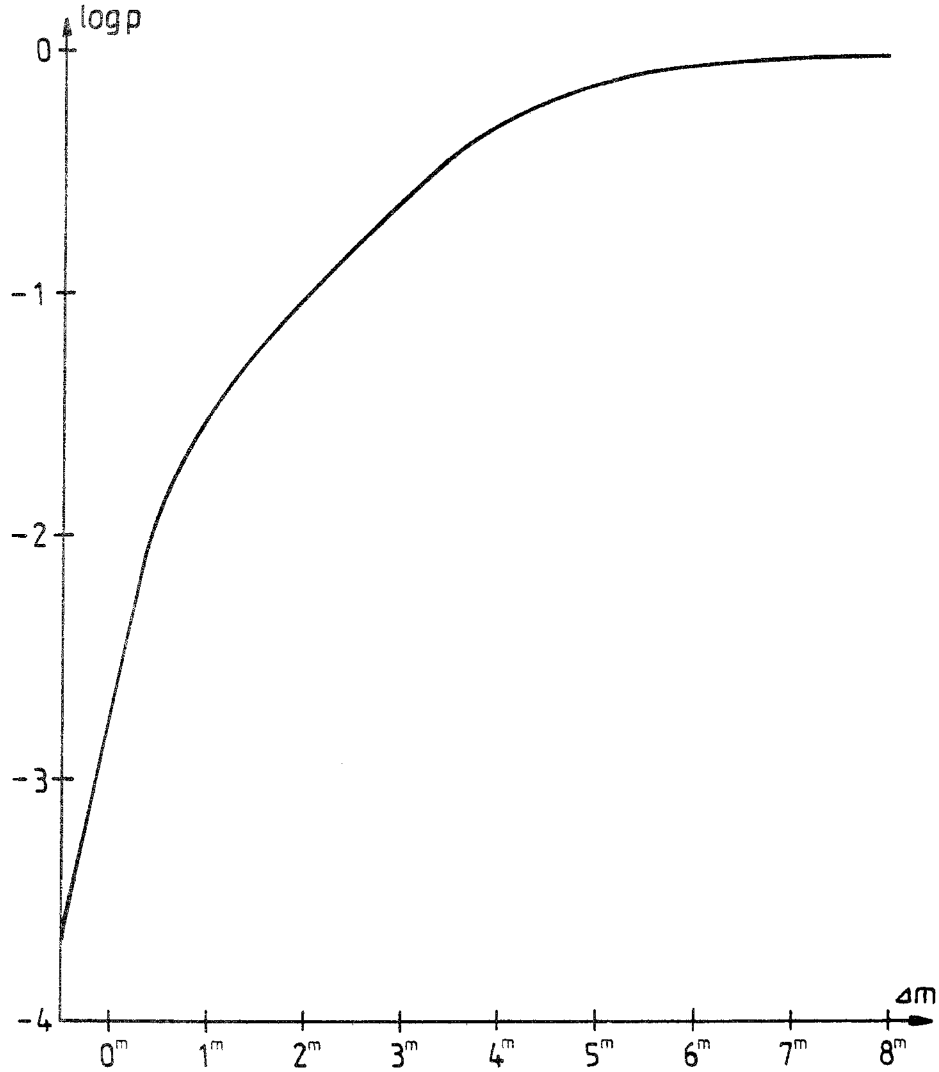

Figure 12 – Probability of perception $p(\Delta m)$ as an average over a field of view of $R = 52.^\circ5$ for the group of experienced observers.

Note that the magnitude class $m = +6$ includes $+5.5 \le m \le +6.5$. Thus all meteors up to $+6.5$ contribute to the terms in equation (11). The correction factor c depends on the population index r and the probability of perception p:

$$c(r) = \frac{\sum_{m=-\infty}^{+6} r^m}{\sum_{m=-\infty}^{+6} r^m p(6.5 - \mathrm{lm})} \qquad (12)$$

Since the observed rate ZHR_o is reduced to $\mathrm{lm} = 6.5$, $p(\Delta m) = p(6.5 - m)$ is used in equation (12) according to equation (4). The range $-\infty < m \le +6$ is only of theoretical importance. Because $\lim_{n \to -\infty} \sum_{m=-\infty}^{n} r^m = 0$, very bright meteors have practically no influence on the result. Since the values $p(\Delta m)$ are averages over a magnitude class of 1 magnitude width, we calculate $c(r)$ for the range $-6 \le m \le +6$ using a step width of 1 magnitude.

Table 7 – Correction factor $c(r)$ for the values of r of practical importance.

r	$c(r)$	r	$c(r)$	r	$c(r)$	r	$c(r)$
1.8	7.08	2.3	12.4	2.8	17.9	3.3	23.0
1.9	8.11	2.4	13.5	2.9	18.9	3.4	23.9
2.0	9.16	2.5	14.6	3.0	20.0	3.5	24.8
2.1	10.2	2.6	15.7	3.1	21.0		
2.2	11.3	2.7	16.8	3.2	22.0		

Instead of the numerical values of Table 7, we may use:

$$c(r) = 10.65r - 12.15 \tag{13}$$

which is sufficient for the range $1.8 \leq r \leq 3.5$.

The spatial number density of meteoroids producing meteors of magnitude at least 6.5 then is:

$$\rho(m \leq 6.5) = \frac{\mathrm{ZHR}_o\, c(r)}{3600 A_{\mathrm{red}}(r) v_\infty} \tag{14}$$

with v_∞ in km/s. For A_{red}, see equation (3). Using A_{red} implies a distance of 100 km and neglecting the effect of extinction. Consequently, we rather obtain the number density of particles causing meteors of at least 6.5 in *absolute* magnitude.

Spatial number density of meteors with a mass $M \geq 10^{-3}$ g

We already described the method for the case $M \geq 2.5 \times 10^{-4}$ g in [2]. For analysis, a mass of 10^{-3} g is commonly used. In [2], an error occurred in the conversion of equation (15) from cgs- to SI-units. Therefore, also the numeric values in the equations (16) and (17) of [2] are incorrect. The correct expressions are:

$$m = 40 - 2.5 \log(2.732 \times 10^{10} M^{0.92} v^{3.91}) \tag{15}$$

$$M = 10^{1.4228 - 0.1023m} v^{-4.25} \tag{16}$$

$$v_0 = 10^{1.4228 - 0.1023m} M^{-0.2353} \tag{17}$$

$$= 40.28 \text{ km/s} \approx 40 \text{ km/s}$$

All other numeric values and equations in [2] are correct, as well as the values given in Table 3 of [2] since these were calculated by means of the equations in cgs-units. (Accidentally, the numbering of these equations is identical in both papers.)

If we consider a mass of 10^{-3} g as a reference, equation (17) leads to $v_0 = 29.1$ km/s. From this we obtain:

$$\rho(M \geq 10^{-3}\text{ g}) = \rho(m \leq 6.5) r^{9.775 \log \frac{29 \text{ km/s}}{v_\infty}} \tag{18}$$

5. Population index and mass index

All relations described before are strongly dependent on the population index r. Especially the number density ρ is affected. Therefore we must pay attention to the determination of this value. We propose the method of Steyaert [5] applying personal probabilities of perception (see part II).

The mass distribution within a meteor shower is characterized by the mass index s. According to Hughes [6] it is defined as follows:

> *The mass distribution index, s, is defined such that the number of meteoroids having individual masses between M and $M + dM$ is proportional to M^{-s}. The cumulative number of particles with masses greater than M will be proportional to M^{1-s}.*

Therefore we may write:

$$\frac{\Phi_1}{\Phi_2} = \left(\frac{M_1}{M_2}\right)^{1-s} \tag{19}$$

and furthermore:

$$\frac{I_1}{I_2} = \left(\frac{M_1}{M_2}\right)^{b} \tag{20}$$

which leads to:

$$m_2 - m_1 = 2.5 b \log \frac{M_1}{M_2} \tag{21}$$

The definition of the population index r gives the relation:

$$\frac{\Phi_1}{\Phi_2} = r^{m_1-m_2} \tag{22}$$

Combining equations (19), (21) and (22), we obtain:

$$\frac{\Phi_1}{\Phi_2} = \left(\frac{M_1}{M_2}\right)^{1-s} = r^{-2.5b\log\frac{M_1}{M_2}} = \left(\frac{M_1}{M_2}\right)^{-2.5b\log(r)} \tag{23}$$

. For the connection between both indices we find:

$$s = 1 + 2.5b\log r \tag{24}$$

or:

$$r = 10^{s-1/2.5b} \tag{25}$$

According to equation (15), we may use the value $b = 0.92$ to obtain:

$$s = 1 + 2.3\log r \tag{26}$$

or:

$$r = 10^{s-1/2.3} \tag{27}$$

6. Conclusions from part I

The method described allows the calculation of the spatial number density ρ from the observed ZHR_o. The restrictions concerning the certainty were already discussed in [2]. They are also valid for $\rho(M \geq 10^{-3}$ g). Comparing the values of the factor $c(r)$ given here and in [2], the question arises how certain all these values are. The factor $c(r)$ is quite sensitive to the probabilities $p(m)$. The probabilities of perception $p(\Delta m, R)$ calculated according to the method described in [1] are too small for large distance classes R. Including the observations with field centers shifted 35°, we now obtained much more certain values. Furthermore, the simplification of the calculation of A'_R in [1] was too large for the outer distance classes. Consequently, the too small $p(\Delta m, R)$ of large distances R were taken into account in equation (5) with a larger weight, resulting in essentially larger values of $c(r)$ in [2] than calculated here.

An evaluation of the entire procedure will be given at the end of part II, scheduled for the *August issue* of *WGN*, after comparing the results of all individual observers participating.

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On the Structure of Ecliptical Meteor Showers

Rainer Arlt

In order to investigate the distribution of ecliptical radiants, a simulation involving 1000 randomly distributed orbits for ecliptical particles was made. It is concluded that, most probably, faint ecliptic radiants are caused by such particles. A few distinct showers may have been caused by short-periodic comets that superimpose the dusty ecliptical plane.

If you look at a radiant list, you will find a jumble of minor showers situated along the zodiac. There are such radiants like σ-Leonids (SLE), μ-Virginids (MVI), α-Scorpids (ASC) and χ-Scorpids (CSC). (The parenthesized abbreviations refer to the radiant list in [1].[1]) Just in spring this unfortunate medley gets out of hand. Rates are very low and radiant drifts are poorly known although activity periods reach one or two months. Do these radiants belong to reliable meteor streams possibly associated with any comet or were they once detected by several meteors happening to diverge from a more or less defined point in the sky? The ZHRs of incidental showers reach 1 to 2 [2] and mostly the activity of the mentioned radiants does not exceed this background. However, since we observe several fireballs and characteristical meteors, an increased sporadic background should exist, caused by interplanetary dust particles concentrated in the plane of the ecliptic. Yet by no means radiants of those bodies are distributed homogeneously over the ecliptic.

In order to find out whether there exist any preferred directions of radiation, we developed a model assuming that all ecliptical particles have an inclination of 0°. The algorithm consists of two steps:

1. determination of the particles' heliocentric velocities while crossing the Earth's orbit;
2. vectorial addition of this velocity with the Earth's orbital velocity.

In this way about one thousand simulated meteoroids were made travel on random orbits crossing that of the Earth's and having aphelions between 1.5 and 5 AU. The calculations yielded the apex distance E of the radiant positions, thus being independent of the date. Not surprisingly, two sections with concentrations of radiants appear, one for prograde and one for retrograde motions. This is just what Hoffmeister found in [3] from his catalogues of meteor radiants. Figure 1 shows the distribution of percentages of radiant positions in ten-degrees-steps dependent on apex distance, produced by the simulated "Eclipticids". Since all known short-periodic comets move progradely the slower section at $E = 80°$ is likely to be more interesting. Which showers can be regarded to belong to this ecliptical "stream"? Undoubtedly, e.g. Virginids, Scorpids, Capricornids, ι-Aquarids and Piscids can.

But what about winter and early spring showers? Therefore, the second part of this investigation delt with measuring meteors' coordinates and determining possible radiants in the period from mid December to the end of March. A considerable number of *AKM* meteors likely radiating near the ecliptic were plotted on large gnomonic star maps with their center at $\alpha = 10^h$ and $\delta = 0°$ (Sextans). All of their backward tracings were drawn at reasonable distances from the beginning points and with lengths corresponding to the angular velocities of the meteors. Taking into account that such ecliptical radiants are less prominent than e.g. Geminids or Quadrantids, we used each map for a five-day period.

There are two similar methods to obtain the structure of a radiant complex. The first one counts the number of lines crossing a certain area of the sky whereas the second one counts the number of intersections of backward tracings in a defined area. Each procedure has its advantages and disadvantages. The second one yields very distinctive distributions. On the other hand, it is very sensitive to badly distributed meteors. If there are a lot of parallel meteor trains, no intersection occurs and a single meteor crossing the parallels perpendicularly will then cause a very sharp radiant.

[1] An updated list can be found in the report announced on p. 30 and the back cover of this issue. (ed.)

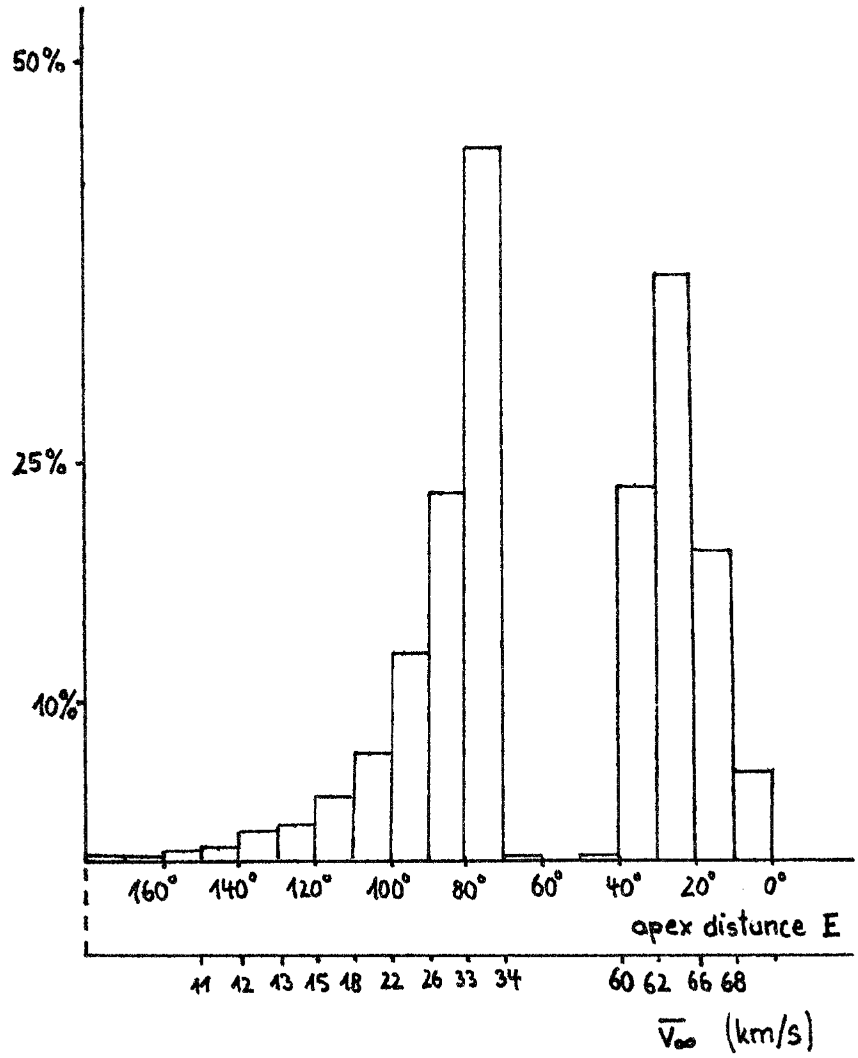

Figure 1 – Distribution of radiants caused by one thousand randomly simulated orbits crossing that of the Earth with semi-major axes between 1.5 and 5 AU, in dependence on the apex distance. Every orbit was used for the calculation of two radiants: one for direct and one for retrogade motion of the imaginary body. Additionally, the averaged geocentric velocities $\overline{v}_\infty$ of these "meteoroids" are given.

Nevertheless, having a great deal of well-distributed *AKM* meteors, we chose the intersection method. The counting area had a size of five by five degrees, referring to the interval length.

What are the results of this rather spot-check-like investigation? The first map of December 12–16 still shows the Monocerotids (MON) very distinctly. (The Monocerotids are not an ecliptical shower, the geocentric velocity is too high). The δ-Cancrids appear on January 10 and reach a very considerable level compared to the background on the map of January 11–15 with the radiant splitting into two centers at $\alpha = 120°$, $\delta = 15°$ and $\alpha = 130°$, $delta = 20°$. They merely disappear on the following map, whereas the January 21–25 map shows them again, with the same high level as ten days before, only with the radiant lying at $\alpha = 130°$, $\delta = 15°$ following the radiant drift. The second component of the double radiant mentioned above seems to move to $\alpha = 150°$, $\delta = 15°$. This position corresponds exactly to what is called the ψ-Leonids in the *Arbeitskreis Meteore (AKM)*. This means we could consider both showers co-existing. The following maps show a widely dispersed radiant structure. Possible ψ-Leonids and δ-Leonids (DLE) and beginning Virginids cannot be sufficiently distinguished. From the February 20–24 map onwards, the radiant of the Virginids appears unambiguously with a steady radiant motion. The extension of the radiating areas amounts to some 10°.

This and the complexity of the radiating structure and its fluctuations are caused to all appearance by various particles filling the space between the planets on nearly random orbits in the ecliptical plane. These particles originated in comets or asteroids or were simply around during the whole life-time of the Solar System. The dusty ecliptical plane is superimposed by several short-periodic comets possibly causing the Taurids and Northern χ-Orionids.

Hence there is no use trying to observe as many showers as possible which are poorly known, whose existence is not even confirmed and whose rates are very low anyway. We think the *IMO* radiant list should rather contain only a few ecliptical showers. Nevertheless, regular observations will give us the possibility to distinguish real showers from ecliptical sporadics unprejudicedly. More comprehensive investigations on computer will provide us with further interesting data about the structure of ecliptical and possibly cometary meteor streams. Therefore, visual observations by plotting meteors on star maps are not to be neglected.

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Estimating the Brightness of Fireballs

André Knöfel

A method is proposed for estimating the brightness of fireballs using street lights. These lights can easily be calibrated using silver-sphere photometry. The relevant formula is given. Also, the relationship between age and brightness of the Moon is given, which can be used to determine the reflection coefficient of the sphere.

The starry sky offers the possibility to estimate the brightness of normal meteors. Comparisons between experienced meteor observers shows that brightness estimates of most meteors (at least of the directly observed meteors) differ only by about half a magnitude. However, as soon as a fireball appears, also experienced observers have very great difficulties in estimating its brightness. The reasons are the absence of any possibility for comparison with stars on the one hand and a lack of experience with bright fireballs on the other hand.

Only the Moon, Venus, Jupiter and, sometimes, Mars are sufficiently bright to serve for comparison. The varying brightness of Venus can be found in any better astronomical almanac. The brightness of the Moon is not given in such an almanac, but we can find its phase. Figure 1 shows the dependence of the brightness of the Moon on its age. The values were obtained by means of a simple method described later.

Unfortunately, these brightnesses are only very rough clues for estimates, since, most often, the fireball will not do us the favor of having the brightness of our object of comparison! What we actually need are more objects of comparison!

Most observers use a special observing site. It is a curse of civilization that the observing conditions are not perfect. Besides general brightening of the sky there are often streetlamps in the immediate surroundings bothering the observer with their disgusting photons. However these troublemakers can be used as reference brightnesses for estimating fireballs. Then of course you need to calibrate these street lamps.

The simplest and cheapest method to do that is a silver-sphere photometer.

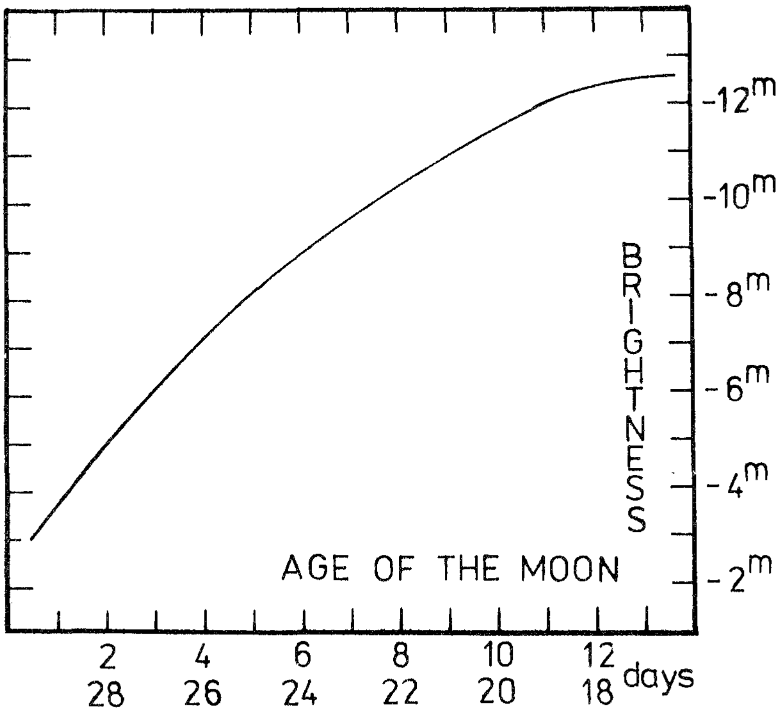

Figure 1 – Relationship between the age of the Moon and its brightness.

Therefore, you need a reflecting sphere (e.g. a colorless spherical Christmas tree decoration), a long tape measure (at least 20 m), a pocket calculator and clear weather. The image of a light source appears in a convex mirror nearly as a point source and can be compared directly with stars. For the calculation of the brightness of the lamps we need the following information:

m_s: the brightness of the comparison star,
r: the radius of the sphere (in cm),
k: the reflection coefficient of the sphere, and
a: the distance between the eye and the silver sphere (in cm).

The coefficient of reflection can be taken $k = 1$ for a new sphere. We observe the image of the light source on the silver-sphere at a distance a, so that its brightness is equal to that of the directly observed (bright) star. The observer's position is such that he sees the image of the light source and the comparison star close to each other. Pay attention to humid nights causing condensation on the sphere!

The brightness of the light source L can then be calculated using the following formula:

$$m_L = m_s + 5\log r + 2.5\log k - 5\log a - 1.5053$$

For a precise value of k, you can transpose the formula to k. With the exact brightness m_L given (e.g the brightness of the Moon obtained from Figure 1), you can then calculate k. If you have calculated some light sources on your observing site you might have a good collection of comparison light sources for the estimation of fireballs. Of course, this does not mean you have to observe meteors "under floodflight"! As a general conclusion however: do not destroy the lamp in your neighbor's garden; once, you might need it after all ...

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Number Densities in η-Aquarids and Orionids

Jürgen Rendtel

Calculations of the number densities within the meteor showers associated with the comet P/Halley are presented. The average values indicate about equal densities from the stream's core in η-Aquarids and Orionids. Comparisons to other showers are added.

Both of the meteor showers associated with the comet P/Halley have been subject of observational programs (e.g. IHW) as well as of model calculations. The Earth crosses the particle cloud twice, resulting in the η-Aquarids and the Orionids. McIntosh and Hajduk [1] proposed a ribbon-like structure, Hajduk's analysis in 1980 [2] yielded a fine structure, but McIntosh and Jones [3] conclude from their model calculations, that the stream cross-section is more complex then the ribbon-like structure mentioned before.

For the verification of any model, observational data are needed. In case of meteor observations, results are given mostly as ZHR (Zenithal Hourly Rate) values. This is the number of meteors appearing when:

1. the radiant is situated at the zenith, and
2. the circumstances of the observation are "ideal" (limiting magn. +6.5, no clouds).

Such values have got to be converted into physical quantities as particle flux or number density in order to use them in model calculations. Of course, there are some uncertainties. One of these concerns the relation between meteor magnitudes and particle masses. An approach was described by Koschack and Rendtel [4]. In this paper, we present the general density distribution within the η-Aquarids and the Orionids. The results agree with flux calculations based on television observations of the Orionids by Duffy et al. [5]. Both use the mass-magnitude relation of Verniani [6].

In May (η-Aquarids), the Earth reaches more inner regions of the particle cloud than in October (Orionids). The density values were calculated using averaged observations of Australian groups (1981–1986) for η-Aquarids, and Dutch and GDR groups (1984–1987) for Orionids. Table 1 and Figure 1 show the results of the calculations.

Table 1 – Number density ϱ_N as a multiple of 10^{-9} per km^3 within the meteor showers associated with P/Halley.

η-Aquarids			Orionids		
$\lambda_\odot$	ZHR	ϱ_N	$\lambda_\odot$	ZHR	ϱ_N
28°	2 ± 1	0.67	190°	1 ± 1	0.39
30°	3 ± 1	1.01	192°	1 ± 1	0.39
32°	3 ± 1	1.01	194°	2 ± 2	0.77
34°	4 ± 2	1.35	196°	2 ± 2	0.77
36°	7 ± 3	2.35	198°	3 ± 3	1.15
38°	8 ± 3	2.69	200°	4 ± 3	1.54
40°	13 ± 4	4.37	202°	5 ± 3	1.92
42°	30 ± 12	10.1	204°	6 ± 3	2.31
44°	46 ± 15	15.5	206°	12 ± 5	4.62
46°	39 ± 15	13.1	208°	23 ± 10	8.85
48°	30 ± 15	10.1	210°	15 ± 8	5.77
50°	18 ± 8	6.06	212°	8 ± 5	3.08
52°	12 ± 5	4.03	214°	5 ± 4	1.92
54°	8 ± 3	2.69	216°	4 ± 3	1.54
56°	7 ± 4	2.35	218°	3 ± 3	1.15
58°	5 ± 2	1.68	220°	3 ± 2	1.15
60°	3 ± 1	1.01	222°	2 ± 1	0.77
62°	2 ± 1	0.67			
64°	2 ± 1	0.67			
66°	1 ± 1	0.33			

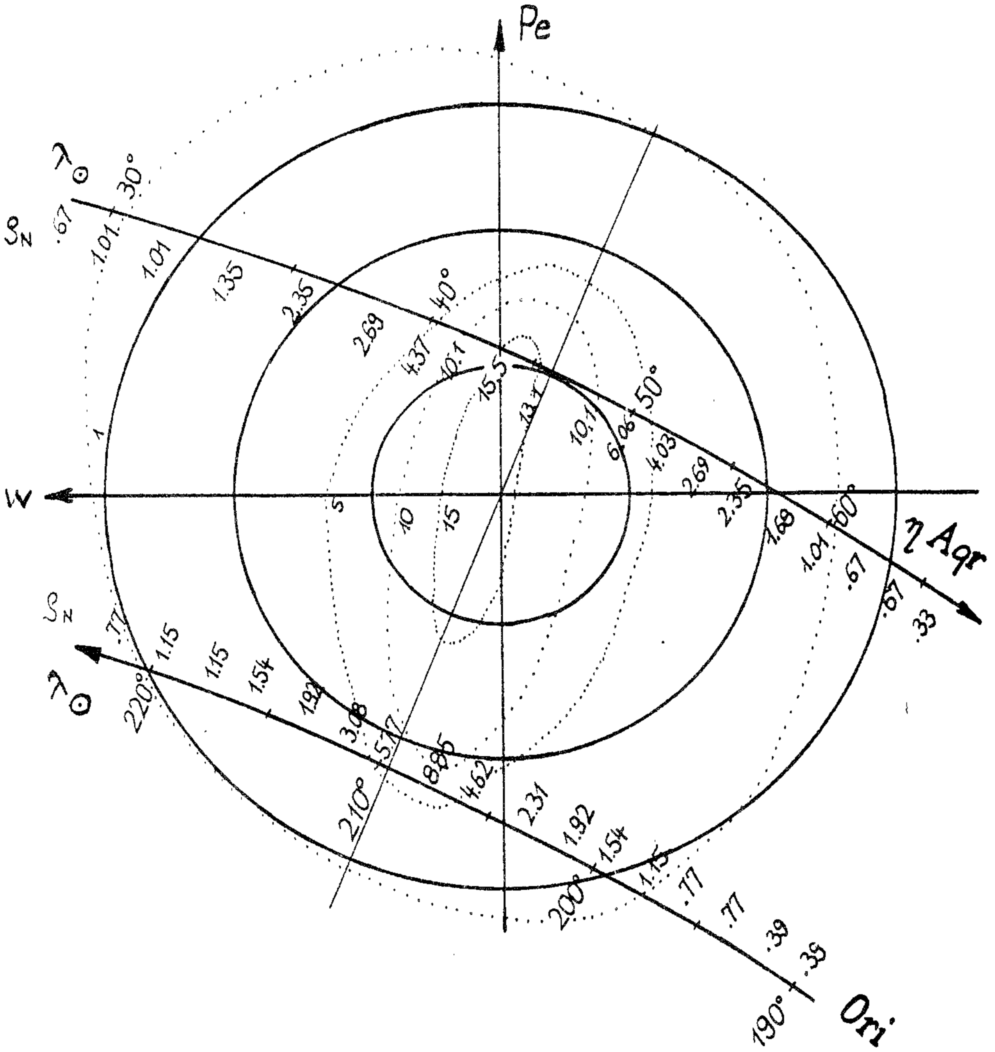

Figure 1 – Passage of the Earth through the streams, after Hajduk [2]. "Pe" is perpendicular to the orbital plane of the comet; "W" is perpendicular to the comet's motion. $\lambda_\odot$ refers to solar longitudes and ϱ_N to number densities ($\times 10^{-9}$ km^{-3}).

The dotted contours are, of course, somewhat speculative. They may indicate similar number densities at equal distances from the core. Compared to other showers (Table 2), the P/Halley associated showers are quite thin. The fine structures mentioned by Hajduk [2] indicate variations of about 50% in number density.

Table 2 – Comparison of number densities ϱ_N (as a multiple of 10^{-9} per km^3) in different showers (particles with masses $m \geq 2.5 \times 10^{-4}$ g); peak values.

Shower	ϱ_N	Shower	ϱ_N	Shower	ϱ_N
Orionids	8.85	April Lyrids	30	Geminids	1760
η-Aquarids	15.5	Quadrantids	230		
Perseids	27	Capricornids	260		

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[3] McIntosh B.A., Jones J., *Mon. Not. R. Astr. Soc.* 235, 1988, p. 673.

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Observational Results

The 1989 η-Aquarids in Australia

Jeff Wood

An overview is given of extensive 1989 η-Aquarid observations by Australian observers.

1989 has seen Australian observers once again carry out extensive observations of the η-Aquarid meteor stream. The 1989 watch began on April 24–25 and ended on May 11–12 when poor weather and moon prevented further observations being made. During the watch, results were obtained on 16 nights. These covered a total of 121 man hours of observing time. A total of 18 people participated in the project. Their names were as follows:

> John Drummond, Jeff Wood, Nicholas Harvey, Martin Coroneos, George Platt, Mark Glossop, Andrew Camineschi, Guy Blackman, Martin Sale, John Kelley, Chris Weighner, Maurice Clark, Kim Felstead, Craig Hinton, Shannon Powell, Adam Marsh, Roger Vodicka, David Stephenson.

ZHR-values for the 1989 η-Aquarids are shown in Table 1.

Table 1 – ZHR-values for the 1989 η-Aquarids obtained from Australian observations.

Date	ZHR	Nr. Obs.	Date	ZHR	Nr. Obs.
Apr 24–25	0.9 ± 0.7	3	May 04–05	43.9 ± 10.5	11
Apr 26–27	3.8 ± 0.8	2	May 05–06	42.6 ± 7.7	13
Apr 28–29	8.4 ± 1.7	10	May 06–07	32.4 ± 4.2	6
Apr 29–30	13.6 ± 1.2	4	May 07–08	28.0 ± 1.6	5
Apr 30–31	16.8 ± 2.6	4	May 08–09	38.6 ± 4.0	8
May 01–02	20.4 ± 0.8	3	May 09–10	25.3 ± 2.4	3
May 02–03	24.6 ± 3.8	3	May 10–11	19.3 ± 2.0	3
May 03–04	29.9 ± 3.9	6	May 11–12	14.6 ± 1.6	3

The 1989 η-Aquarid data clearly shows the double maximum that has characterized displays of previous years. The first maximum occurred on May 5 with a ZHR of approximately 50 and the second on May 8 with a ZHR of approximately 40. Below is a global magnitude distribution of the 1989 η-Aquarids.

Table 2 – Magnitude distribution of the 1988 η-Aquarids in Australia.

Magnitude	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot	$\overline{m}$
Number	1	4	13	31	88	116	182	291	403	379	230	45	1783	2.64

Using correction factors described by Kresakova (1966), upon the magnitude distribution listed above we find that the magnitude ratio is $r = 2.4$ for meteors between -4 and $+5$.

Of the 726 η-Aquarid meteors of magnitude +2 or brighter, 44.7% were white, 42.4% were yellow, 5.2% were green, 3.4% were blue, 3.0% were orange, 1.2% were red and 0.1% were violet. 32.2% of the η-Aquarid meteors seen had a train. All of these were of short duration with none lasting more than 10 seconds after the meteors themselves disappeared from view.

Fall and Winter 1989 Observations from Maryland

Richard Taibi

An overview is given of meteor observations conducted in Maryland, USA, during the fall and winter of 1989. A mini-outbreak of the Leonids on November 17 after 10^h UT is suggested.

Observers worldwide had to contend with the Full Moon during Leonid and Geminid maxima. The Moon also interfered with the Orionids and the Taurids. Maryland's weather sometimes exacerbated the celestial nuisance factor by adding clouds or extremely cold (−35° C) windchills. All of these factors kept my meteor total well below what I would have liked to have seen in 1989.

16 Taurids were seen during 15 hours' observation from October 8 to November 13. No fireballs were seen, in contrast to 1988's total of four fireballs. I was puzzled, too, by not seeing any meteor on November 13, the date of the Northern Taurid maximum.

I assumed that the Leonid rate was still very low, or that the nearby Full Moon had hidden almost all the Leonids in my sky. Until George Gliba, another Maryland observer, contacted me and reported that he had seen 10 Leonids in a 40 minute period between 10^h10^m and 10^h50^m UT, in a cloudless sky with a poor average limiting magnitude of 4.38. This period commenced 10 minutes after I had given up on November 17. Whether this constitutes the beginning of a Leonid mini-outbreak or simply better perception on Mr. Gliba's part, I do not know. I hope that observers who have more westerly longitudes will report their findings to elucidate the possibility of an outbreak.

Poor weather prohibited intensive monitoring of the Geminids this year. Clouds parted long enough to see 8 Geminids in a two-hour post-peak period on December 14. One highlight, however, was seeing a −6 Geminid while driving home after an observing session on December 1!

The Ursid maximum occurred during a frigid blast from the North pole. I did not see any Ursids in what amounted to two sky checks on December 22. Mr. Gliba braved the -35° C windchill to observe for one hour and was rewarded with six Ursids (seen between 10^h05^m and 11^h05^m UT with a limiting magnitude 5.5). A nearby Alexandria, Virginia, observer, Ruthi Moore, saw two Ursids in about forty minutes' observing about 9^h UT to 9^h40 UT on December 22 also.

Visual Counts from Radio Echoes of the Geminid Meteor Shower

T.R. Manley

A method is described for obtaining activity profiles of meteor showers from radio observations. The method is applied to 1988 and 1989 Geminid observations.

Visual Counts from Radio Echoes of the Geminid Meteor Shower Meteor showers have two "M" patterns in them. One of them is due to diurnal rising and setting of the shower radiant and the other "M" results from a peaking of the meteor counts. In the case of Geminids, the two "M" patterns are separated from each other. The highest visual counts occur near the middle low of the "M" patterns. Because of this fact, missing values have to be inserted graphically by extending the values at lower altitudes upward in a smooth sinusoidal fashion.

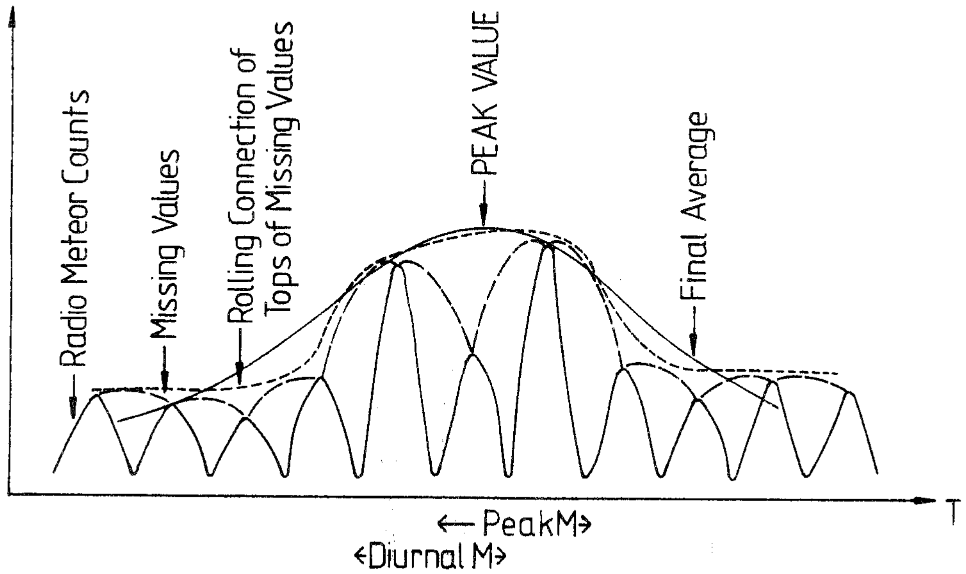

Figure 1 – Smoothing an activity profile obtained from radio observations.

In order to obtain graphs of the 1988 and 1989 Geminids, the tops of the graphically inserted missing values of diurnal and peak curves were connected into a rolling curve as shown in Figure 1. An average line was then drawn through this rolling graph. The graphs of the Geminids in Figure 2 are result of using this method. My graphs for the Geminids of 1988 and 1989 are quite similar to the one of the 1985 Geminids found on page 180 of Roggemans's well written 1989 *Handbook for Visual Meteor Observations*.

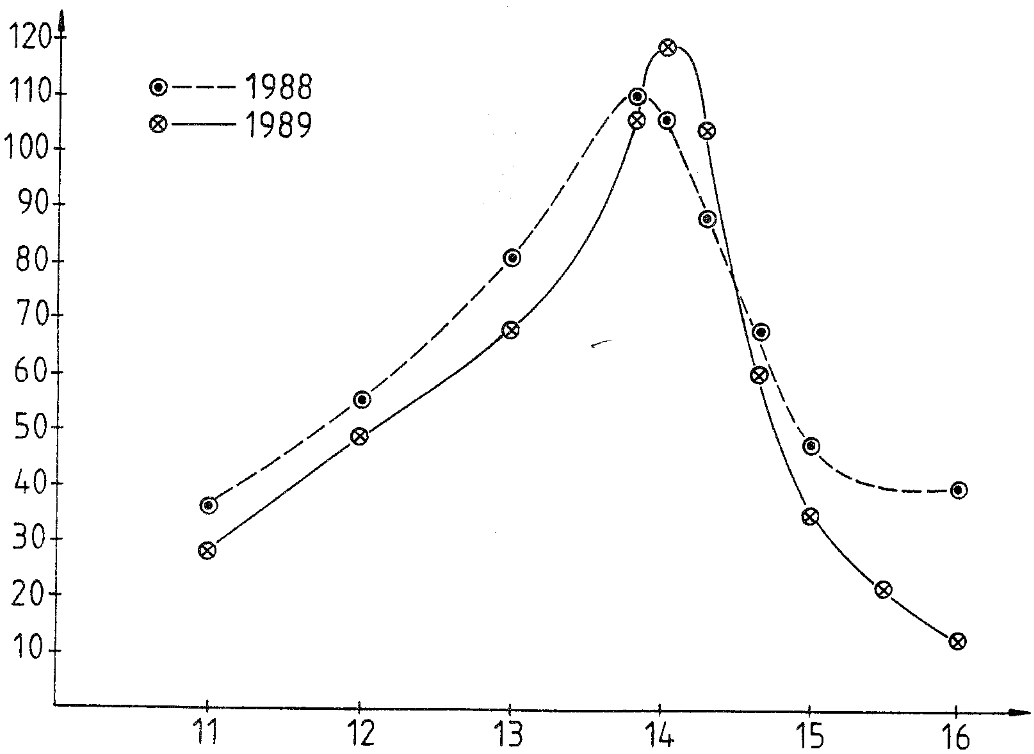

Figure 2 – Radio activity profile of the 1988 and 1989 Geminids

To obtain accurate values for these graphs, one must use the appropriate horizontal and vertical scales. Also, the voltage cutoff values for the visual component of meteor showers must be determined at a time when no major shower is present. Usually, about 2 to 10 meteor counts per hour occur at these times.

New Evidence for a Cassiopeid Meteor Shower?

Peter Aneca

On November 4–5, 1989, an enhanced meteor activity radiating from a point near ε Cassiopeiae was noted.

The Belgian amateur Jan Janssens started his observation more in the spirit of stargazing on the night of November 4–5, 1989 at the *Weekend of Amateur Astronomers*, an annual meeting of members of the *Vereniging voor Sterrenkunde (VVS)* in Belgium. Starting at 23^h15^m UT, he saw five meteors radiating from Cassiopeia in a time span of only 6 minutes! Besides those meteors, also Taurids and sporadics were seen. After those amazing six minutes still more Cassiopeids were observed, although they were generally fainter than those of the earlier bunch. In total, 13 Cassiopeids were observed before 0^h15^m UT, in a 15 minute watch (interrupted by clouds). During the observation 20% of the sky was covered with clouds and the limiting magnitude was 5.8.

Jan Janssens also noted some details of the observed Cassiopeids. The brighter meteors, brighter than magnitude 3, were of long duration: 0.5 to 0.7 seconds, and they were red-colored. The fainter meteors had shorter durations of 0.4 to 0.5 seconds. All of the meteors started in the neighborhood of ε Cassiopeiae. When observing conditions were worse, still some bright meteors were seen radiating from the Cassiopeia radiant, however, these are not included in the 13 mentioned above. In the period between 23^h15^m and 0^h15^m UT, also 4 sporadic meteors and an unknown number of Taurids were observed.

In [1] two possible showers are found. The first is number 754, active from November 5 to December 10 with a maximum ZHR of 2 between November 13 and 17. Reference [1] gives a double radiant with $\alpha = 40°$, $\delta = +60°$ and $\alpha = 34°$, $\delta = +65°$. The other one is number 759, Active between November 8 and 13, with a maximum ZHR of 120 on November 9 ($\lambda_\odot = 226\overset{\circ}{.}98$). The latter shower was discovered in 1969. It is not possible to indicate which of the two candidates is the most likely. In [2–6], no possible showers could be found. So two questions arise. First, if the showers mentioned in [1] are real, then the observation of Jan Janssens could be new evidence of their existence. On the other hand, it is very well possible that the showers mentioned in [1] are spurious and, then, the high activity noticed by Jan Janssens could be a new meteor shower. However, it is impossible to jump to conclusions without further information. Therefore a detailed analysis of data of the past (especially the 1989 Taurid data) is necessary as well as new observation campaigns.

Acknowledgments

I wish to thank Jan Janssens for communicating his observations, as well as Christian Steyaert who informed me about the Cassiopeids in [1].

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[2] Roggemans P. (ed.), "Handbook for Visual Meteor Observations".

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Editor's comment: *The editor feels obliged to warn the reader when considering showers from the "BMS Radiant Catalogue". A very considerable fraction of these showers were obtained by methods and observing techniques that did not allow to distinguish statistical convergences. Consequently, many showers in this catalogue are spurious. In particular, shower 759 was based on one observation of short duration under poor circumstances by an unexperienced observer.*

A 1989 Perseid Fireball near Birmingham

Noel White

Details are given of the track of a −6 Perseid fireball that appeared on August 12, 1989 at $23^h34^m45^s$ UT in the are of Birmingham, Leicester, Nottingham and Derby, England, UK.

On the cover of the *February issue* of *WGN* (*WGN* 18:2), one of my two photographs of −6 Perseid fireball on August 12, 1989, $23^h34^m45^s$ was shown. These photographs turned out to have an interesting sequel.

Following recent information in the *Astronomer* magazine, contact was made with Gary Poyner, an amateur astronomer, who observed and plotted this fireball from Birmingham, UK. An analysis was attempted by Roy Panther of Northamptonshire, UK, well-known for his comet discovert, who, at one time was engaged in meteor observation, photography and computing.

Although the results are approximate because part of the data is visual, they are as follows. The fireball track commenced at a height of 86.6 km near Nottingham, UK and ended at a height of 81 km to the NNW of Birmingham, UK. The observed track had a length of 40.6 km. The speed was 42.7 km/s. A map shows the position and relation to the North.

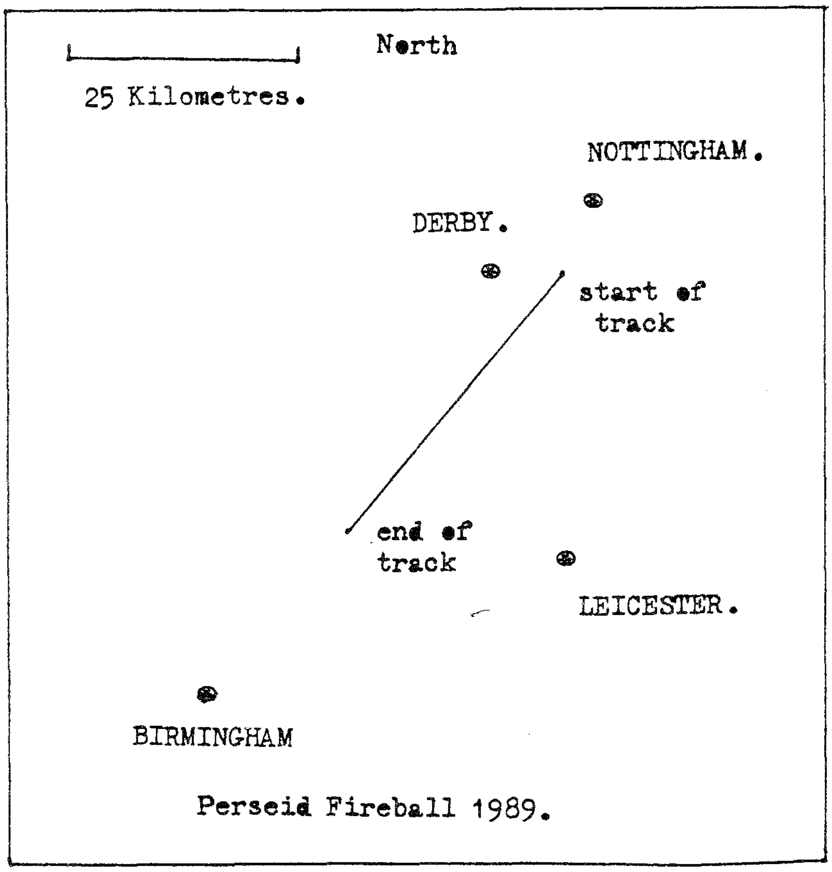

Figure 1 – Track of the 1989 −6 Perseid fireball near Birmingham, UK.

After a very busy period last fall *the number of contributions for WGN is down a little bit the last couple of months. As a consequence, this issue, which could contain up to 54 pages, has to be limited to 42 pages. So, please, take your pen at hand and write down what you did in meteor astronomy lately! (Ed.)*

Pegasoft Programs for Meteor Astronomy

Casper ter Kuile

Most participants of the 1989 *International Meteor Weekend* at Balatonföldvár in Hungary have learned about the programs for meteor observers. A number of these programs have been developed by *Pegasoft*. This software is especially intended for use by meteor observers. This article presents a list of programs available now and the latest developments.

1. `MOONEFM`: An efemerid of the Moon,
2. `SUNEFM`: An efemerid of the Sun,
3. `RADEFM`: The height of the radiant,
4. `MOONFASE`: Phases of the Moon,
5. `EASTER`: Dates of Easter,
6. `METORBIT`: Meteor dynamics in the atmosphere,
7. `SIMPRO1`: Multi-station meteor predictions 1, and
8. `SIMPRO2`: Multi station meteor predictions 2.

All these programs have been translated into English. It is expected that they are self-explaining. Nevertheless, there is a `README.TXT` and an `INFO.TXT` file supplied with the programs. If one has suggestions for improvements, please send them to *Pegasoft*. We can include these in new versions of the software which will be for the benefit of all meteor observers. The software is intended to run on an *IBM* or compatible personal computer. 640 kB RAM memory, a hard disk and coprocessor are recommended to run the software smoothly. We are working on a version for *Atari* based machines too. The software is supplied on two 360 kB or one 720 kB floppy disk. The *Pegasoft* programs for meteor observers are still in the public domain. One can obtain these programs by sending a request to *Pegasoft, C. ter Kuile, Akker 145, NL-3732 XD De Bilt, the Netherlands*, including two 360 kB 5.25″ floppies.

Book Review

Paul Roggemans

- *"Saintly Tears", published by "Sirius", Triq Il-Migbha, Marsascala, Malta. Price:* 8.5 *USD. (Not available from IMO; order directly from "Sirius")*

This special issue of *Sirius*, the magazine of the *Astronomical Society of Malta*, is entirely devoted to the impressive work during the summer of 1988 by the Maltese meteor observers. Malta is an independent island in the Mediterranean Sea, 316 km^2 large, numbering about 350 000 inhabitants, and few places on Earth count so many meteor observers as Malta, percentagewise. The publication covers all the observational results obtained in the Perseid epoch of 1988. The style of an observational report has been improved to make it attractive and informative for a more general readership. Contributions are presented in separate chapters with a lot of descriptive text, several line diagrams and only a few numeric tables.

Through the entire work, the different contributors were successful in the purpose of discussing 1988 results, always comparing these to previous years' results. The numeric tables are kept to a strict minimum, to provide some summarized raw hourly rate data to people who want to use the observational data for their own analyses. The raw hourly rate table is a very close match to the *VMDB* format of *IMO*; I only missed the geographical coordinates of the observing sites. The only aspect neglected in the raw data summary are the magnitude distributions. All literature references are listed in detail in a separate bibliography. The overall impression of this work is very positive and I recommend meteor workers to order a copy. As the number of available copies was 175, do not wait too long to order your copy!

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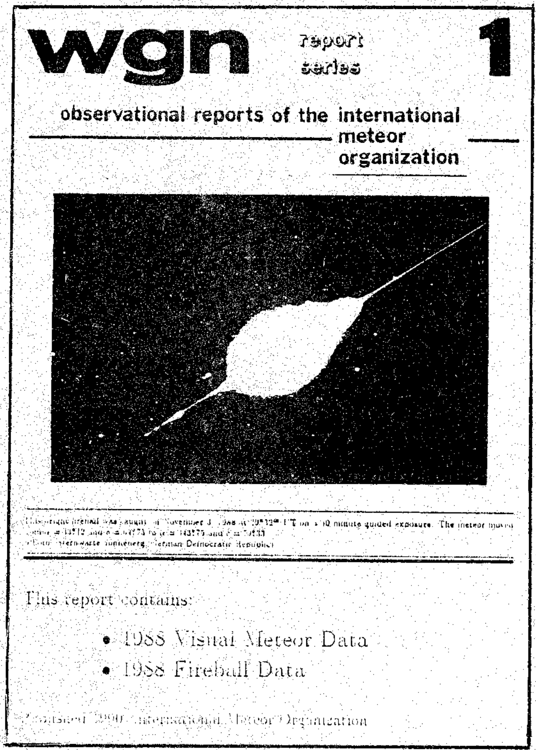
Other author's addresses

Philip Bagnall, 9 Airedale, Hadrian Lodge West, Wallsend, Tyne and Wear, NE28 8TL, *England*
Christopher Spratt, 314-2100 Granite Street, Victoria, *British Columbia V8S 3G7, Canada*
Richard Taibi, 7002 Coolridge Drive, Temple Hills, *Maryland 20748, USA*
Vladimír Znojil, Karly Pfeiferové 22, CZ-628 00 Brno, *Czechoslovakia*
José Trigo, Avda Antic Regne de Valencia 35, 9 aptda, E-46005 Valencia, *Spain*
Luis Ramón Bellot Rubio, C/Ronda 105, 4E, E-18003 Granada, *Spain*



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International Meteor Weekend 1989

Balatonföldvár, Hungary, October 5–8, 1989

The proceedings of this International Meteor Weekend are under preparation now. The book will contain more than 20 articles in about 80 pages, about various fields of meteor astronomy—almost entirely covering the conference. Included are: visual and photographic observations, radio meteor work, new techniques in meteor observation, data processing, computerization of meteor astronomy, databases, investigations on meteorite events in the past, and the International Meteor Organization itself.

These proceedings are a common publication of the *International Meteor Organization*, the *Hungarian Amateur Astronomical Association* and the *Hungarian Meteor Fireball Observing Network*. They will be available early in the summer of this year. Detailed information on the price and ordering will be provided shortly.