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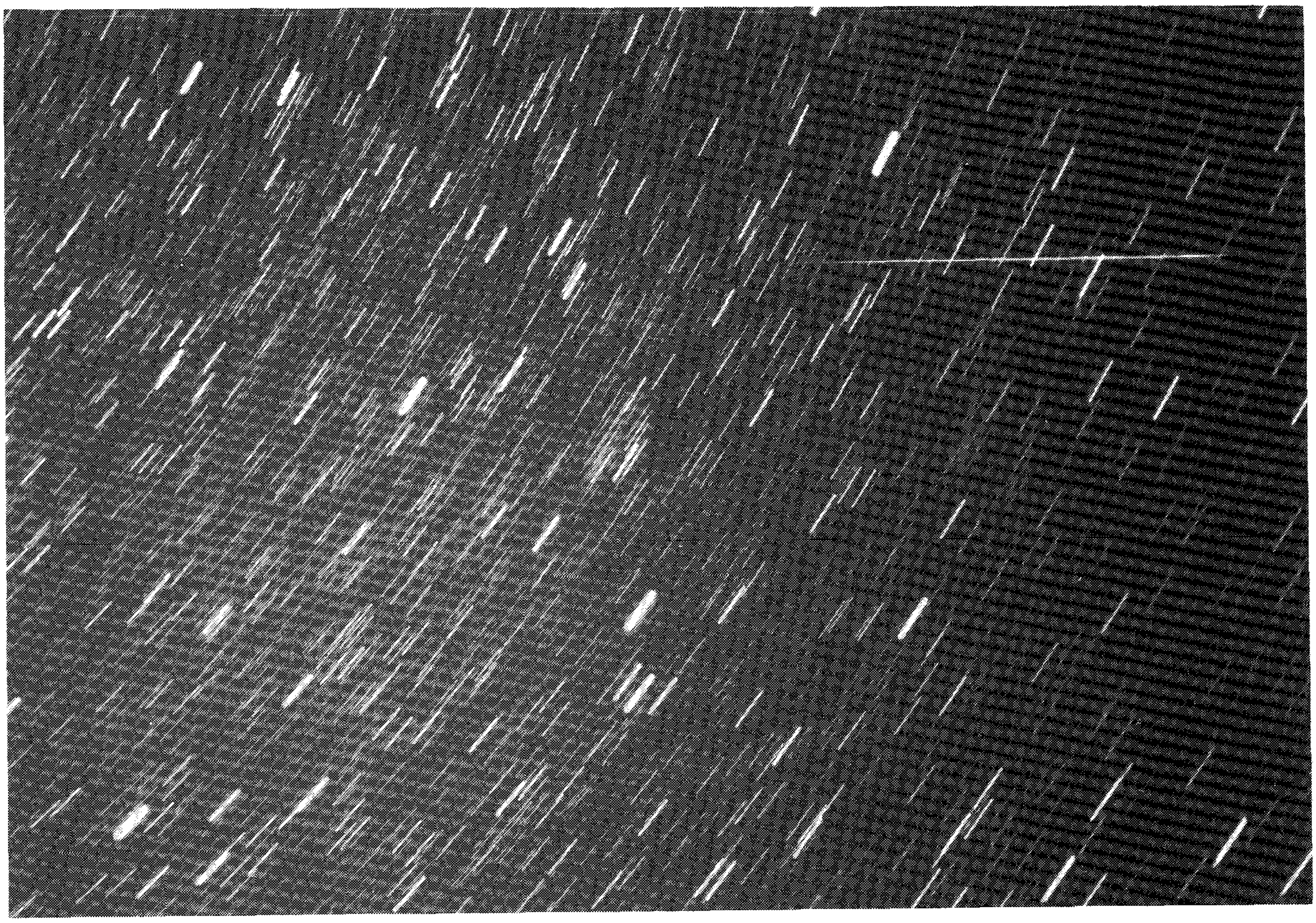

This −1 meteor was photographed by Paul Roggemans on August 16–17, 1988, $0^h43^m43^s$ UT, at Lardiers, France. The meteor moved from near Andromeda towards Pisces. The photograph was exposed from $00^h39^m28^s$ until $00^h44^m29^s$ UT with a 50 mm $f/1.4$ Pentax on Tri-X, 800 ASA.

In this issue:
- Reporting fireball phenomena
- Practical information for all observers
- Why telescopic meteor observing?
- Call for action for the 1989 Taurids event
- The 1988 Perseids and the calculation of perception coefficients
- The 1988 Perseids in the USSR

In case of non-delivery, return postage guaranteed. Please return to:
v.u.: Paul Roggemans, Pijnboomstraat 25, B-2800 Mechelen, Belgium

Afgiftekantoor: 2800 Mechelen 3

WGN, volume 17, nr 5, October 1989, pp. 169–196

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Useful Information

The December Issue *(WGN 17:6)*

Due to professional engagements of the Editor-in-Chief, this issue will be mailed a little later than usual: around mid-December. We ask the readers to apologize us for this inconvenience. Contributions are due *November 10*. 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

All information can be found on pp. 169–170 of this issue of *WGN*. We urge all 1988 subscribers **to renew promptly**. By paying early, you are sure that your payment will be received and processed well before the end of the year and that you will receive the first issue of 1990 in time. For us, late renewals imply having to go to the post office all the time for mailing back-issues. Once more, please allow us to work efficiently, and pay duly!

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

We received quite some reactions on the remarkable trains mentioned by Christian Steyaert in the previous issue, as well as on the double Perseid maximum also mentioned in that issue. We welcomed these reactions very much; you can read them on the following pages. In the future, this letter section can develop into a lively forum for scientific discussions between amateur and professional meteor astronomers.

In this issue, you also read some news from various IMO commissions. In particular, special attention is asked for the 1989 Taurids. There is also a contribution on the calculation of perception coefficients from the stream activity, without having to rely on the sporadic background.

Meanwhile, we are entering the final months of 1989, implying that we have to ask you to renew your subscription and/or membership. Persons already being member of IMO will see their membership renewed automatically with the payment of their subscription. Other subscribers wishing to become a member should ask Paul Roggemans for an application form. Additional information about renewing your subscription can be found below.

IMO Contributions/WGN Subscriptions for 1990

Marc Gyssens and Ann Schroyens

In our continuing effort to keep *WGN* as inexpensive as possible, subscription rates and membership fees for 1990 have been fixed as follows:

1. *IMO*-members (airmail delivery)	400 BEF	12 USD	1500 JPY
2. non-*IMO*-members (surface mail delivery)	400 BEF	12 USD	1500 JPY
3. non-*IMO*-members (airmail delivery)	600 BEF	18 USD	2250 JPY

The last option only exists for countries outside Europe. As said, these prices are kept as low as possible. Therefore, if you can afford to give something extra, please do so! You will help us in our continuous effort to improve *WGN* and the services *IMO* can render as well as in keeping subscription rates low and thus making the information available to the widest possible audience.

Please do not postpone your payment! Having to send back-issues to late renewers means an extra workload for the administration. Also, you should observe the guidelines given below. Otherwise, bank costs may constitute a considerable fraction of the entire subscription fee, and in view of our policies outlined above, we cannot afford such costs.

People in North America can pay through *Peter Brown*. If you pay him by postal money order, just transfer the required amount; if you pay by personal check, add another 2 USD. People in Japan can pay on the postal giro account (nagano) 8-36-445 of *Masahiro Koseki*, referring to *WGN 1990* and mentioning name and address in Roman characters. People in the UK can pay through *George Spalding*. Please contact these persons if you need further details.

All others should pay through *Ann Schroyens*, preferably by international postal money order (made payable to Ann, *not IMO*) or by Eurocheque (made payable to Ann, drawn in Belgian francs in a Belgian city (mention e.g. Brussels) and with your Eurocheque card number figuring on the back). Please avoid using bank checks, because, no matter what your bank may claim, they invariantly cause cashing expenses for us. If, for some reason, you have to pay with a bank check, you should add *at least* 300 BEF to the amounts listed above! Also, the check must then be drawn to a Belgian bank in Belgian francs, otherwise we simply cannot accept it.

Of course, you might also want to consider paying cash by sending us bank notes of a convertible currency. However, you should be aware that postal regulations in many countries do not allow sending considerable amounts of cash and that we cannot accept any responsibility for loss or theft! The same comments hold for sending traveler's checks. Please note in that case that we only accept USD traveler's checks and that you should add 100 BEF banking costs for each check you use.

Finally note that the addresses of all persons above figure on the inside of the back cover!

Letters to WGN

compiled by Marc Gyssens

Remarkable Trains

We received several comments on the remarkable train observations by Gotfred Møbjerg Kristensen, reported by Christian Steyaert in WGN 17:4, pp. 115–116. While Paul Roggemans suggests laser-beams as an explanation on p. 116 of that issue, the letters below blame auroral displays or a rocket explosion for the remarkable observations of Kristensen.

From the description of the phenomenon, and the photographs, I could almost guarantee that what Kristensen saw was, in fact, a form of aurora known as a *ray*. These can occur in bunches or singularly and, contrary to Steyaert's comments, do not always appear to move *nor* are they short-lived. In fact, rays are one of the most common forms of aurora but are often mistaken by the public—and by inexperienced astronomers—as search-lights.

Philip M. Bagnall, July 28, 1989

It seems likely to me that the supposed "trains" were in fact auroral rays, both from the photographs and from the accompanying text. Contrary to the text however, aurorae are not always short-lived nor are they always swift-moving. The major auroral storm of March 13–14 this year, for instance, persisted throughout an entire night from UK sites at least, and I have on occasion seen auroral rays persist for some considerable time without showing any real change other than a slow fading - one of the more memorable occasions being February 14–15, 1982, when a solitary ray was observed to persist from 20^h40^m to 20^h55^m UT before fading away. The green-white color seen in the forms over Denmark is a very typical auroral shade. The straightness of the streaks together with the knots of greater brightness (presumably most noticeable near their bases, as shown in the photographs), the fact that all where seen in the northern sky and that all appeared to converge at a point near the zenith (auroral rays normally seem to converge at a point near the observer's magnetic zenith, which for northern European sites lies a short way south of the true zenith) all tend to confirm this hypothesis. The slow drift is not unusual in some aurorae. Auroral sightings were made from sites in northern Scotland this year on April 27–28 too, together with one from south-west Scotland, between 22^h56^m and 1^h07^m UT according to reports in *The Astronomer* magazine, vol. 26 nos. 301 and 302 (1989), pp. 12 and 29, which sightings included persistent rays, providing further support. While these Scottish sites all have somewhat higher geomagnetic latitudes than those for Denmark, it is not impossible that the upper parts of an auroral display taking place further to the north could have been seen: observers have often noted auroral rays when other forms could not be seen due to this effect, myself included. Naturally, it would not do to discard all other possibilities out of hand, but it seems most probable to me that the effect seen was simply a manifestation of the aurora. It is often surprising how many such sightings are misinterpreted or ignored altogether!

Alastair McBeath, July 27, 1989

The pictures as well as the description of the phenomena reminded me of a light show I had also seen in early April of this year. Although I am unsure of the exact date, this display occurred during the second week in April. I happened to step outside after a friend had called to say he had just seen two "explosions" in the sky. Going outside I saw what looked like an auroral arc lying to the North-East of the City at an altitude of perhaps 30°. I missed the actual explosions but did see the expanding aftermath of the luminous display. What we had witnessed was an upper atmospheric sounding rocket launched from Fort Churchill in Manitoba, some 2000 km to the East of Fort McMurray. Apparently with these rockets, as the payload reaches a certain altitude, the sounding rocket explodes and releases an ion which interacts with the Earth's magnetic field and produces a light display similar to that of an aurora. Different colors are produced by different starting substances, such as barium and strontium. Because of the force of the explosion, the cloud of ions remains circular for only a few seconds before the ions spread out and assume the form of a vertical ray. Due to the structure of the magnetic field at high altitudes the rays appear nearly perpendicular to the observer's line of sight, thus explaining the nearly vertical appearance. From the first hand observations I made and the comments made by those who had seen the same thing about one week earlier, the vertical cloud usually appears light green or white in color, drifts slowly with time, and takes 3–5 minutes to disappear. Perhaps this might explain the strange appearance and dynamical behavior of these trains as well as the fact that they occurred in a large group.

Peter Brown, July 30, 1989

A double Perseid maximum in 1988?

As could be expected, we got many reactions on the reporting of a double Perseid maximum in WGN 17:4, pp. 127–137.

Personally I do not believe in the "hollow meteoroid stream" idea (there was also a write-up by David Hughes in *Nature* at about the time of Jones' paper), although I have not looked at in detail. Double maxima (or multiple maxima) are seen for other showers—why? It could represent two or more phases of meteroid emission by the comet. I hope to get on looking at the orbital evolution of the Perseid stream within a year or two. It is interesting since, like the Geminids, one expects little or no dispersion (in a, e, etc.) due to gravitational perturbations—the stream avoids all of the giant planets. I have not yet looked into the available data but would have thought that from my point of view we probably have the data needed—cfr. Bertil Lindblad's long run of radio/visual results from Onsala. The way in which the activity changes from year to year, over many decades, is of course needed so as to know how the stream is evolving (rotation of ω, Ω).

Duncan Ollson-Steel, Univ. of Adelaide, August 2, 1989

I think we should keep an open mind on this matter; I do not see any reason why a double maximum should not be possible. It will be interesting to see if this year shows the same effect. Of course, we must always be aware of the possibilities of statistical effects on the results leading to dubious conclusions. But on the other hand, we should not reject conclusions just because we do not expect them. It may be, of course, that there are local irregularities in the Perseid structure, and that some years we may have a clear peak, others it may be double, etc. Incidentally, I have noticed that when you average results over a 6, 8 or 10 hour period you use a different way of estimating the standard deviation of the rate from me. You use the series of numbers to determine the mean rate and the standard deviation; I work out the mean rate the same as you do, but then use the total number of Perseids (or Sporadics) to work out the standard deviation in the same way as for the individual rates. I'm not sure which is the most rigorous statistically! Your way, however, does seem to give low standard deviations if the individual ZHR values used in assessing the average agree well, even if they are based on just a handful of meteors. It seems to me that a final averaged ZHR should have a standard deviation associated which does reflect the amount of meteors that went into its determination. But no doubt there are counter-arguments!

George Spalding, August 16, 1989

The amount of observations brought together here is amazing and proves your point that only global analyses of a stream are useful. However, I don't agree with your conclusion about the double maximum, and I think there is a more obvious explanation: statistics. I fully agree to mid p. 130 and Figure 3. But as soon as you start using less than 12 hour intervals, I doubt that the results are still reliable. First of all, the technique of averaging ZHRs should be made clear. It is *not* simply averaging all ZHRs, as each of the ZHRs has a different weight. Hence, I won't comment further before knowing the formulae you used. I believe that the correct formulae are:

$$\mathrm{ZHR}_i = a_i\,(n_i \pm \sqrt{n_i})$$
$$\mathrm{ZHR}_{\mathrm{avg}} = \frac{1}{\sum_i \frac{1}{a_i}}\left(\sum_i n_i \pm \sqrt{\sum_i n_i}\right)$$

I don't agree with the statement in the last sentence on p. 130 that Figure 5 "clearly" shows a double maximum, as no error bands are shown. The dip around $\lambda_\odot = 139^\circ\!.25$ is studied in detail, but what about the relatively larger dip around $\lambda_\odot = 140^\circ\!.6$? It is also not clear to me how ZHR and spread in Table 1 are obtained. I have the impression that the spread is too large, due to too high weight for low ZHRs. Also ZHR = 81.1 at $\lambda_\odot = 138^\circ\!.9$ and ZHR = 80.4 at $\lambda_\odot = 139^\circ\!.4$ can hardly be called maxima, when the value in between is 79.7, considering the large spread! Even if there exists a slight dip in the ZHR profile, it is not necessarily true that all observers will experience it that way due to the limited number of meteors. I have shown some examples about this at the occasion of the Hingene meeting, also published in the proceedings of this conference. Hence, I don't think that personal impressions of one or another individual are of value in proving high or low activity. A more objective technique in finding the profile of a stream might be trying to fit a unimodal curve. Only when some points differ significantly from this curve (according to e.g. the χ^2 test), there is a need to look for some more complex curve, such as a doubly peaked one. The spread on individual ZHRs is larger than based on the number of meteors only (Poisson distribution). This is mainly due to errors on the correction factors, which are estimates themselves too. Especially the correction factors for the limiting magnitude and cloudiness are subject to such estimation errors. A double maximum in the Perseids stream hasn't been observed yet in the past. Also the characteristics of the maximum seem to vary a lot from year to year. In 1982, observers in the Swiss Alps saw a rare, high maximum. It was suggested then that the Perseids have a very narrow (single) peak superimposed onto a more gently varying activity. The prediction that this would happen again in 1986 didn't come true. Assuming that this maximum—or the position of the alleged double maximum—shifts from year to year is too easy. Personally and with the information available, I stick to the single maximum Perseid stream, and I believe that visual observations are intrinsically too unreliable to be able to detect variations in a time span of a few hours. If, after revision of the formulae, there is still a significant dip in the activity, I'll be glad to share the excitement of this discovery. If however the double maximum doesn't exist at all, I believe *IMO* should be more careful about block lettering announcements similar to the discovery of the cold fusion some months ago. In any case, the Editorial Board should carefully review articles with far reaching conclusions.

Christian Steyaert, August 4, 1989

Answer from Paul Roggemans:

I agree with Steyaert that we have to be careful when conclusions are made when dealing with statistical data, I do not agree with the points raised in Steyaert's letter. Let's consider his letter point by point. First of all, Steyaert disagrees with the use of sampling periods less than 12 hours long. A maximum length is 6 hour as the spreading due to the shower activity can be considerable in a 12 hour period; the 1988 Geminids decreased from 120 to 20 meteors per hour in about 12 hours! The larger the sampling interval, the smoother the resulting profile will be, but short duration features will be smoothed away, whatever they are, spurious or real. Taking into account the number of observations dealt with, I did not use a weighing factor as the correction factor used in a ZHR was limited, allowing only data obtained under acceptable conditions. I did apply the formulae you proposed, which resulted in Figure 1 below. The shape of the curve did not change very much. Experimental work with the *VMDB* must enable us to find the most suitable sampling period and weighing factors. Another important factor to be taken into account is the number of ZHRs used in the average. The dips at $\lambda_\odot = 140^\circ\!.6$ is insignificant, as too few ZHRs were reported at that time.

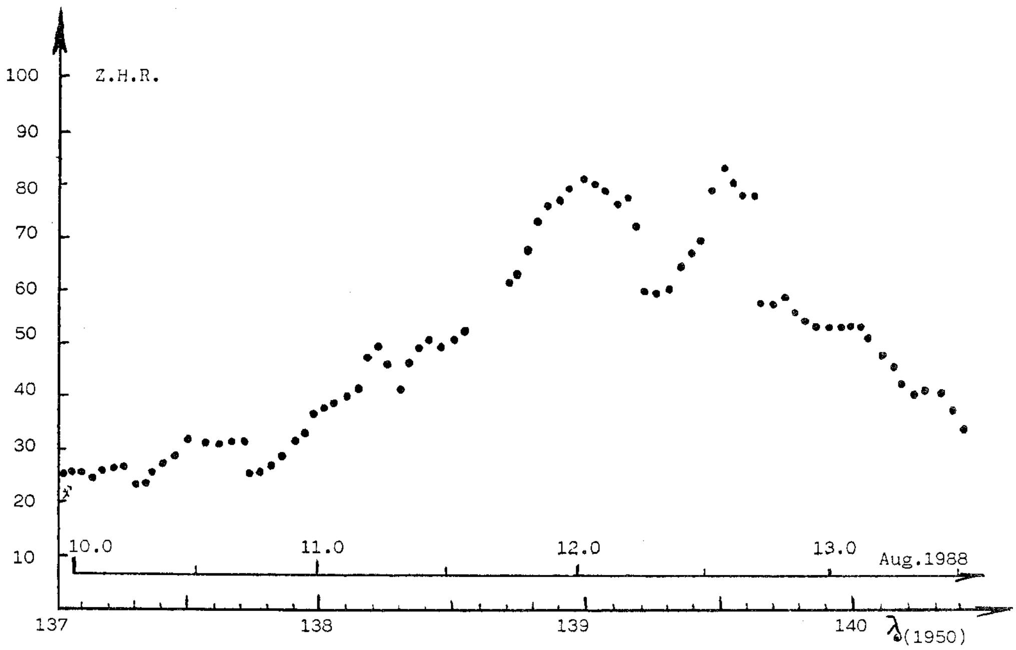

Figure 1 – ZHR profile of the 1988 Perseids using the formulae proposed by Steyaert.

A double maximum has not been mentioned often. Šimek and Lindblad found a main maximum at $\lambda_\odot = 139^\circ\!.22$ and a secondary maximum at $\lambda_\odot = 139^\circ\!.75$. The spatial distance between both features is similar to the features found in the *IMO* data, except that in 1988, they came $0^\circ\!.2$ earlier in solar longitude. The original data used by Lindblad does not enable to distinguish short duration features. Another important aspect, which you do not mention is the influence perception may have in observing periods covered by few observers.[1] Anyway, visual work can never provide proving evidence. It gives observational support to theoretical studies on stream evolution. The editorial board must be careful not to publish questionable articles, but there is need for new ideas to provoke further investigation. If the first idea turns out to be incorrect, the point will at least be cleared up. The 1988 Perseids profile indicates a profile, with a twin peak: several explanations are possible, but the results should be compared with global analyses of the stream activity in other years.

Paul Roggemans, August 28, 1989

[1] This problem is dealt with in an article on p. 189–193 (Ed.)

I.M.O. Computer Section Questionnaire

Please return before October 30, 1989 to:

Chris Steyaert
Dr. Van de Perrestraat 83 , B 2440 Geel Belgium

Provisional results will be discussed at the International Meteor Congress, Lake Balaton, October 5-7

I have/can use a **computer** of following type:

- ☐ IBM (or compatible) ☐ Apple .....
- ☐ Commodore .... ☐ other : ....

Configuration:

memory : ... K
diskette drive : ☐ 5"1/4 ☐ 3"1/2
Hard disk : ... MB graphics screen : ......

Other hardware:

- ☐ mouse ☐ modem speed 300/1200/2400
- ☐ printer: .... ☐ plotter: ....
- ☐ scanner

Preferred **programming language**(s) :

- ☐ Pascal .... ☐ C
- ☐ BASIC .... ☐ other : ....

Packages used :

- ☐ Lotus
- ☐ dBase / Foxbase ☐ other .....

Personal information :

Name, country :

I see as the main tasks for the Computer Section :
(priority : Low, Medium, High)

L M H standardizing file layouts (PMDB, RMDB, VMDB , scans)
L M H distributing ready-to-use programs
L M H distributing source programs and toolkits
L M H developing mathematical methods in meteor astronomy
L M H data communication (by means of modem)
L M H advising selection of hardware / software
other : ....
....

Suggestions / remarks :

To Whom do You Send Your Visual Observations?

Paul Roggemans

The aim of *IMO* is that observers report as much as possible observational reports to *IMO* coordinators. To share the work, some people will help to keep the *Visual Meteor Database (VMDB)* up to date.

The *VMDB* central version is kept by Paul Roggemans who collects all the input and distributes the updates to the *VMDB* subcenters. All West European observations have to be sent to him, except for Norwegian reports. Trond Erik Hillestad takes care of all Norwegian data and transfers these on diskette to the central *VMDB*. Australian data for 1989 are also entered by Roggemans. Jeff Wood will soon run a copy of *VMDB* for pre-1987 Australian observations, and will take over from 1990 onwards. Another copy of *VMDB* is run by Rainer Arlt, Ralf Koschack and André Knöfel. All East European data (including those from the USSR) have to be sent to them. Finally all American data are to be submitted to Peter Brown in Canada. Further pre-1988 observing results are entered by Glenn Ticket and Ghislain Plesier.

Please check the 1988 *IMO* report, which is to appear soon, for the codes and formats of the *VMDB*. If everybody makes an effort to modify his or her reporting format accordingly, we save a lot of time when keying in the data!

At the Start of IMO's Computer Commission

Christian Steyaert

In order to establish a direction for the Computer Commission, we would like you to return massively the questionnaire on the previous page. (Please photocopy the questionnaire in order not to damage your copy of *WGN*.) Many thanks!

Telescopic Meteors—Surely You are Not Serious?

Malcolm J. Currie

Telescopic-meteor observing is compared with the naked-eye method. The latter is found wanting due to its poor plotting accuracy and because it is prone to bias, unlike telescopic work. The benefits that accrue from accurate meteor plotting are described, and the potential science from the study of telescopic meteors is briefly reviewed.

1. Introduction

Some people think that I am crazy. My next-door neighbors certainly do. Most amateur astronomers and even most meteor observers would say surely attempting to observe telescopic meteors is a waste of time. Why bother to observe with a telescope, when there is the eye—one of the finest panoramic detectors known? The recent *Sky and Telescope* article about the future of amateur meteor astronomy [1] does not mention telescopic meteors. Even an authoritative source—a famous television astronomer and popularizer—says dogmatically in a recent book [2]: *Meteor plotting is a useful amateur pursuit, but I do not propose to say more about it here simply because binoculars are of no use whatsoever. The best instrument is the naked eye.*

Well! It seems that I am in the minority. In this article I hope to convince you that I am not completely mad, and there are good scientific reasons for observing meteors through telescopes.

2. Why Telescopic?

To answer this question, we need to review the visual technique, and see its limitations.[1] It may be the "finest panoramic detector", but the eye has many disadvantages and problems. Please do not interpret what I write below as derogatory towards the naked-eye observers—the foundation and mainstay of amateur meteor astronomy, and who are responsible for much of what we know about meteor showers—all I am saying is that the naked-eye watcher has to realize the limitations of that kind of observation. It still has an important place. However, some discoveries and observational tests of theories require alternative techniques.

Professionals tend to ignore amateur work, because results of different groups are not intercomparable, or simply do not agree. It is also too subjective—interpretation of an event occurs before and it is even recorded by the observer. I am particularly thinking of shower identifications. The observer has to make a snap judgement to decide the association or otherwise of a given meteor. Different observers disagree over observations of the same meteor. There are also biases. Some observers feel that it is better to record as many shower meteors as possible, and therefore many sporadic meteors are incorrectly classified. This can lead to phantom showers, like the υ-Pegasids [3]. There have been experiments where a group of observers were told that a new radiant had been discovered, and were asked to record meteors from it. Naturally enough they saw lots of meteors from the radiant. Unfortunately, the shower was fictitious! Jürgen Rendtel described such a test [4]. International standardization in observing methods and data reduction, which ought to be one of primary goals of *IMO*, should greatly help the amateur's standing. Another *IMO* achievement will be, I am sure, the compilation of large datasets. These will produce new results previously lost in the noise, and anomalous observations by a small number of observers are readily identified. An example, is the double Perseid maximum in 1988 recently reported by Paul Roggemans [5]. However, there are still biases and errors that plague visual observation and will not go away. Standards and the accumulation of data only go so far.

A fundamental problem is the poor plotting accuracy of the naked-eye observer. Various workers disagree what the errors are, partly I think due to the varying experience of the observers concerned and their different methods. Typical values for a practised observer are $\pm 3^\circ$ in each coordinate for a position on the meteor's path, and $\pm 4^\circ$ for flight direction given a field of at least 100°. What does this mean in practice? I have performed some Monte-Carlo simulations for a typically sized radiant and an impartial observer (let us ignore any bias).

The radiant was assumed to be a two-dimensional Gaussian with $\sigma = 0\overset{\circ}{.}3$. Meteors were generated randomly within the radiant and could appear at any position angle; their radial distribution being normalized by the volume of atmosphere. The "observer" was allowed some movement within the field of view. Given the distance of the meteor from the observer's view, the event was deemed to be observed if a random number was below the perception taken from Table 4 of [6] for $\Delta m = 3.5$. Random plotting errors were then applied to derive the observed path. A representative simulation is shown in Figure 1. The paths were traced back and the intersections plotted for pairs of meteors whose position angles were different by 20–160°. (This is not the best method for determining the radiant, but it is simple and amenable to graphics.)

For about a hundred meteors the mean radiant position can be determined to $\pm 0\overset{\circ}{.}5$, but the overall size of the radiant is much bigger than the true dimension, about twelve times. I also computed the percentage of meteors that appeared to pass through the canonical 2°-radius circle for assigning shower association. On average only 45% would be classified as shower meteors given this criterion! If the larger area is adopted, the contamination by sporadics increases. This may not matter much for a strong shower like the Perseids, but identifying minor centers

[1] Note I use *visual* and *naked-eye* synonymously.

of activity becomes difficult indeed. (Of course, other features like angular speed, distance from the radiant and path length must be used to reduce contamination). It should be sobering to naked-eye observers that it is difficult to decide upon shower membership visually, let alone assess the position, size, and motion of the radiant.

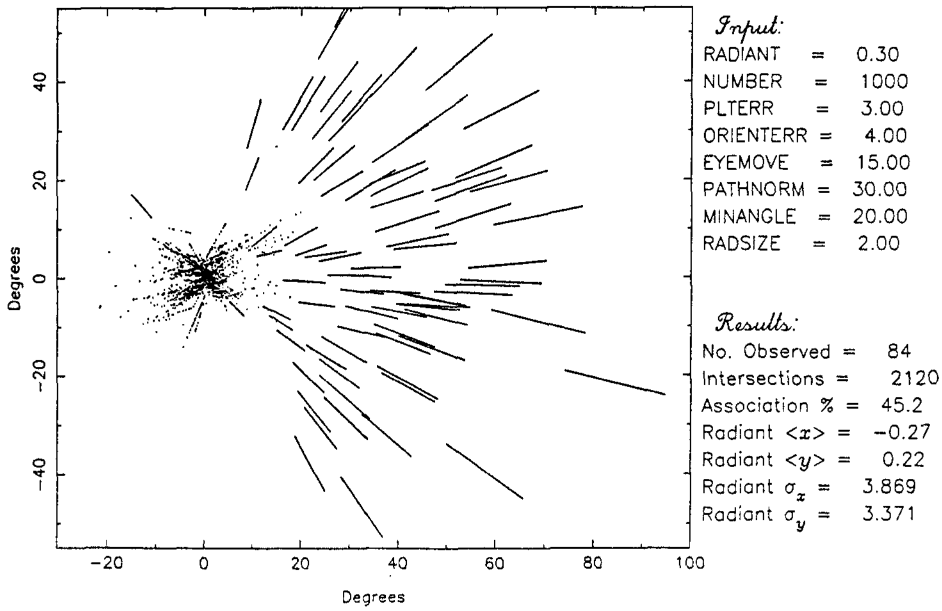

Figure 1 – A simulation of a naked-eye watch. Only shower meteors have been plotted. The radiant lies at $(0,0)$. The dots are intersection points of meteor trails traced back towards the radiant. See the text for further details.

The next problem is that the average visual watcher is biased towards observing the major showers, indeed just a few of the major showers. This means that most months of the year are just not being observed systematically and thoroughly. As a result reports of all but a few minor showers are regarded as apocryphal. A cautious approach is certainly justified given the plotting inaccuracies that cause minor radiants to be smeared and buried in the noise, and the bias described above, but a body like the *IMO* could go a long way to determine what showers are active and when. There is a more alarming consequence of seasonal observing. The sky is not static. Showers come and go. Either because there are new comets, or perturbations of stream orbits by the giant planets, or they are periodic. For example, the Geminids were only discovered in the latter half of the last century; the π-Puppids were first observed as recently as 1977. We were fortunate in the latter case that a shower was predicted. For existing streams recently perturbed by Jupiter that is not possible. We ought to maintain a vigil for such new showers. By rigidly sticking to what we already know, many new horizons are obscured. We become prejudiced and see just what we expect to see.

So far I have only addressed the naked-eye observer. Can telescopic observation tackle any of the criticisms leveled above?

3. Accuracy

One of the principal advantages of the telescopic technique over ordinary visual watching is the restricted field of view. At first glance that may sound like a strange remark to make—are not the rates much lower because there is far less sky visible? Actually, no! This is because there are a lot more faint meteors that are unobservable with the unaided eye—about 2.5 times more per magnitude. Also, the eye's acuity drops dramatically away from the direct line of vision. A visual observer will only detect meteors just brighter than the limiting magnitude when they are directly ahead, whereas a fireball can be detected 75° away—looking at the zenith that is an observing area of about 15 000 square degrees. Thus restricting the apparent field of view only reduces significantly the observed rate of the comparatively rare bright meteors. (See Figure 7 of [6]). For a 50° field, more meteors are missed than observed only for those brighter than four magnitudes above the limit. Given these compensating factors telescopic rates are down to half of those seen by the naked eye. That is not too bad, but nevertheless that is still worse than visually. Surely that is not advantageous? What you obtain in compensation is that the assessment of the path of a meteor against the stellar background is more accurate. This is because the eye does not have to rove about an enormous field of view. The observer's attention is fixed on a much smaller area in which a greater fraction of events appear. Meteors cannot be seen "out of the corner of the eye". Put another way, the trail length is no longer a small fraction of the diameter of the field of view. Another contributing factor probably is that the observer's head does not move in telescopic observation. The increase in accuracy is not negligible. For an apparent field of view of 60° the improvement is a factor of about three compared to a typical naked eye that gives coverage of over 100°; and as the field size is further reduced the gains multiply, so at 50° the accuracy is almost five times better, and at 40° it is a remarkable six times. Of course, you would not want too small a field, because you would see very few meteors. A good compromise is about 50–60°. Incidentally, if visual observers used blinkers to constrain their viewing area, they too would gain similar improvements in plotting accuracy.

The second advantage also relates to the plotting accuracy. The magnification of the telescope reduces linearly the error in the position of the trail. Experienced BAA observers in the 1960s measured relative positions to $\pm 40'/M$ for a 60° field, where M is the magnification, and $\pm 1°$ in direction. This yields radiant determinations superior to radar techniques. Only high-quality photographic work can better it for accuracy, but telescopically we can record more meteors per unit time, and see events tens of thousands times fainter.

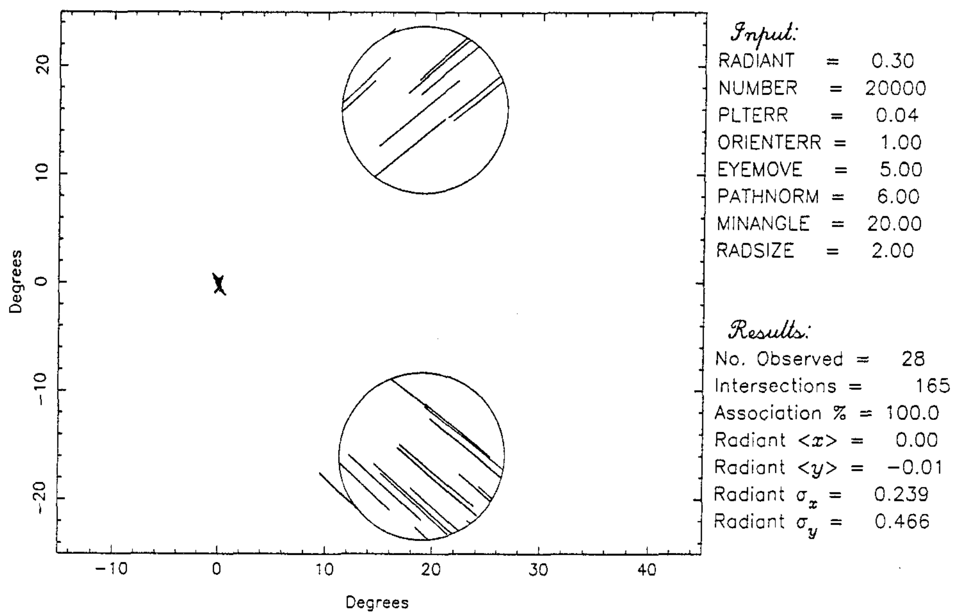

Figure 2 – As Figure 1, except this shows simulations of telescopic observations. The telescopic fields of view are magnified 5.5 times for clarity.

I have repeated the simulations for a pair of 2°.8 field at 18× magnification (see Figure 2) assuming these measuring errors. Notice the observed field is about 25° from the radiant. The main things to note are that the observed radiant size and position are both near the actual values, the latter can be determined to 0°.2 for only 30 meteors; and the shower association is complete. I also made further simulations for a double radiant composed of two Gaussians separated by 1° in the ordinate direction. The intersection points were summed into bins to make images of the radiant. Contour plots of the images are shown in Figure 3.

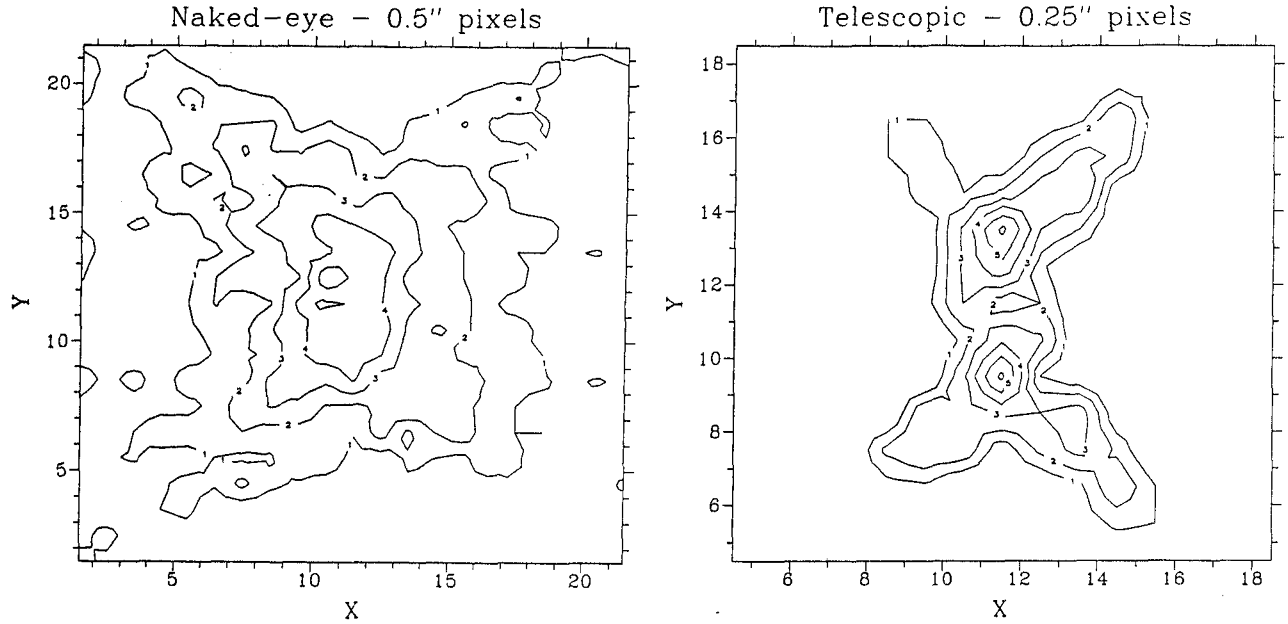

Figure 3 – Contour plots of binned path intersections from simulations of a double radiant. The left shows the visual data at contour heights corresponding to 40, 80, 140, 210, and 250 intersections per square degree. To the right are the telescopic data at heights 96, 160, 240, 336, 448 and 576. Note the smaller pixel size in the telescopic plot. The X-shaped pattern is an artifact.

The telescopic data on the right for 122 meteors clearly resolves the two components, whereas for 342 visual meteors the binary nature of the radiant is detected but only marginally. Each image comprises data from four separate simulations to reduce the number of artifacts. The number of meteors in these simulations is atypical. Given fewer meteors the visual data is hard pressed to show any structure, but the telescopic data shows both components with as few as 30 meteors.

4. Bias

During telescopic work the observer plots meteors. There is no judgment required to assign shower membership. So there is less bias towards shower meteors. Also there is a permanent record, which can be analyzed without preconceptions. It can also be reanalyzed and combined with other data, perhaps from another epoch, to decide its probable shower association. Contrast this with the naked-eye observer's snap decision which can never be reviewed. It would be wrong of me to give you the impression that telescopic observation is unbiased towards shower association. One preconception is the selection of the field centers. Before observing commences the observer selects or has been instructed to look at particular star fields. These will often be chosen to give a good fix on a known radiant, by being at suitable position angles with respect to the radiant and not too distant from it. This does not mean that distant radiants cannot be studied, just that the accuracy of their parameters is lessened. Early telescopic workers thought that you had to view close to the radiant otherwise the magnified velocity would make observation impossible. It is not the observation of the star-like head that is important; this is rarely seen, but persistence of vision allows us to see even the faintest meteors as lines of light.

At telescopic magnitudes, the major naked-eye showers are far less prominent. Their activity compared with the sporadic background diminishes by approximately three quarters for each magnitude the mean meteor brightness dims [7]. So there is less incentive for seasonal viewing. Further, since little is known about telescopic activity throughout the year (rather than at certain times), there is plenty of scope to make worthwhile observations and undertake interesting research at any time of the year. There are bound to be showers that are rich in faint meteors awaiting discovery. The 11 Canis Minorids, and July α-Lyrids are just two examples. If we stick to the traditional meteor season many will escape detection. There are already many suspected minor radiants in the archives awaiting confirmation. Our map of telescopic showers is largely incomplete. Let us fill in the uncharted territory.

Numerous authors have pointed out the difficulty of observing minor showers (e.g. [3]) because the number of chance alignments by sporadic meteors is large compared to their likely maximum rates; the number of path intersections goes approximately as the square of the number of meteors; and chance clusters of intersections due to statistics are likely. The telescopic observer can do better due to accurate plotting, and the review process mentioned above. The ability to pinpoint a "radiant" reduces significantly the probability that it is a chance association. Chance alignments are reduced. If you see just a handful of meteors from at least two field centers, whose paths when traced back cross within a degree of each other, and the other intersections are widely scattered, the odds are that this is a shower. For example, Keith Hindley could be confident that the five "sporadic" meteors that intersected within a 35′-diameter area on 1964 Dec. 10 was a shower—the 11 Canis Minorids [8]—the probability that it was due to chance alignments of sporadic meteors was 1 in 10^4. I have been able to review possible showers by delving into the BAA archives [9]. Some are regularly detected, giving significant proportions of the total number of meteors, thereby lending strong weight to their reality. Ideally, a full computer analysis of a large database is required to be sure.

5. Other advantages

Although the telescopic watcher will see fewer meteors, and especially bright meteors, the bright ones that do cross the field amply compensate in my view. The excitement of seeing the meteor phenomenon close at hand is unrivaled. I cannot express it more eloquently as Keith Hindley who wrote: *There is the thrill of seeing a pastel-tinted elliptical meteor head, flickering as it tumbles, or fragments as it crosses the field, and the delicate train left behind, which expands and is distorted by winds in the upper atmosphere as it fades.*

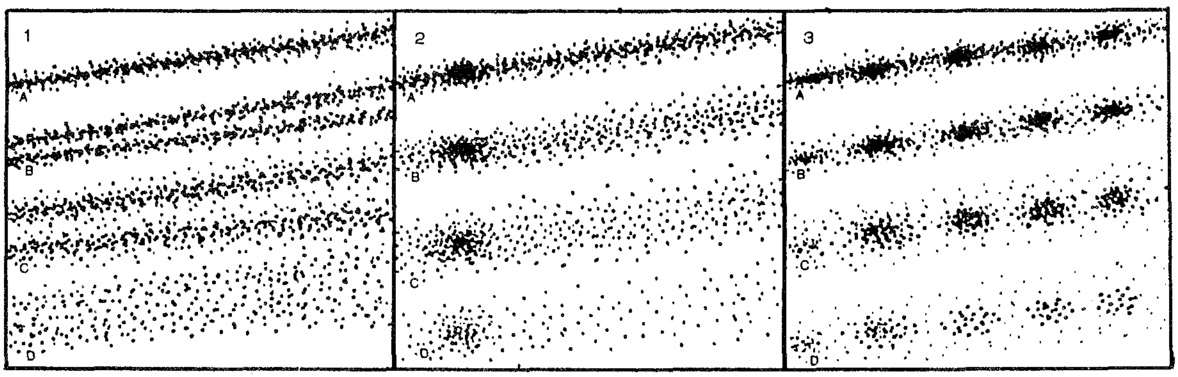

Figure 4 – Some examples of meteor trains. See the text for a description.

Early telescopic work showed that trains come in different forms (see Figure 4), but we lack statistical information about their frequency and association with given showers. In Figure 4, the first example (panel 1) is a train which bifurcated as it expanded, suggesting that it is a hollow cylinder of material—a rather rare type. More commonly, trains are denser in the center and fade to give a band of uniform brightness (panel 2), and any flares on the meteor's path give a stronger path of train that persists longest. Another rare type (panel 3) of train consists of a series of blotches of luminous material, often with these spaced at regular intervals. Such trains may be formed by a rotating flat meteoroid which ablates more material when flat side on than when sideways on.

Hitherto I have been comparing the relative merits of the naked eye and telescopic techniques, but there is an important advantage of telescopic observing which complements the visual watches. When we observe meteors through a telescope we see faint meteors, in other words we are studying the properties of a different, less-massive, population of meteoroids.

6. Science from Telescopic observations

I have already alluded to some of the possible investigations that can be carried out telescopically. Now I am am going to expand my remarks.

The markedly better plotting accuracy enables the telescopic observer not only to determine more reliable shower associations, but it also permits the tracking of a radiant's motion [10], and can probe into the radiant identifying sub-centers of activity (e.g. [11]). The puzzle of stationary radiants would have been resolved much sooner had telescopic methods been widely employed. The properties (size, shape, activity) of the sub-centers and their motion that give rise to the phenomenon still warrant investigation. The Orionid stream is a classic case [12].

Recent modeling by Jones [13] suggests that meteor streams can be hollowed by planetary perturbations. Telescopic observations are ideal to test this theory. Well-separated double radiants like the Taurids and δ-Aquarids are well known, but we need to observe a series of showers to see whether we can find streams in the intermediate stages of being bifurcated. There ought to be a progression. The relative frequency of showers with various separations coupled with orbit information should give an idea of the timescales involved. Showers that have multiple maxima can be studied to see whether the meteors are coming from different radiants. Areas of complex activity can be mapped, though some may defeat even telescopic work. I am particularly thinking of the several ecliptic complexes like the Virginids.

We can extend the luminosity function obtained from photographs and by the visual observer. So we can attempt to measure the flux of meteoroids from a wide mass range (as requested by Soviet scientists at the recent Uppsala conference [14].) However, I think it is unlikely that we will be able to determine a standardized telescopic hourly rate given that there are an order of magnitude more unknowns than for the visual ZHR, which is itself still the subject of controversy in some circles. At the very least there would have to be activity curves for meteors of different mean magnitudes as seen through instruments of different apertures.

One thing we can compute is the rate of a shower with respect to the sporadic background during the same time, assuming the visual corrections for radiant altitude. Since the sporadic activity is believed to be moderately constant from year to year, and smooth from day to day, this method can produce at least for a given mean meteor magnitude the shape of the activity curve and the time of maximum rate. Therefore, variations in shower activity from year to year can be monitored. Data from a small range of telescope apertures (e.g. 40–60 mm) can be combined to produce more accurate activity curves. This method for deriving rates makes many other assumptions, probably invalid, like the fact that the luminosity functions of the shower and sporadic meteors are the same. The fact that we cannot yet produce a meaningful telescopic ZHR does not detract from telescopic-meteor observing, on the contrary it emphasizes the need for many more observers and observations.

Relative activity curves as a function of mean meteor magnitude are particularly important in meteor-stream evolution. By looking at their shapes and time of maxima compared with the visual ZHR curve, we gather information about the distribution of meteoroids of different masses within the stream, and how the various dispersive effects (Poynting-Robertson, Yarkovsky-Radzievskii) have operated. This in turn can give an approximate age of the stream.

Figure 5 is an example based on 1960's BAA Quadrantid data.

Again at the recent Uppsala meeting [14], Hughes requests that we investigate minor showers. As I demonstrated earlier this is very difficult visually, and so we should be using telescopic and video techniques. There is a tendency to study the most prominent in a class of objects (for obvious reasons), and for those to become regarded as typical representatives of all such objects. I regret that this is true of meteor showers.

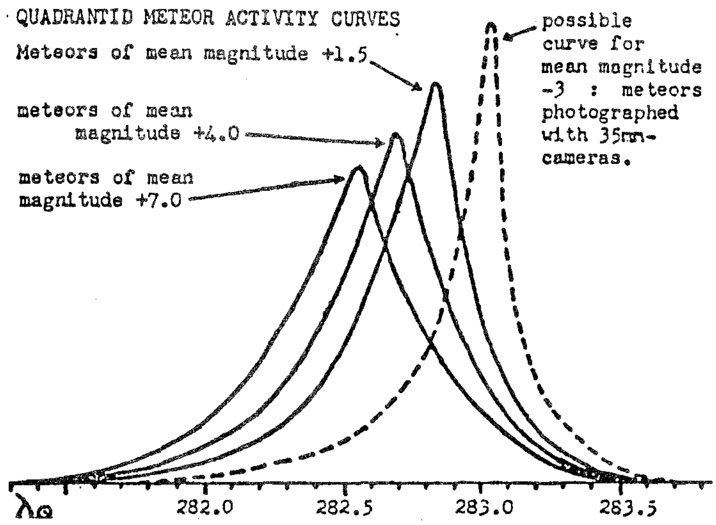

Figure 5 – Quadrantid activity curves at different mean magnitudes from BAA data. Notice the progression of earlier times of maximum and broader activity curves as the magnitude gets fainter. The solar longitude scale has a 1950.0 equinox and 1974.0 epoch.

In the 1950's Slovak workers determined the distribution of sporadic radiants from observations spread evenly by time of year and hour of night [15]. This was based on only ~ 1000 meteors. Unfortunately, these pioneering telescopic observations did not include plotting, and even a comparatively recent analysis of showers (e.g. [16]) was hampered by the poor plotting accuracy created by viewing through ultra-wide-field binoculars. Given a sample of 15 000 plus, today's fast computing and modern analysis techniques I think we should obtain much better results. In addition observations with larger apertures offer a chance to study the properties of the toroidal meteor system. Members of this system have high-inclination orbits (about 60°) and short periods. Towards fainter magnitudes the fraction of toroidal meteors increases, being half the population at magnitude 10.

I hope that I have shown that the observation of telescopic meteors is relevant, worthwhile and rewarding. Much remains undone; the amateur has a vital role to play in our understanding of the smallest interplanetary particles.

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Visual Observers' Notes: November–December 1989

Jeff Wood

1. Introduction

The months of November and December are characterized by the large number of major showers that are active at this time of the year.

The Geminids, Puppid/Velids, Ursids, Taurids and Leonids together with a host of minor streams make for a period of excellent viewing. Even though southern hemisphere observers are favored by summer weather, northern hemisphere observers are to be encouraged to get out and brave the cold winter nights. Meteors do not feel the cold and *IMO* needs information on *all* meteor streams appearing throughout the year!

Table 1 below lists sixteen of the more important showers that occur during November and December.

Table 1 – A list of some of the meteor showers to be seen in November–December 1989.

Shower	α	δ	Period	Max
Taurids S	51°	+14°	Sep 15–Dec 1	Nov 3
Taurids N	58°	+22°	Sep 19–Dec 5	Nov 13
Andromedids	25°	+44°	Nov 8–30	Nov 15
Leonids	152°	+22°	Nov 11–22	Nov 17
α-Monocerotids	107°	−6°	Nov 15–25	Nov 20
δ-Eridanids	58°	−9°	Nov 6–29	Nov 18
Puppids/Velids	123°	−43°	Nov 2–Dec 30	Several
Phoenicids	18°	−53°	Nov 28–Dec 9	Dec 5
Monocerotids	100°	+14°	Nov 27–Dec 17	Dec 10
σ-Hydrids	127°	+2°	Dec 2–18	Dec 11
χ-Orionids N	84°	+26°	Dec 3–16	Dec 10
χ-Orionids S	85°	+16°	Dec 6–15	Dec 11
Geminids	112°	+33°	Dec 4–18	Dec 14
δ-Arietids	52°	+22°	Dec 7–14	?
Coma Berenicids	175°	+25°	Dec 12–Jan 23	?
Ursids	271°	+76°	Dec 17–24	Dec 22

Table 2 on the next page shows moonlight and observing conditions.

Table 2 – Moonlight and observing conditions in November–December 1989.

Date	k	Date	k
Friday October 27	0.06−	Friday December 1	0.06+
Friday November 3	0.17+	Friday December 8	0.71+
Friday November 10	0.85+	Friday December 15	0.93−
Friday November 17	0.81−	Friday December 22	0.32−
Friday November 24	0.17−	Friday December 29	0.01+

New Moon:	October 29, November 28, December 28
First Quarter:	November 6, December 6
Full Moon:	October 14, November 13, December 12
Last Quarter:	October 21, November 20, December 19

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 Taurids

This shower is broken up into several substreams, the most important of which are called the Northern and the Southern Taurids respectively. The Taurids have one of the longest periods of activity known lasting from early September through to early December. They reach a broad maximum in late October and early November. Although the date of maximum for the Southern Taurids is given as November 3 and that of the Northern Taurids as November 13, these were derived from the orbital elements and not from visual observations. At maximum, Taurid activity can be very erratic with rates ranging from 1 or 2 meteors per hour to as high as 10 to 15 meteors per hour.

With the radiant positions reaching culmination just after midnight, Taurid meteors can be observed for most of the night. The Taurid meteor stream is noted for its many brightly colored meteors. Although the dominant color is yellow, many orange, green, red and blue fireballs have been recorded. This together with their relatively slow geocentric velocity means that they can be recorded on film more easily than most other showers. Perhaps you could try and photograph some for the *Photographic Meteor Database (PMDB)*.

Although the Moon affects viewing towards the middle of November, the Taurids are generally free of its influences for most of the period of major activity. Observers are encouraged to carry out an extensive Taurid watch this year.

3. The Andromedids

Produced from the debris of comet P/Biela the Andromedids are one of two November meteor showers that have on occasions produced meteor storms, though in their case the last one of these was about 100 years ago. Since then the Andromedid orbit has been perturbed by the planet Jupiter so that the center of the stream's orbit misses the Earth by a considerable margin. Thus the likelihood of another one appearing is very remote. However, observations have indicated that there is a remnant shower to be seen each year as the Earth passes through the outer fringes of the stream.

The modern day Andromedid shower is active from November 8 to 30 with a broad maximum of between 1 and 3 meteors per hour occurring around November 15. The Andromedids are characterized by their very slow geocentric velocity and their often ruddy hue. Although badly affected by the Full Moon on November 14, they should be able to be seen in the early evening hours in dark skies just after maximum.

IMO urgently requires data on this shower and despite unfavorable circumstances, observers are asked to keep an eye out for these meteors in 1989.

4. Leonids

The Leonids are the second November meteor shower that has produced a meteor storm, the last occasion of which was in 1966. They are a young stream, being produced by the debris of comet P/Tempel-Tuttle which means that, like the parent comet, they have a 33 year periodicity in their maximum activity. As we are now within 10 years of the next return of the parent comet and hence the next predicted storm, Leonid rates should be on the increase. Last November a maximum ZHR of between 15 and 20 meteors was recorded, the highest for some years.

The Leonids, which will be badly affected by the moon, reach maximum on November 17 and are fast meteors that have a bluish hue. They produce many fireballs and trains.

5. The Geminids

The maximum of this stream occurs on the night of the Full Moon which should reduce the normal observed rates by a factor of between 5 and 7. Despite this handicap, Geminid activity is so high that even with this handicap rates of between 10 and 20 meteors per hour can be seen, which is still good viewing.

Even though their radiant has a declination of $+32\overset{\circ}{.}5$, the Geminids can be observed well from both the northern and the southern hemispheres. The Geminid radiant is easy to find being situated near the bright stars Castor and Pollux. Geminid meteors have an average type speed and a yellowish hue. Very few leave a train. Another feature of the Geminids is the large number of bright meteors produced.

6. The Ursids

The Ursids are a northern hemisphere stream that is active from December 17 to 24. They reach maximum on December 22. The maximum hourly rate is usually between 10 and 20 meteors, except in 1945 when rates exceeded 100 per hour. Ursid meteors are typically faint and have an average speed. They should have little interference from the Moon in 1989.

7. Minor showers

The *α-Monocerotids* have received little attention from observers, but over the years have produced rates of over 30 meteors per hour on several occasions, the last being in 1985. In 1989 the shower reaches maximum on November 20 which means that the sky at this time will be affected by a Last Quarter Moon.

The *δ-Eridanids* are a southern hemisphere stream with an activity period that extends through most of November. It reaches maximum on November 18 with a ZHR of 3 to 5 meteors. It will be badly affected by the Moon in 1989.

The *Puppid/Velids* is a name given to a large group of showers that occur in these constellations during the months of November, December and January. The most likely parent body is the Apollo asteroid Tantalus. The Puppid/Velids have several maxima, but in general peak during early to mid December. The Puppid/Velids have a faster than average speed, are often brightly colored and have a train. Around maximum they reach 10 to 15 meteors per hour. Since they are best seen after midnight, the First Quarter Moon on December 6 should not greatly affect viewing in 1989.

A First Quarter Moon will partly affect observations of the *Phoenicids* in 1989. Despite this, the stream is a must for every southern hemisphere meteor observer. The Phoenicid meteor stream is active from November 28 to December 9. At maximum on December 5, activity generally ranges from 2 to 6 meteors per hour. Phoenicid meteors are slow in speed and are best seen in the early evening hours.

The *Monocerotids*, the *σ-Hydrids* and the *North and South χ-Orionids* all reach maximum on either December 10 or 11 which means they will be badly affected by the Moon in 1989. Apart from the σ-Hydrids which can reach over 5 meteors per hour, all of the others generally produce only 1 or 2 meteors per hour at best which means that with the Moon, very few meteors will be seen.

The *δ-Arietids* are best observed in the early evening hours during early to mid December. Not that much is known about this stream except that they generally provide low rates and quite a few fireballs. Despite the interference from the Moon in the later stages of activity, observers are urged to give this stream special attention in 1989.

The *Coma Berenicids* are a stream that until very recent times was given very little attention. However, observations made during and after the 1988 Geminids indicate that they should be placed on the regular meteor observer's calendar. In 1988–89, the Coma Berenicids were found to produce several meteors per hour just before sunrise. They appear to have a maximum somewhere between December 20 and 30. Coma Berenicid meteors are fast and frequently bright. They should be generally free from the effects of the Moon this year.

8. Conclusions

We invite meteor workers to set up well defined observing projects or to propose specific observing efforts. Please make sure your observations reach *IMO*! Observing groups are welcome to provide us with a summary report of their observations and these will generally be published in *WGN*. We look forward to seeing the results of your observations. Clear skies and good viewing!

Telescopic Observers' Notes: November–January

Malcolm J. Currie

November and December are unfavorable for the Leonids and Geminids, and so it is an excellent time to do some telescopic observations of minor showers, two poorly studied major showers and the sporadic activity.

The Ursids are well placed this year. This shower has been poorly observed, and little is known about its radiant and telescopic activity, so any observations are worthwhile. The Ursid shower is amenable to telescopic work because it has many faint meteors—my visual data for 1971–74 show an average magnitude of 3.02 for 287 magnitude estimates and a limiting magnitude of 6.8. Here are my suggested field centers. For mid-northern latitudes (40–60° N) $\alpha = 23^{h}12^{m}$, $\delta = +74\overset{\circ}{.}5$ and $\alpha = 8^{h}42^{m}$, $\delta = +65\overset{\circ}{.}5$. After midnight some observers may find these inconvenient. An alternative pair are $\alpha = 4^{h}10^{m}$, $\delta = +83\overset{\circ}{.}5$ and $\alpha = 13^{h}40^{m}$, $\delta = +54°$. Further south (around 30–40° N) try $\alpha = 4^{h}10^{m}$, $\delta = +83\overset{\circ}{.}5$ and $\alpha = 10^{h}25^{m}$, $\delta = +64°$. Alternate between the two fields viewing for about half an hour at a time. Observers at other latitudes should select a pair of fields situated 20–40° from the radiant such that the paths of Ursid meteors seen in the fields would intersect at angles between 50° and 130° when traced back to the radiant. The fields should also include stars well distributed both spatially and in brightness, enabling the path of meteors to be accurately plotted against the star background, and the meteor magnitudes to be estimated reliably.

During October and November there is a complex of weak radiants in Aries and Taurus, the most famous and prominent being the Taurid duo that emanate slow-moving meteors, and that have a broad activity curve. Professional researchers are keen that we should give the Taurids greater attention. Visually, the Taurids have a bright mean magnitude and, therefore, do not expect more than weak telescopic activity. Peak telescopic activity may occur several days before the visual, so watches during the October New-Moon period may be more productive. The selection of field centers is tricky because there are two radiant areas, which are also elongated in ecliptic longitude [1]. If you select a pair of fields they should be at $\delta = +16°$, i.e. midway between the Taurid radiants, and displaced about 15° east and west of them. An even better arrangement is to use four fields with pairs situated at the same right ascensions as before, but with $\delta = +27°$ and $\delta = +6°$. This configuration has little occlusion and will give a more reliable radiant determination. Do not forget to allow for radiant motion when selecting where to look (see Ralf Koschack's notes on pp. 188–189).

The Quadrantids are well placed as the Moon only interferes in the first half of the night, when the radiant is low. I have recently described the scientific rationale and background to observing this shower telescopically [2]. Potential observers can obtain copies from me. The telescopic maximum occurs several hours before the visual peak. For small binoculars the maximum is expected to occur on January 3 at $16^{\rm h}$ UT, so observers around the North Pacific will be best placed. Since the duration of the Quadrantids is brief, if we are to obtain a reasonable activity curve, observations worldwide are necessary. This is another example of how international cooperation benefits meteor science. For mid-northern latitudes I suggest the following: before $1^{\rm h}$ local time $\alpha = 13^{\rm h}40^{\rm m}$, $\delta = +65°$, and $\alpha = 17^{\rm h}36^{\rm m}$, $\delta = +69°$; the alternative (especially for small apertures) are $\alpha = 10^{\rm h}25^{\rm m}$, $\delta = +64°$, and $\alpha = 19^{\rm h}15^{\rm m}$, $\delta = +66\overset{\circ}{.}5$; between $1^{\rm h}$ and $3^{\rm h}30^{\rm m}$, use $\alpha = 16^{\rm h}10^{\rm m}$, $\delta = +75°$; and $\alpha = 13^{\rm h}12^{\rm m}$, $\delta = +40°$; after $3^{\rm h}30^{\rm m}$, take $\alpha = 17^{\rm h}02^{\rm m}$, $\delta = +35°$, and $\alpha = 17^{\rm h}36^{\rm m}$, $\delta = +69°$. For other latitudes use the rules given above.

There is some complex activity in the Lynx, Leo Minor and Coma region during the latter half of December into January. In 1987 observers in France noted activity from a radiant in Coma Berenices. Kronk [3] lists a Coma Berenicid shower from a radiant at $\alpha = 165°$ and $\delta = +30°$. BAA telescopic results last season indicated a radiant in Leo Minor on December 16–17 at $\alpha = 143°$ and $\delta = +40°$ and at $\alpha = 167°$ and $\delta = +34°$ on January 4–5, 1989. A shower called the 38 Lyncids was active during the early 1970s radiating from $\alpha = 140°$ and $\delta = +42°$. Indeed in 1971 at $\lambda_\odot = 268\overset{\circ}{.}1$ a burst of activity for about an hour occurred with a ZHR in excess of 40. This shower was rich in faint meteors (average magnitude of 3.51 for 328 meteors, with an average limiting magnitude of 6.65). My feeling is that these three showers are related and indeed it is not inconceivable that there is a single shower. Kronk [3] similarly believes that the Leo Minorids and the Coma Berenicids are one and the same shower. The case for the Leo Minorids being the 38 Lyncids looks more convincing to me. Clearly, some telescopic observations are vital to ascertain how many radiants are present and when they are active. The region is too confused for naked-eye observations to discriminate.

Earlier this year BAA observers found marked telescopic activity from the α-Leonids around $\alpha = 140°$ and $\delta = +17°$. Kronk [4] finds this to be a long-duration telescopic shower, with peak activity towards the end of January. There are some other minor showers, such as the χ-Orionids (mid November to mid December), and the ζ-Aurigids (throughout December) which are slow meteors and were active telescopically on December 6–7, 1988 from a radiant at $\alpha = 85°$ and $\delta = +43°$. Finally, Kronk [5] has requested data for a possible shower rich in telescopic meteors at $\alpha = 233°$, and $\delta = +37°$ during January 16–18. In 1990 moonlight may be obtrusive.

I would like to be able to describe southern showers, but at present I have no telescopic data for radiants south of $\delta = -30°$ ... Southern-hemisphere observers might attempt to study the known visual showers of this period. Kronk lists the Phoenicids and α-Puppids of early December, γ-Velids in the first week of January, and α-Hydrids in the second half of January. Prospective observers should contact me for details of the observing method.

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Taurid Observations in 1989

Ralf Koschack

1. Introduction

Several professional meteor astronomers suggested observations of the Taurid complex. Observations of the Taurid complex are of great interest, both because of its link with one of the most studied comets (Encke), and because of the apparent complexity of the radiant structure.

Therefore we call upon telescopic, visual, video, and photographic observers to pay attention to the Taurids.

2. General information

Target of the observations is the study of the activity profile, the population index and the radiant structure. There are two main centers of the complex, called Taurids North and Taurids South.

Table 1 – Radiant positions of the Taurids North and the Taurids South

Date	Taurids N		Taurids S	
	α	δ	α	δ
Oct 10	41°	+18°	36°	+10°
20	46°	+19°	41°	+11°
30	51°	+21°	50°	+14°
Nov 09	56°	+22°	56°	+15°
19	61°	+23°	62°	+16°
29	66°	+24°	68°	+16°

Table 1 shows the drift of both centers. Observers should distinguish both. Apparent angular velocity has to be taken into account for shower association (see Table 2). The altitude of the radiant should be larger than 20° during observations.

Table 2 – Apparent angular velocity (degrees/second) depending on the altitude of the beginning point of the meteor h_b and the distance D_e between its end point and the radiant.

	$h_b = 10°$	20°	40°	60°	90°
$D_e = 5°$	0.3	0.5	1.0	1.3	1.5
10°	0.5	1.0	1.9	2.6	3.0
20°	1.0	2.0	3.8	5.1	5.8
40°	1.9	3.8	7.1	9.6	11
60°	2.6	5.1	9.6	13	15
90°	3.0	5.8	11	15	17

Taurids are active from mid September until early December. Highest rates will be observed during the first decade of November.

3. Photographic observations

Please follow the instructions in [1].

4. Visual observations

Target of the visual observations should be deriving the activity profile and population index. A problem is the complex radiant structure. For doing shower association, one has to know the size of both radiants (Taurids N and S). This can be studied by means of telescopic, photographic, and video observations. Therefore the following procedure is recommended. In order to distinguish Taurids N and S, the observing field should be located 20° east and west of both radiants. All meteors possibly radiating from an area of a diameter of about 15° around one of the radiants should be plotted. After analyzing telescopic, photographic, and video observations the size of both radiants will be published. Then observers can carry out shower association by means of their plotting taking into account angular velocity and path length.

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The 1988 Perseid Meteor Stream and Observers' Perception Coefficients

Paul Roggemans

A new technique to derive perception coefficients is described and applied to the 1988 Perseid activity profile. A main maximum is found at $\lambda_\odot = 139\overset{\circ}{.}0$, followed by a secondary maximum at $\lambda_\odot = 139\overset{\circ}{.}55$. These results are compared to past data when similar features were found to occur $0\overset{\circ}{.}2$ later in solar longitude.

1. Introduction

The twin peaked activity profile of the 1988 Perseids [1], caused some comments. The subsequent studying on all aspects of the analysis gave some useful information for all observers. First of all the activity profile has been recomputed using a weighted sliding mean, proposed by Steyaert [2]. The resulting activity profile[1] does not differ so much from Figure 5 in [1], which is not so much a surprise seen the large number of ZHRs used.

A point of more concern, not very well covered in [1], are the perceptions. In a global study such as this one, there is the continental grouping effect of meteor observers. Most data were contributed by Europeans. Unfortunately we get very few contributions from America and the Japanese people were hampered a lot by bad weather. In such circumstances, one assumption in our method is not fulfilled, namely that the large number of contributors represent observers of the entire perception range. If this condition is not satisfied, there is a substantial risk of having perception effects, as the small number of people at a given sampling period may be high perceptive or low perceptive observers. This leads to spurious features in an activity profile. Figure 6 in [1] was obtained from observations done under nearly perfect circumstances, average over a very short (2 hour) period. The perception coefficients were then obtained through the sporadic HR, taking the mean HR as a reference. At this point, criticism was expected but did not come. Indeed, sporadic rates always represent a small number of meteors, heavily affected by statistical uncertainties. The sporadic rates show a daily variation, although this is not always evident from the observations. Last but not least, the HR can be badly influenced by observational errors such as shower meteors counted as sporadics (then the observer will have less shower meteors, while his/her HR is high, indicating a high perception, causing a reverse effect on the corrected ZHR). There are not so many ways to obtain a perception coefficient for separated observers. Therefore a new program was added to VMDB which computes perception coefficients based on the stream activity rather than the sporadic background.

[1] *see Figure 1 in Roggemans' reply to Steyaert's letter [2] (Ed.)*

2. Computing perception coefficients

The proposed method works as follows. A sampling period of 6 hours is chosen for which the mean ZHR is computed (using a weighing factor, cfr. the formulae in [2]). Next all ratios P_j of individual ZHRs (ZHR_j) relative to this mean ZHR are considered in the sampling period:

$$P_j = \frac{\mathrm{ZHR}_j \sum_i \frac{1}{C_i}}{\sum_i N_i}$$

with N_i the number of shower meteors and $Ci = \mathrm{ZHR}_i/N_i$ the total correction coefficient used to compute the ZHR.

To average out the influence of shower activity variation within the sampling period, this period is advanced by 1 hour at the time. This way each ZHR is compared to the mean values of several sampling periods in an interval stretching for 6 hours at both sides of the time for which the individual ZHR was computed.

This procedure was applied to the Perseid activity profile between $\lambda_\odot = 136°$ and $\lambda_\odot = 142°$. About 6500 perception coefficients were obtained for 144 observers. These perception coefficients were then averaged per observer. A first average was taken from all coefficients. Then all coefficients which do not deviate more than ±60% from the first average were averaged again, and this value was registered with its standard deviation as the perception coefficient.

A high P-value (perception coefficient) means that person got a higher ZHR under the reported sky conditions than the "average" observer. It can be explained by the fact that the observer really sees more meteors, but it is often explained by the limiting magnitude not being properly estimated. The opposite happens too: somebody with a very faint limiting magnitude with a low perception coefficient may report a limiting star magnitude which is too faint compared to his or her meteor limiting magnitude. In other words, this P-value reflects to some extent the deviation from mean perception, and in many cases systematic deviations in the ZHR due to observational shortcomings can be corrected for.

Table 1 below gives all the results for the 144 Perseid observers of 1988. It is only a by-product obtained during the activity profile processing, but very worthwhile to each observer.

There are many advantages in using the shower profile to derive the perception coefficients rather than the sporadic background. Perception is likely to be dependent upon the shower characteristics. An observer may see meteors more easily when they are slower or medium speed, often producing trains. This is in favor for the use of perception coefficients derived from typical showers. Perception characteristics need further investigation. The perception coefficients were used to correct all individual ZHRs. Next these perception corrected ZHRs were averaged again using a weighted sliding mean over a sampling period of 6 hours. The result of this has been shown in Figure 1.

The shape of the curve has been modified a bit. The main maximum is centered around $\lambda_\odot = 139\overset{\circ}{.}0$. The dip at $\lambda_\odot = 139\overset{\circ}{.}26$ becomes less pronounced, which means that the continent effect biased these results towards underestimated ZHRs in [1], as the number of observers involved is much less than at $\lambda_\odot = 139°$. The secondary maximum at $\lambda_\odot = 139\overset{\circ}{.}5$ becomes less abundant. Here, only Japanese observers are responsible for this secondary maximum.

The steep increase to the maximum level takes only $0\overset{\circ}{.}6$ in solar longitude. The maximum is followed by a much slower decrease. In any case, the main maximum felt some $0\overset{\circ}{.}2$ earlier in 1988 than in previous years [3,4]. The secondary maximum that occurred about $0\overset{\circ}{.}5$ in solar longitude after the main maximum may be related to the "shoulder" reported on the Perseid activity profiles of previous years. It is visible on for instance the profiles presented by Lindblad [5].

Šimek [4] mentions this feature as an indication of a secondary peak at $\lambda_\odot = 139.^\circ75$! Both features seem to be reflected in the 1988 profile, but in 1988 they occurred $0.^\circ2$ earlier in solar longitude. Figure 1 in this article can be compared to Figure 2 in [4] which depicts the profile of the Perseid maximum in great detail based on Czech radar data.

Table 1 – The observers' perception coefficients derived from the 1988 Perseid activity profile. The abbreviations can be found in [1].

Obs.	P	Nr.	σ	Obs.	P	Nr.	σ	Obs.	P	Nr.	σ
ANEPE	1.36	105	0.34	ARLRA	0.89	108	0.20	BADPI	1.74	22	0.26
BALPE	0.70	106	0.18	BARSA	0.61	44	0.19	BERDI	0.57	6	0.01
BROPE	1.71	105	0.53	BRULU				CAMMI	1.20	143	0.34
CARDO	0.31	4	0.00	CLASV				CLEKO	1.94	6	0.08
CLESA	1.25	41	0.33	CORPS				D'ALU	1.16	18	0.17
DANTI	1.03	18	0.20	DE BA	1.00	119	0.19	DE CA	1.07	12	0.21
DE FR				DE JU	0.94	12	0.15	DE MA	0.82	218	0.22
DE PA				DEBJA	1.00	1	0.00	DEGBE			
DELST	0.67	12	0.06	DEMKR	1.63	24	0.47	DEQKU	1.45	90	0.37
DEWAN	0.87	6	0.02	DEWJE	1.46	60	0.31	DEWPA			
DIAJO	0.59	57	0.21	DIEFI				ELTMA	0.85	6	0.11
FERRA	0.69	175	0.22	GAAKA	2.30	110	0.54	GAUIR	1.06	1	0.00
GEUKO	1.29	72	0.32	GOEHA				GORPE	1.25	30	0.39
GORRO	3.30	6	0.09	GYSMA	0.67	12	0.04	HADGA	1.56	6	0.04
HANRO				HANTE				HASTA			
HAVRO	0.51	56	0.09	HEELA	1.62	111	0.30	HEIBE	1.24	54	0.27
HILTR	1.54	76	0.31	JANCA	2.05	6	0.08	JOBKL	0.91	163	0.24
JONKU	1.37	78	0.26	KAWCH	0.76	6	0.08	KAWNO	1.22	18	0.25
KIRBE	1.00	6	0.00	KIRJO	0.68	35	0.13	KIRRO	0.67	30	0.18
KNOAN	0.90	120	0.19	KOCBE	0.84	127	0.20	KOSDE	1.45	30	0.21
KOSRA	0.74	124	0.14	KUSRA	0.92	64	0.29	LAEPA			
LATAL	0.76	6	0.03	LAUDI	0.72	18	0.12	LOBST	0.45	6	0.02
LUNRO	0.94	123	0.21	MAAHA	2.68	6	0.06	MAMKA	0.88	18	0.22
MARAN	1.24	6	0.04	MARMA	0.46	6	0.04	MCBAL	0.76	59	0.19
MCLNO	0.72	60	0.14	MIZHI	1.35	18	0.29	MONAN	0.60	67	0.20
MORDI	0.34	6	0.01	MOYAN	0.44	59	0.14	NEYKR	1.17	24	0.17
NOLMI	0.95	64	0.26	OSAKU	0.95	72	0.16	PARPE	0.48	12	0.09
PAUDI	0.85	24	0.19	PLEFR	0.71	36	0.10	PLEGH	0.67	68	0.24
POLGI				RADED	0.99	60	0.28	RAFST			
RAJLE	0.57	6	0.01	RENAN	1.54	55	0.45	RENIN	0.89	124	0.19
RENJU	0.93	124	0.15	ROGPA	1.03	182	0.25	ROOMA	0.72	24	0.12
RUTCH				SAKKO	0.82	6	0.07	SCANA	0.75	12	0.07
SCHAN	1.21	18	0.38	SCHDA	0.93	54	0.19	SCURE	1.78	12	0.27
SEIHO	1.19	120	0.28	SHIYA	1.01	20	0.26	SIMKA	0.81	64	0.25
SIMWA	0.70	76	0.18	SIMWE	0.59	36	0.16	SKJOL	1.65	48	0.43
SMILI	1.15	12	0.12	SMIPA				SPAGE	1.45	52	0.37
SPAPE	0.72	37	0.28	SPEUL	0.99	58	0.22	STOEN	0.90	30	0.22
STOST	0.82	36	0.24	STRST	1.08	36	0.44	SUYDO	0.97	26	0.31
SVAMA	1.19	33	0.35	SWADA	1.23	36	0.36	SWERI	0.80	60	0.14
TAIRI	1.22	16	0.54	TAKYU				THIEM	0.63	13	0.20
TICGL	1.01	208	0.25	TRIEM	0.58	12	0.07	TRIJO	1.62	170	0.39
VANAN	0.62	6	0.05	VANDI	1.09	20	0.37	VANFI	0.36	4	0.00
VANFK	1.37	36	0.23	VANGR	0.99	12	0.29	VANHE	1.63	24	0.12
VANJN	0.96	12	0.19	VANJO	1.10	12	0.14	VANKA	0.99	6	0.06
VANMR	0.62	18	0.11	VANPE	0.96	6	0.03	VANPI	1.05	6	0.04
VANTM	1.25	6	0.05	VANTO	1.06	6	0.06	VERCI	0.58	101	0.19
VERIO	1.35	6	0.05	VERIV	0.64	24	0.16	VERSA	1.80	12	0.52
VINWI	0.95	12	0.09	WISJE	0.88	12	0.29	WUNNI	1.13	102	0.19

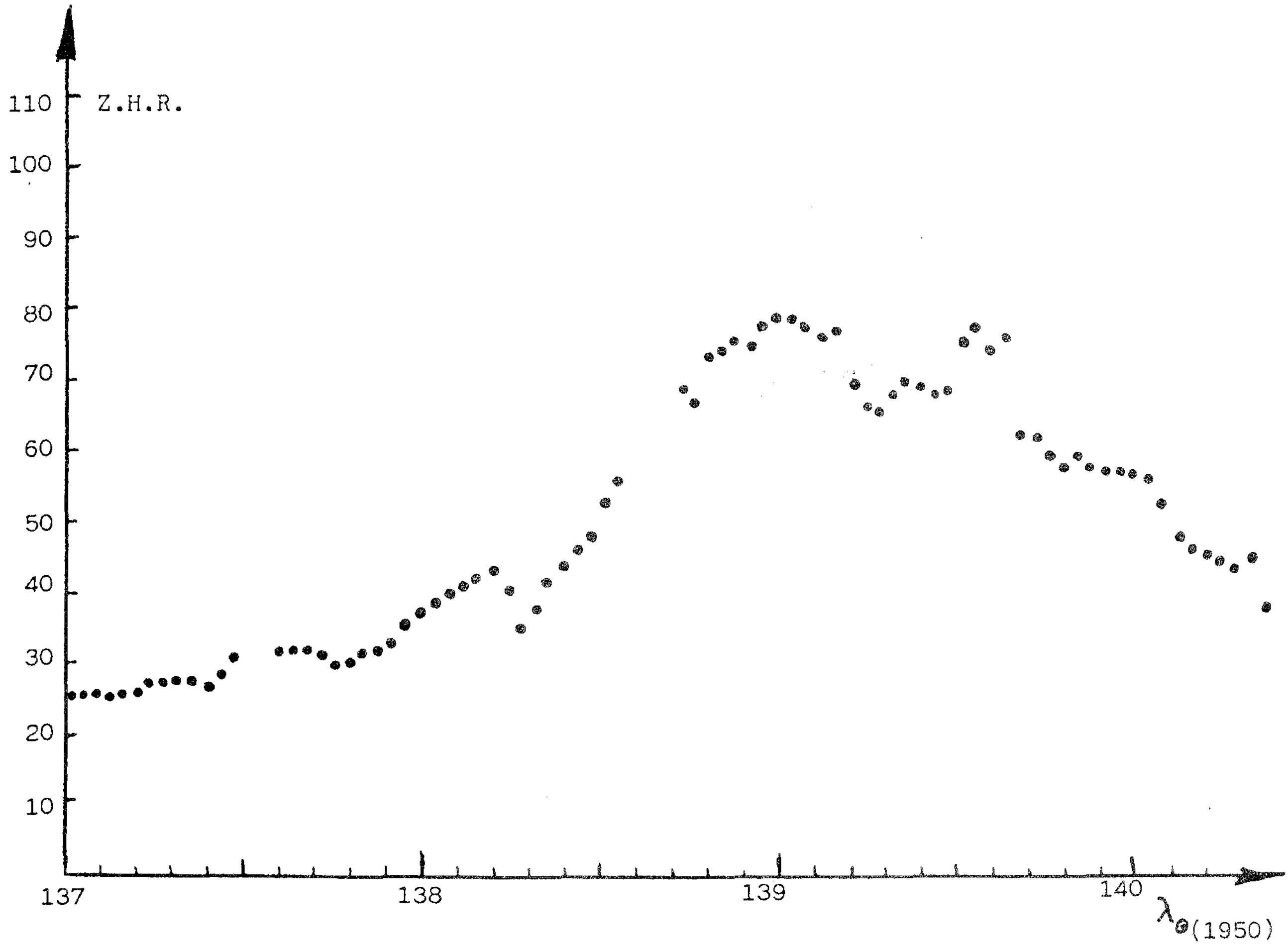

Figure 1 – Mean Perseid ZHRs, perception corrected, over a 6 hour sampling period, the inverse total correction factor being used as the weighing factor.

3. Conclusions

An immediate conclusion from this investigation is that a perception coefficient is necessary to give the final correction to the ZHRs. It may be a good idea to use an iterative procedure, using the first perception corrected smoothed profile to reestimate the perception coefficient and to repeat this process as to minimize the spreading on the mean values. The perception coefficients thus obtained are probably reliable. It is possible however that a repetition of the process in an iterative way does not change anything and, thus, is of no use. A final word to people who try to compare these results with older reports. The *VMDB* analysis represents an amount of computational work that would simply be impossible by hand and pocket calculators. Never before so much data were brought together and never before data from so many sites around the world came together. Global analyses cause their own specific problems. How long is the ideal sampling interval? What error margin should be quoted? Which effects cause spurious features on an activity profile? Which method should be used to average ZHRs (weighing factor)? Which parameters can be derived from the shape of an activity profile? The first results from the *VMDB* are now published. Only the readers who attempted this type of work before will be aware of the amount of work involved. With all programs debugged and ready for the files (input of 1800 reports took some time too), a PC AT compatible needed about 6 hours (at 12MHz speed) to derive ZHRs, perception coefficients and, finally, Figure 1 in this article. Who said the *VMDB* is not useful? The twin peaked activity profile in [1] at least seems to be a confirmation of a similar secondary maximum found before. There is not yet conclusive evidence at the moment, just indications which await older and future active profiles for comparison. Questions like this make observing so worthwhile!

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The 1988 Perseids in the USSR

V.V. Martynenko, A.S. Levina, A.I. Grishchenyuk and D.G. Sukhov

Soviet observations of the 1988 Perseids are presented. Magnitude distributions and activity profiles are shown. Physical data on the Perseid stream are given and comparisons with previous years are made. The authors also believe that the 1988 Soviet observations confirm the hypothesis of a double maximum for the Perseid Meteor Stream.

In the USSR, the Perseid shower was monitored in 1988 by 90 observers. 27 of them had at least 3 and the best 20 years of experience. Among the observers were scholars, students, engineers, teachers, and instructors of astronomical circles. There were 17 observing points: from the settlement Dal'negorsk (Far East), 183 Perseids were observed; at Lake Baikal (settlement Listvyanka and Peschanaya Bay) 2263 meteors were recorded, 1641 of which were Perseids. Furthermore we had: Tourist Camp Safidorak on the Pamirs with 974 Perseids out of 1515 meteors; settlement Novotroitsk, in the Donetskaya region (268 meteors, 214 Perseids); village Arzni, Armenia (257 meteors, 201 Perseids); village Dmitrievka in the Chernigov region (379 meteors, 185 Perseids); village Vyazynka, in the Minsk region, Byelorussia (734 meteors, 475 Perseids); Krasnosel'sk, Chernovtsi region (1073 meteors, 777 Perseids); Sudak, Simferopol, Dzankoi and L'govskoe in the Crimean region (6799 meteors, 3688 Perseids).

The organizational and methodical direction of this Soviet meteor relay-race was realized by the Crimean G.O. Zateiskchikov Meteor station, a section of the All Union Astronomical and Geodetical Society, and the Youth Astronomical Observatory of the Crimean Young Technicians Station. The organizing committee included V.V. Martynenko, A.S. Levina, A.I. Grishchenyuk, S.Ya. Zhitelzeif, G.V. Akman, V.M. Mozhzherin and M.N. Bidnichenko. The best observations were carried out by V. Ivashchenko, D. Sukhov, V. Frolov, V. Dmitriev, V. Gofonov, M. Groznov, I. Kruzman et al.

Table 1 shows the magnitude distribution of the Perseids and the sporadics.

Table 1 – Global magnitude distributions for the 1988 Perseids and the sporadic background as seen in the Soviet Union.

Shower	−10	−7	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	Tot
Perseids	0	0	1	2	4	21	66	125	309	537	1373	2033	243	239	4953
Sporadics	2	1	0	1	3	5	9	14	93	161	522	1360	1160	1172	3798

The total number of bright meteors was less than in 1986. For example the more than 15 observers who watched meteors in Sudak and Simferopol, recorded only 3 Perseids of magnitude -3 or -4, in the total of 2637 Perseids. On August 3, the brightest meteor observed was of magnitude -5. In the village Dmitrievka a fireball of magnitude -10 was recorded. There is no certainty it was a Perseid however.

Some observers overestimate brightness of bright meteors. After compilation at our station, the data showed many differences. This is mainly caused to real large-scale and small-scale structure in the stream, the clouds, and compact groups of meteoroids.

To study the activity of the Perseids in 1988 we calculated ZHRs for the best observations, the relative activity $C = n/N$, where n is the number of Perseids observed, and N the total number of meteors seen. To get a more reliable profile of the activity, we tried to combine observations of meteors of magnitude 2 and brighter, taking into account the observed part of the sky, to calculate group ZHRs. So, we found that C is 88% for the group in Listvyanka (Baikal), 88% for Safidorak, and 90% for the group in Sudak.

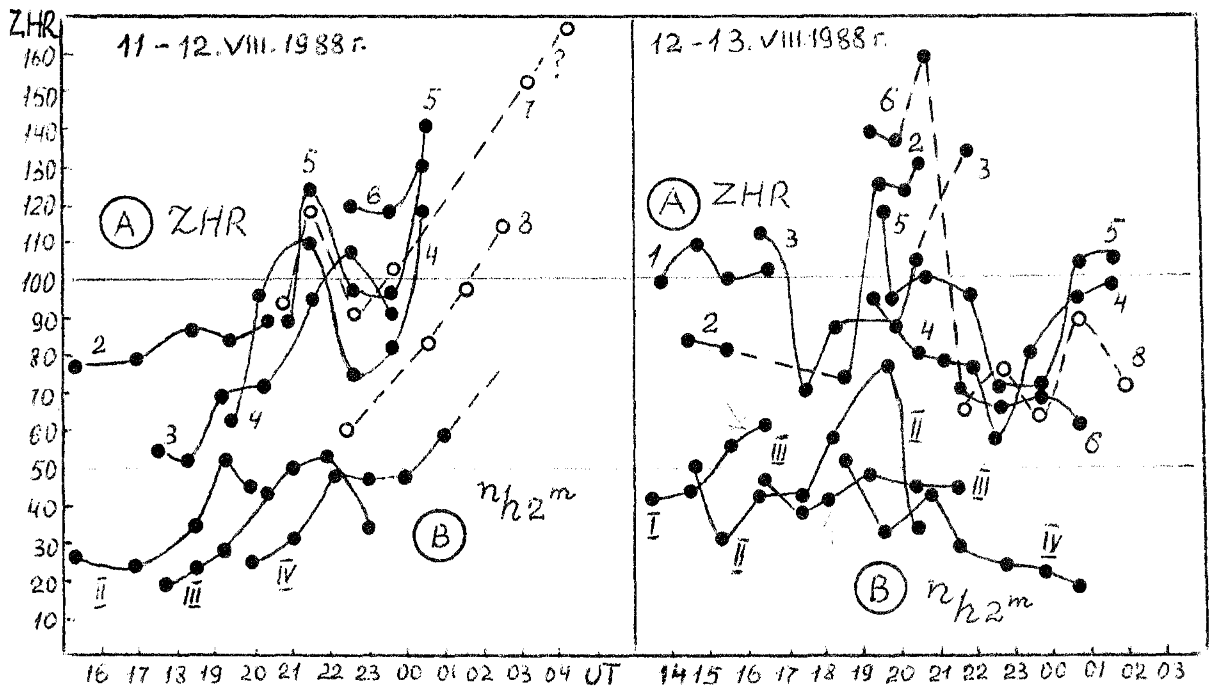

Figure 1 – Activity profiles of the 1988 Perseids. 1 – Dal'negorsk; 2 – Baikal; 3 – Safidorak (Pamir); 4 – Sudak (Crimea); 5 – Simferopol (Crimea); 6 – Novotroitsk; 7 – Spain (J.M. Trigo); 8 – France (P. Roggemans). "A" represents the ZHR and "B" the ZHR for Perseids of magnitude 2 and brighter.

Profiles for the ZHRs are shown in Figure 1. Our ZHRs for the night of August 11–12 are in good agreement with those found by José Maria Trigo (Spain). At August 11–12 we found a preliminary peak in the ZHR profile near $21^{\rm h}$ UT. The mean value of the ZHR for Simferopol, Sudak and Novotroitsk was about 134 in the morning of August 12 at $0^{\rm h}\!.5$ UT. The Baikal group noted a sharp increase in bright meteors on August 12 at $19^{\rm h}\!.3$ UT. To this peak of bright Perseids there is a corresponding peak in the ZHR-profile on August 12 at $20^{\rm h}$ UT.

We also studied short-lived increases of activity expressed in the appearance of pairs, triple meteors, bundles, and bundle-chains. It was even possible to forecast some bundles. Unique bundles were recorded by V. Martynenko on August 16 and 21. The last one started from the radiant position $\alpha = 52°$ and $\delta = +59°$, (see Figure 2) Almost no Perseids did appear after this.

The Baikal group of observers counted 29 close meteor groups each of which contained 6 to 14 Perseids. From August 11 to 13, many pairs and twins were recorded: 11 pair appearances in an intervall of less than 1 second, 37 in less than 3 seconds and 23 in an interval between 3 and 10 seconds long. Sometimes small outbursts of Perseids were observed, for example when 8 Perseids appeared in only 30 seconds of time.

The true distribution of the Perseids was also studied using M (the absolute magnitude) by the method of individual counting in a group. We got the result in numbers of meteors per square kilometer and per hour. The exponent of the luminosity function κ was determined by the formula:

$$\log \kappa = \frac{\log n(M_1) - \log n(M_2)}{M_1 - M_2}$$

The characteristics of the shower we found for the range of $m_v = -3$ to $m_v = +3$ are presented in Table 2:

Table 2 – Shower characteristics of the 1988 Perseids derived from Soviet observations.

Date	κ	Influx of meteors	Distances between particles
Aug 11–12	2.85	4.17×10^{-3} meteors/km^{2}h	372 km
Aug 12–13	2.43	3.42×10^{-3} meteors/km^{2}h	395 km

This luminosity function permits to solve controversial questions about the general activity of the Perseids in 1988, compared to 1980 (see Figure 2).

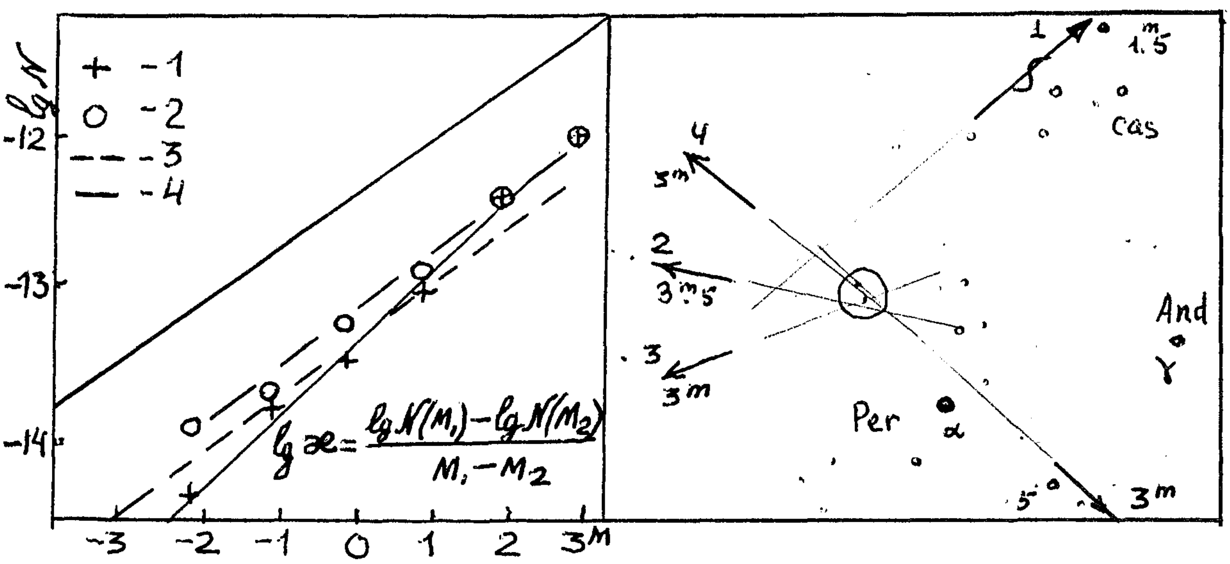

Figure 2 – Left: the 1988 Perseids' luminosity function (1 – Baikal, August 11–12; 2 – Baikal, August 12–13). This is compared with the distribution of 1980 (August 11–12) and of 1986 (3,4 – Sudak). Right: One of the last short-time bundles of Perseids on August 21, 1988, observed by V.V. Martynenko. Meteors 2 and 3 appeared at the same time.

In 1980 the shower activity was about an order of magnitude higher.

One group of observers plotted Perseids on maps in gnomonic projection and they obtained coordinates for the radiant (equinox 1950.0).

The results are as follows:

Table 3 – Radiant positions for the 1988 Perseids obtained from visual plottings on gnomonic maps by Soviet observers.

Date	α	δ
Aug 09–10	42.°5	+57.°5
11–12	44.°0	+57.°0
12–13	45.°0	+56.°5
13–14	46.°0	+58.°5

Most Perseids diverged from this radiant. Radiant centers of radiation near η, α, h, and ε Persei were also noticeable.

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A New Technique To Detect Meteors

Jeroen Van Wassenhove

The author briefly discusses the application to meteor work of a technique originally used to measure voltages during thunderstorms and heavy rainfall.

In the June issue of the magazine *Electronics and Wireless World* [1] a new method to detect meteors is discussed. The principle is based on the fact that a meteor generates an electric field. Electrically seen, the Earth is a spherical capacitor with the ionosphere as the outer plate and the surface as the inner plate. The atmosphere is the dielectric. Now one measures the voltage of the atmosphere with a special meter. If suddenly a meteor appears, there will be a short variation of voltage in the atmosphere which can be measured by this special Volt meter. The technique was originally used to measure voltages during thunderstorms and heavy rainfall. Now it has one more application!

Reference

[1] A. Hopwood, "A New Meteor Logging Technique", *Electronics and Wireless World*, June 1989, pp. 540–542.

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