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Bright meteor photographed by Victor Bortas from Târgoviste, Romania, on August 4, 1994, at 22^h35^m UT. The exposure was made with a 50 mm $f/1.2$ Nikkor objective on Azopan 200 ASA film. The exposure lasted 10 minutes.

In this issue:

- Practical information for all observers
- More on the Leonids and α-Monocerotids
- Double-station video observations of the 1995 Quadrantids
- Observing meteors with video and radio
- Fireballs and meteorites
- Observational results

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Contents

From the President

Jürgen Rendtel

Beyond any doubt, 1995 is a year to remember for many people dealing with meteors: not only the "regular" meteor shower events took place, but also an outburst which had been expected but about which we were not certain in advance. Even though the α-Monocerotids have been recorded with almost all available techniques, their mysteries are still not fully solved. It is clear that we do not yet know the parent object, although we do have much better data to search for it.

With the α-Monocerotids and the Leonids, in terms of meteor work, November became the most interesting month of the year. This is a situation as we had it about 100 years ago, when the Leonids were accompanied by the Andromedids.

At this place, I would like to point on another aspect of meteor shower returns. Until recently, outbursts seemed to be extraordinary events, but with the better coverage of many periods of the year and fast exchange of information, apparently there are more such events than before, if we do not live to see a period with a real increased number of peculiarities. On the other hand, I am afraid that we see an "inflation of words" here as in many other fields of life. Many things which are slightly different from the average, become "super," "mega" or whatever, and in meteor astronomy the magic word may be "outburst." Like "meteor storm," this is not a well-defined term, and the practical use will finally determine what an outburst is.

During the 1995 IMC, a wide variety of topics has been discussed, including "remotely" meteor-related areas such as mesosphere items and noctilucent clouds, or unsolved phenomena like "dark meteors." Discussions showed that there exist many observations which may help to deal with these items in more detail. As in the case of the previous meetings, the many talks and the relaxed atmosphere will remain in the minds of the participants, and I hope to meet many of you also at this year's conference.

In my last year's note, I put the rhetoric question what to expect in the coming year. I think the events of 1995 were a very good advertisement for observers to be alert throughout the entire year—and an excitement for those who witnessed the interesting events, of course. We need the regular patrol of meteor activity, and the gathering of many small samples of minor sources to improve our knowledge of these. A first summary of the results currently available in the IMO's VMDB is presented in the graphs found in the new Handbook for Visual Meteor Observers *and the revised working list of meteor showers. Although this is one important part of the work, do not forget to keep contacts with other observers, to give your enthusiasm to newcomers, and use our Journal* WGN *as a platform to introduce your group and activities.*

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

New Editorial Policies

Marc Gyssens

As usual, I join the President in wishing you a successful 1996. Personally, I hope that the strain put on me by my professional commitments will ease towards the fall, and that the problems this causes in preparing WGN *in time will then subside. In any case, we are firmly committed not to resort again to the emergency solution of preparing a double issue, like this one. I apologize for any inconvenience in receiving the first issue of 1996 so late and hope you may find comfort that it contains as many pages as a normal issue and a thick issue combined.*

There are, however, a few other problems which have to be addressed now. Most of these are caused by a strong increase in postal rates for matters such as this journal. Postal rates in Europe are in a process of being made uniform, which means things get more expensive! Therefore, you will notice this year that WGN *will not always be mailed from the same country: depending on the weight of the issue and the travel schedules of* IMO *officers, we shall try to optimize mailing costs. Even then, however, a further growth of* WGN *is not possible unless we increase the subscription rate, and this is something we definitely do not want to do.*

An anomaly that was mentioned to us by several IMO *officers and members is the unreasonable amount of space taken by the "informative" part of* WGN *(the "small-print section"), which in the past often accounted for half the number of pages of a normal issue.*

We have therefore chosen to solve two problems at the same time: by reorganizing the "small-print section," we can reduce its size and use the free space thus created for regular articles.

More concretely, the visual observers' notes will disappear in their present form. The background information contained in them can be found in the completely revised Handbook for Visual Meteor Observers— *which ought to be in the possession of every meteor observer!—and the actual data are contained in the* IMO Meteor Shower Calendar. *Instead, we shall publish the* IMO Meteor Shower Calendar *within* WGN, *in two parts (April–September in the February issue, October–March in the August issue).*

Of course, special calls for observations will be made when the possibility is anticipated that something unusual might occur. Photographic and telescopic notes will concentrate on the essentials and only appear if something essential has to be said! Finally, the list of potential radiants from comets and asteroids will disappear from WGN, *but we shall make arrangements so that this list can still be consulted on the WWW page of the* IMO *on the Internet. The "Frequently Asked Questions," however, will stay, and we also expect to start shortly with a series of articles by our new Photographic Director, Marc de Lignie, on photographic work.*

In the future, we shall also be more selective in accepting contributions to the "Fireballs and Meteorites" section. Only events that can arouse general interest from this journal's readership will be covered in the future. We think in this respect primarily of peculiar meteorite craters and/or falls, and fireballs for which trajectory and orbital data could be calculated. Other events can be mentioned in WGN *and discussed in detail in* FIDAC News. *Each of the three periodicals of the* IMO*—the* WGN Bimonthly Journal, *the* WGN Observational Report Series *and* FIDAC News*—each have their own function, and we should avoid excessive overlap. This change of accent announced here should be seen in the same light as a similar change of accent in our policy regarding observational reports in this journal several years ago, when we decided to no longer print raw data—unless they covered a very unusual event—to reduce inefficient overlaps with the* Report Series.

So, all the changes announced serve only one purpose, and that is to make our journals better, more tailored to the needs of the readers, and at the same time offer as much information as possible at as little a cost as possible. For that reason, we would also like to have your feed-back and start a discussion in the "letters section" on the issues raised in this editorial to make sure that we really satisfy your needs. Let us know what you think!

Whether or not we shall succeed in pleasing our readers, of course, does not only depend on the policies we adopt, but first and foremost on the contributions we receive. We hope we can keep counting on you for that aspect, in 1996 too!

Supporting Members and Subscribers in 1995

Ina Rendtel

The following people were Supporting Members or Subscribers in 1995:

> Per Aldrich, Lars Bakman, Luis Bellot, Ichiro Hasegawa, Werner Hasubick, Robert Hawkes, Masao Kinoshita, Masahiro Koseki, Jean Christophe Lernould, Marc de Lignie, Michael Luciuk, Norman McLeod, Sirko Molau, Philip Roberts, Hans-Georg Schmidt, Kazuhiro Suzuki, Richard Taibi, Yuko Takeuchi, Casper ter Kuile, Leonard Tomko, Yasuhiro Tonomura, Masayoshi Ueda, Mark Vints, Yasuo Yabu, Shin-Ichiro Yanagi, Takatsugu Yoshida, and George Zay.

We recall that people paying for Supporting Membership are free to send us a photograph of themselves together with a short description for publication to *WGN* so that other readers can get to know you!

The following people made a gift to the *IMO*, e.g., by paying a little extra for some services of the Organization:

> Ben Apeldoorn, Rainer Arlt, Neil Bone, Peter Brown, Malcolm Currie, Marc Gyssens, Yasunori Fujiwara, Lars Trygve Heen, Trond Erik Hillestad, David Hughes, Klaas Jobse, André Knöfel, Michael Luciuk, Kouji Maeda, Alastair McBeath, Ina Rendtel, Jürgen Rendtel, Paul Roggemans, Casper ter Kuile, Mihaela Triglav, Cis Verbeeck, Erich Weber, Noel White, and Jean-Marc Wislez.

We thank all these people! If those of you who can afford paying a little extra effectively do so, we can keep our prices low and keep the journal affordable for all observers.

Letters to WGN

compiled by Marc Gyssens

How big was the Leonid outburst in 1966?

A sentence in the new Visual Handbook *dismissing a suggestion by Peter Jenniskens that the Leonid outburst in 1966 was in fact much more modest than usually claimed stirred some controversy. Below is a letter on this topic by Marco Langbroek, followed by a reply from Jürgen Rendtel.*

During the *DMS* Leonid and α-Monocerotid expedition 1995 to Andalucia, Spain, I had the opportunity to read the brand-new *IMO* Visual Handbook. Though I would have preferred including a broader data context than just *IMO* in the handbook (from a scientific viewpoint, the handbook would have benefited from other than occasional discussion on activity profiles obtained by other contemporary groups and investigators), I want to make a compliment to the authors: it is a very valuable resource on stream activity, a significant contribution to the field of meteor astronomy and a publication to be recommended to all readers of *WGN*.

While reading the handbook, I encountered a few remarks which struck me as either open for discussion or (in view of the data gathered by the *Dutch Meteor Society*) incorrect. Of course, such a "disagreement" is part of science and a good thing as long as constructive discussion is possible. Therefore, I do not want to go into detail on that in this letter; it is a topic to be handled in scientific publications (and actually we did that in, for example, Peter Jenniskens's recent series of articles in *Astronomy and Astrophysics* [1,2]).

There was one passage, however, which aroused some anger with me, since I believe it is a misrepresentation of scientific facts in a way I would not have expected from an organization like the *IMO*. It was a statement in the chapter about the Leonids, concerning Peter Jenniskens's opinion that the peak ZHR of the 1966 Leonid outburst has been overestimated by a factor of 10 [2]. In the statement, Peter's conclusion was subject to doubt with the argument that "radar data rather support the higher figure [of 150 000 instead of 15 000]."

This is certainly not the case. And, actually, the remark is of rather questionable character (hence my use of the term "misrepresentation of scientific facts" earlier in this letter) given the fact that Jenniskens actually remarks on the radar data because they *support his conclusion* that peak rates have been overestimated by the Kitt Peak observers! I quote from Jenniskens ([2], emphasis added):

> Peak rates [of the 1966 outburst] are usually quoted as $\approx$ 150 000 (Milon 1969, Yeomans 1981), but this may be too high. Note that the visual counts of Milon c.s., the only ones available to me, show a sudden increase of rates by a factor of 8 (fig. 2b), coinciding with a change in observing technique at maximum. Instead of regular counting, they opened the eyes for 1 second during a sweep of the head and counted projected (!) meteor trails. *The sharp increase in rates is not seen in radar data (Plavcová 1968; Millman 1967a; McIntosh and Millman 1970), where the slopes of ascending and descending branch and the reduction procedure give no reason to assume that this is because of saturation in the radar data.*
>
> Therefore, I conclude that the main peak did not increase up to ZHR $\approx$ 150 000 but only to some 15 000 $\pm$ 3 000. Strength and duration of the main peak are similar to the outburst in 1866.

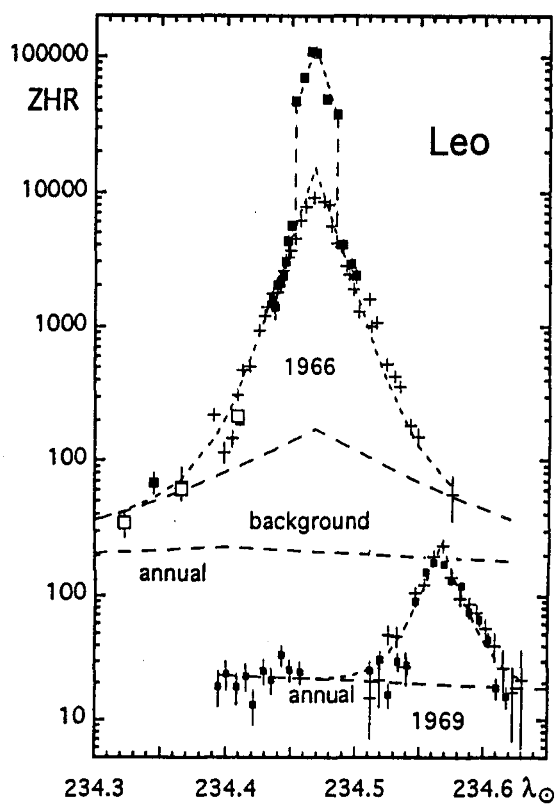

Figure 1 – Figure 2b by Jenniskens [2]. Please refer to the letter for explanation.

Jenniskens's figure 2b is reproduced with this letter; black blocks refer to the visual data of Milon c.s. from Kitt Peak, crosses to radar data by Plavcová. Evidently, these radar data support the *lower* figure for the peak ZHR. Visible is is the sudden and suspicious "jump" in the visual data by Milon, coinciding (!) with the change in observational technique as mentioned by Jenniskens. The radar data, supporting the *lower* figure for the peak ZHR, do not show a similar jump, already odd in itself. No doubt, something went wrong. As a matter of fact, it might be worth noting that I discussed this topic once with a psychologist friend. About this "one-second counts," said to have produced (and we are all familiar with this claim) Leonid numbers over 40 per second, she remarked that this must be utter nonsense because it is a well known phenomenon from psychological research that a normal human being is not able to oversee more than 5 (!) items at an instance and record accurate numbers! Therefore, the numbers as claimed by Milon c.s. must be disregarded—unless the Kitt Peak observers were autistic.

Returning back to my original complaint, evidence supports that radar data underline Jenniskens's conclusions, contrary to what is suggested in the *IMO* Visual Handbook. Since radar data were actually used as corroborative evidence by Jenniskens, it is rather strange to read that the mythic ZHR of 150 000, one of the persistent myths in meteor astronomy, might appeal to romanticism and some people would rather prefer it for that reason. I do think that an organization like the *IMO* should adher to science, not myth, and therefore I am quite disappointed in the particular passage in an otherwise fairly good handbook.

[1] Jenniskens P., *Astron. Astroph.* 287, 1994, pp. 990–1013.

[2] Jenniskens P., *Astron. Astroph.* 295, 1995, pp. 206–235.

The references mentioned in the quote from [2] are Milon, *JBAA* 77, 1967, p. 89; Yeomans, *Icarus* 47, 1981, p. 492; Millman, *NASA-SP* 150, 1967, p. 399; McIntosh and Millman, *Meteoritics* 5, 1970, p. 1; and Plavcová, *IAU Symposium* 33, 1968, p. 432.

Marco Langbroek, November 28, 1995

Marco Langbroek's letter deals with two different items, one of which is the inclusion of other than *IMO* data in the shower description section of the new *Handbook for Visual Meteor Observers*. It was not our intention to compare or evaluate results of shower analyses obtained by various groups. There are two major reasons for the decision to restrict ourselves to the IMO's database.

Analyses of meteor shower activity apply reduction methods to data sets obtained by groups of observers distributed over smaller than global scales, i.e., the gaps between data points are larger than the periods covered with observations. Problems with observing conditions over a limited area add to the periods for which no data is available. Since 1988, the *IMO* collected data from observers around the globe which are obtained with a standardized observing method. This allows analyses of meteor shower activity on a global scale, regarding both the size of the data sample and the more complete coverage of the activity period. While this seems to be of lower importance for minor showers with rather smooth activity profiles, all ZHR profiles with significant variations require a continuous series of data.

Furthermore, the activity profiles reproduced in the Handbook are mainly thought of as an information on the average activity rather than a sophisticated analysis of each shower. For a number of showers, however, the profiles shown are one of the few profiles existing at all, for example the δ-Cancrids, δ-Aurigids, χ-Orionids, and the Coma Berenicids. At least, they are based on one reference list of radiant position and size over the period analyzed. This cannot be assured in many other analyses, where little or no information on the radiant positions, assumed sizes and other criteria for shower association are given. Consequently, at least absolute comparisons are expected to be of limited value, and could become part of individual shower analyses.

The other question raised by Marco Langbroek is the Leonid activity of the 1966 peak.

It seems difficult to discuss the absolute figures of the peak ZHR for the 1966 Leonid peak period. The reason is that simply because of the huge number of meteors appearing at one instance the data seem to be of limited accuracy: who wants to declare to count or estimate some 10 meteors appearing simultaneously?

The comparison with other data yields several results. Millman [1] states that the radar observations he analysed are in agreement with Milon's figures. Bronšten [2] also finds rates from soviet observers which are consistent with the high figures.

Generally, a steep increase of the ZHR in the moment of the entry into the actual core of a meteoroid stream can be considered reasonable: we lived to see such a narrow "border" recently when the Earth encountered the α-Monocerotids. Here the rate rose from "zero" (or, if you take the average of the neighboring 2 hours at both sides, from 1) to more than 300 in just a few minutes—this is an increase by a factor of at least 300 [3].

As for the calculation of the actual peak rates of the Leonids, I think we face a general problem of activity determination when rates approached storm levels during past Leonid returns: all observational techniques were at or above their limits to record such an activity. Probably, we will be at a better position in 1998+, when video techniques will certainly solve this problem. In his recent paper, John Mason [4] has also tried to summarize the peak activities of the Leonids, and he found evidence for the higher figures from various observations as well.

However, we should bear in mind that the suggested level of the Leonid rate of 15 000 instead of 150 000 implies that the observer saw only 4 instead of the stated 40 meteors at one moment—I guess that this can be distinguished. Even if we doubt the estimate of 40 per second and assume it was rather 10 or 20, this results in a ZHR well above 15 000.

We may try to approach the rate question also from the photographs taken by one of Milon's team. He used ISO 400/27° film and a rather slow 105 mm lens, and recorded roughly 0.3 to 1 Leonid meteor per second (i.e. 1000–3600 per hour) in a field close to the Big Dipper [5]. We can try a calibration assuming a sporadic rate of 15. Of this rate, the given lens-film combination may catch about 1 meteor every 3 hours, which is probably an upper value. Hence the Leonid rate was of the order of 60 000 to 180 000 (not considering the limited camera field and the high angular velocity of the Leonids on the one hand, and the effect of persistent trains on the other hand). To put it the other way around: if we photograph Leonids as mentioned above, and the rate was about 15 000, we should record on average 1–4 sporadic meteors per hour, which is certainly not the case.

Considering 1000 to 3600 meteors per hour of magnitude at least -1 appearing within the field of view of the camera (about 20° edge length) and assuming the value of the population index $r \approx 2$ being constant to magnitude about $+4$ (within the error margins for this rough estimate), we obtain a rate of 10 000 to 36 000 Leonids per hour *within the field of the photographic image*. The situation would, of course, become better if we could analyze series of photographs taken before, during, and after the peak with the same camera set-up in order to overcome the calibration problems.

I agree that we do not need to keep myths about past events, but the hints on the extremely high figures cannot be neglected as well.

[1] Millman P.M., "Meteor news", *J. R. A. S. Can.* 61, 1967, pp. 89–92.

[2] Bronšten V.A., "Observations of the Leonid meteor shower in November 1966 in the U.S.S.R.", in *Physics and dynamics of meteors*, L. Kresák, P.M. Millman, eds., IAU Symp. 33, Reidel, Dordrecht, 1969, pp. 440–445.

[3] Rendtel J., "α-Monocerotid activity burst on November 22", *WGN* 23, 1995, pp. 200–203.

[4] Mason J.M., "The Leonid meteors and comet P55/Tempel-Tuttle", *JBAA* 105, 1995, pp. 219–235.

[5] Milon S., "Great Leonid meteor shower of 1966", *Sky and Telescope* 33, 1967, pp. 4–10.

Jürgen Rendtel, February 15, 1996

What is a low-cost video system in meteor astronomy?

In the December 1995 issue of *WGN*, Peter Gural describes the project of an automated meteor detection system. The costs for a state-of-the-art set-up are estimated as high as 8000 USD per unit. An image intensifier tube for 3500 USD is used to reach magnitude 8 with a 28 mm $f/1.8$ lens in a $12° \times 16°$ field and magnitude 9 with a 50 mm $f/1.4$ lens in a $6\overset{\circ}{.}5 \times 9°$ field. The system is called "low cost."

Among the goals of Peter Gural's project, there are ideas like a multiple imager all sky coverage and a multiple site world-wide network. To realize this, amateur contributions become essential and from this point of view we have to re-define the term low cost.

In the past few months, I also developed an MCP-based imaging system for meteor astronomy. The cost for the camera is below 800 USD. With a 50 mm $f/1.4$ lens, at least magnitude 7 is realized in a 25° field.

After the test of the prototype camera, a series of 8 imaging systems with even faster $f/0.75$ lenses is planned. The whole network will see first light around spring 1996. Computer programs for an automated meteor detection are currently developed by Sirko Molau.

Technical details of the imaging systems and first results from the video network will be presented at the 1996 *IMC*. Preliminary information is available from the author.

Mirko Nitschke, January 7, 1996

Analyzing the η-Aquarids

We received some comments from Ralf Koschack on the 1994 η-Aquarid analysis by Godfrey Baldacchino in WGN *23:6, pp. 213–216.*

Great to see the author collecting data on this shower from widely spread southern latitude observers. What else if not the use of their data in global analyses can encourage observers to send reports to the *IMO*. It is very natural that data originating from widely spread and often new observers are of different quality which requires some care in analysis. The author has chosen a method assuming a constant sporadic rate and calculating the shower rate from the observed ratio between shower meteors and sporadics:

$$\mathrm{HR}_{\mathrm{Sh}} = \frac{N_{\mathrm{Sh}}}{N_{\mathrm{Spo}}} \times \mathrm{HR}_{\mathrm{Spo}}.$$

The ZHR results from $\mathrm{HR}_{\mathrm{Sh}}$ by applying the zenith correction factor. The method is very simple and does not require the limiting magnitude or the effective observing time.

Some suppositions are implied, however:

1. The sporadic hourly rate ($\mathrm{HR}_{\mathrm{Spo}}$) assumed to be constant is subject to annual and diurnal variation and depends on latitude [1]. The average $\mathrm{HR}_{\mathrm{Spo}}$ varies between 5 and 25 [2]. Since η-Aquarid watches are restricted to the morning hours, the diurnal variation can be neglected, and also the annual variation due to the activity period of few weeks only. But the latitude dependence is very strong for the mornings of early May. In [2], an average $\mathrm{HR}_{\mathrm{Spo}} = 9$ was found for a latitude of 45° N and $\mathrm{HR}_{\mathrm{Spo}} = 18$ for 30° S.
2. The method implies the sporadic population index to be identical with the population index of the shower, which is the exception rather than the rule.
3. Uniform definition of sporadic meteors (i.e., which minor showers are considered) and accurate shower association are the basis for application of this method.

Even if these suppositions are considered properly, there is one main disadvantage as the $\mathrm{HR}_{\mathrm{Spo}}$ is subject to random fluctuations which heavily affect the results of small data sets. If $\mathrm{HR}_{\mathrm{Spo}} = 12$, an observer under medium circumstances (lm ≈ 6.0) will see about 6 sporadics per hour. Statistical theory learns that this expected number is affected by a random error of $1/\sqrt{N}$. For $N = 6$, the error amounts to $\pm 40\%$. Let us consider the following example:

The real values are as follows: $HR_{Sh} = 48$, $HR_{Spo} = 12$, $lm = 5.9$, $T_{eff} = 1^h\!.0$. It is to be expected that the observer sees 6 sporadics and 24 shower meteors. Due to random fluctuations, he observed only 4 sporadics (error of 30%) which is a rather moderate difference. But the shower rate HR_{Sh} is computed to be 72 instead of 48. And, going further, the observer was not sure about one actually sporadic meteor appearing on the edge of his field of view and classified it erroneously as shower member. The resulting HR_{Sh} then amounts to 100! This example shows that individual results obtained by this method can scatter considerably as the accuracy of the shower ZHR is determined by the number of sporadic meteors. Even if the number of shower meteors is high the result is affected by random fluctuations introduced by small numbers of sporadic meteors. To obtain reliable results, a large data set is required. This main disadvantage in conjunction with (3) makes the analyzing method rather unreliable being some kind of last chance to get some results out of reports failing to submit essential data. Anyway, if essential data (limiting magnitude, effective observing time) are available, it is more accurate to assume a reasonable value for the population index and to use the "regular" ZHR computation procedure.

The analysis of the 1994 η-Aquarids shows the large scatter expected from the analyzing method. It seems reasonable to reduce the scatter by excluding results basing on small samples. As shown before, the number of sporadic meteors is crucial to the accuracy of the ZHR and should have been used as selection criterion in conjunction with the number of shower meteors.

The early and high maximum of ZHR = 70 at solar longitude $\lambda_\odot = 43^\circ\!.48$ is the main statement of the analysis. From Tables 1 and 2, it becomes clear that the ZHR of 70 results from averaging two observations, one resulting in ZHR = 19, and the other one in ZHR = 131. Even if the reasons for large scatter are considered, it is obvious that there is something wrong with one of both reports. One must not average in such cases but look for the reasons. Even worse, conclusions ("the maximum occurred earlier and was higher than usual") appearing in the abstract have been drawn. Nothing has been said about the contradicting ZHR values in the discussion. To find the bug, the reader had to examine the numeric values fortunately given in the tables. As shown by D. Steel in the foreword of the new Visual Handbook [3], this is the way legends are born.

I fully agree with Godfrey Baldacchino to take the η-Aquarid shower as a challenge to the *IMO*'s southern flank. As we know from the Orionids, the Halley meteor stream contains a lot of sub-structures telling something about origin and evolution of the stream. The η-Aquarid shower can provide information from regions closer to the core of the Halley stream than the better investigated Orionids do.

[1] Znojil V., "Sporadic Meteors", in *Handbook for Visual Meteor Observers*, Rendtel J., Arlt R., McBeath A., eds., International Meteor Organization, 1995.

[2] Koschack R., "Global Analysis of the Sporadic Activity from VMDB Data", in *Proceedings of the International Meteor Conference*, Puimichel, France, 23–26 September 1993, Paul Roggemans, ed., pp. 16–19.

[3] Steel D., "Foreword", in *Handbook for Visual Meteor Observers*, Rendtel J., Arlt R., McBeath A., eds., International Meteor Organization, 1995.

Ralf Koschack, January 30, 1996

Meter-sized bodies in the Perseid stream

Dr. Ryabova's letter in the previous issue sparked the following reflection by Tony Markham.

Dr. Ryabova's letter, in *WGN* 23:6, regarding meter-sized bodies in the Perseid stream reminded me of how the Perseids were portrayed in a TV program by the BBC in 1968. The program involved was the long-running science-fiction series "Doctor Who." The story, entitled "The Wheel in Space," is set aboard as space station somewhere between the Earth and the Moon around the middle of the 21st century.

In this story, the Cybermen are about to make another of their attempts to take over the Earth. Rather than launch a direct attack on the Earth, however, they have devised a somewhat more complicated plan, which first involves capturing the space station. As a first step, they cause a star in Messier 13, to go nova. So intense is the radiation from this nova that it is able to deflect the Perseid meteor stream such that it will become a hazard to the space station. Normally this would not be a problem because the space station is equipped with a laser which is capable of destroying any large Perseids that are on a collision course with it. Unfortunately, on this occasion, the Doctor's companion Jamie has just sabotaged the laser to prevent it being used to destroy a near-by freighter on which the Doctor's time machine is currently located. The space station is equipped with a convolute force field, but this is only capable of deflecting the smaller Perseids. Those with masses over 200 tons (!) will get through. Fortunately, with the Doctor's help, they are able to repair the laser, destroy the large Perseids, and thwart the Cybermen's plans. However, before they do so, we get to see the large Perseids. They are shown as large spherical spinning objects which seem to make a whirring/hissing sound as they travel through space. In addition, they do not arrive at random time intervals—typically, the people manning the lasers destroy some Perseids, then have a break, and then rush back to the laser when the approach of another swarm is reported.

Much of the above is not scientifically valid. However, given Dr. Ryabova's report of Perseids with diameters of up to 28 meters, it seems that the reference to 200 ton Perseids may not be so far-fetched after all!

Tony Markham, January 8, 1996

About dark meteors and related phenomena

This topic continues to receive interest from our readers.

I have read with interest about "dark meteors," but have never seen this phenomenon, although I have observed effectively for at least 1210 hours since 1964.

Nevertheless, I have seen other, strange phenomena, such as a nebulous meteor on the night of December 16-17, 1995, at $19^h27^m11^s$ UT. This meteor was ghost-like and rather fast. Its diameter was around 1° and reminded me of M 31 in Andromeda. Surprisingly, I found that the phenomenon was accompanied by a rather powerful radio signal, lasting 48 seconds! I have seen ghost-like meteors before, but not so large and bright. Their total magnitude was never brighter than +4. Could this be frozen gas, coming down through the atmosphere with meteoric speed? The object was not radiating from any known radiant.

More than ten years ago, I saw a red spot near the Pleiades. It happened the night of October 21-22, when I was observing the Orionids. It appeared at $0^h03^m58^s$ UT and lasted for about 3 seconds. It was stationary, had a diameter like the Full Moon, and its total magnitude must have been +4. Although the phenomenon was aurora-like, I do not think it had anything to do with aurorae. At that time, I had not yet the possibility to check radio signals by pen recorder.

Again, in 1992, on the night of December 13-14, $3^h00^m31^s$ UT, I observed a luminous spot, aurora-like, as the red one back in 1985. It was green and bright, with a total magnitude around +2. I happened to look right at it, from its appearance to its disappearance. It was located in Ursa Minor, and around 2° long and 1° wide, and lasted for at least 5 seconds. It produced a very powerful radio signal with a duration of 34 seconds.

Both aurora-like spots occurred during a meteor shower maximum, and I wonder if there is any connection. I would be interested to hear if other observers have seen similar phenomena.

Gotfred Møbjerg Kristensen, January 8, 1996

In reference to dark meteors, I have made an interesting observation about myself. I used to observe meteors all night from sunset to sunrise. During these periods, I have noted a little over a dozen per year. In 1995, I started most of my observations around 10 p.m. local time, usually preceded by a 3- to 4-hour nap. In all of 1995, I have probably "seen" no more than 5 dark meteors. Although I felt fresh during some of those earlier sightings, perhaps this is an indication that some sort of fatigue is at work?

George Zay, February 14, 1996

1. The North American Meteor Network

Below, Mark Davis reports on an initiative he took together which George Zay to advance meteor observing in North America. We wish to congratulate the founders with this very important initiative!

As relatively new members to the electronic community, George Zay and I "accidentally" met each other over `America OnLine`. Since George Zay lives on the West Coast of the United States, and I live on the East, we decided to combine our efforts and coordinate our meteor observing sessions. After a couple of successful attempts, we wondered why not try to coordinate many observers at the same time over the entire North American continent? To our knowledge, this had never been attempted before.

To accomplish this, we created the *North American Meteor Network* (*NAMN*) in June 1995. The Network has three main purposes: to recruit amateurs into the ranks of meteor observing; once recruited, provide guidance, instructions and training in the methods of meteor observing; and finally, to coordinate as many North American observations as possible to insure extensive coverage of sporadic and meteor shower activity.

Since dedicated meteor observers are few in number, recruitment of observers is one of the primary goals of the *NAMN*. Anyone with an interest in meteors has been welcome to "join" the Network. The Network is very informal with no membership applications, dues or monthly journal. We primarily use email for communication among our members, but coordinated meteor watch notices and data reporting is also done by letter and telephone.

Results of all of our observations are published in the North American Meteor Network Newsletter which is produced after each coordinated observing session. A guide for beginners starting out in the field of meteor observing has just been published and is available electronically. Recently, member Gary Kronk created a World Wide Web home page and continues to maintain it for the Network. All of these materials have been made available to interested persons free of charge.

We have formed what we call a partnership with both the *Association of Lunar and Planetary Observers* (*ALPO*) and the *International Meteor Organization* (*IMO*). The *ALPO Meteor Section* is the most active group in the United States and serves as the location where all of the data we collect is archived. The *ALPO* Recorder then assembles our data, publishes them, and forwards them to the *IMO*. This ensures our data is available to the international community for research purposes.

Currently, our membership stands at about 75 people. Not all are active observers since many only have an interest in meteors, but those who do observe are being taught the methods put forth by the *IMO*. Since June, the *North American Meteor Network* has contributed over 5000 meteors in more than 400 hours of observing.

Mark Davis, March 2, 1996

International Meteor Conference

Apeldoorn, the Netherlands, September 19–22, 1996

Registration Form

Each individual participant should fill out a form and return it to *Ina Rendtel, Gontardstraße 11, D-14471 Potsdam, Germany*, as soon as possible.

Your registration will be guaranteed only after Ina Rendtel has received the minimum pre-payment of 100 DEM. If you wish to participate, but cannot yet decide, simply return this form with the proper option checked to stay on the mailing list for further circulars.

Name: ______________________________ Birth date: ____________

Address: ____

____

____

Phone: ______________ Fax: ______________ E-Mail: ______________

- o wishes to register for the 1996 *IMC* from September 19 to 22;
- o intends to participate, cannot yet register, but wishes to stay on the mailing list.

I intend to travel by ________, together with ______________________________

Additional requests:

- o I need to be picked up at the Apeldoorn railroad station;
- o I need travel information from ________________ to Apeldoorn.

For participants wishing to contribute to the program:

Lecture: ____

Duration: ________min. Required equipment: ______________________________

Workshop or discussion: ______________________________________

Poster presentation: ______________________________ Space: ________ m^2

Either the entire fee of 195 DEM or a pre-payment of at least 100 DEM should be sent to the Treasurer, *Ina Rendtel*. Follow the payment instructions below. Participants paying only 100 DEM have to pay the remaining 95 DEM upon arrival in Apeldoorn.

Date and signature: ______________________________________

Please send your payment to the Treasurer or one of her assistants as indicated below:

- in Europe (except the Netherlands): pay in DEM to Ina Rendtel, postal giro account number 547234107 at Postbank Berlin, bank code 10010010. No bank checks, please! (Bank checks can only be send to Peter Brown, see below).
- in the UK: proceed as above or pay to Alastair McBeath, 12A Prior's Walk, Morpeth, Northumberland NE61 2RF, England.
- in Japan: pay to Masahiro Koseki, 4-3-5 Annaka, Annaka-shi, 379-01 Gunma-ken, Japan.
- in the Netherlands: pay to the Werkgroep Meteoren NVWS, postal giro account number 4466085.
- all others pay in USD to Peter Brown, Dept. of Physics, Univ. of Western Ontario, London, Ont., N6A 3K7, Canada. In case you pay by bank check, make it payable to Peter Brown, *not* the IMO!

People wishing to pay in other currencies should contact the appropriate IMO contact person for exchange rates

The 1996 International Meteor Conference

Apeldoorn, the Netherlands, September 19–22, 1996

Urijan Poerink

The 1996 *International Meteor Conference* will be held in the city of Apeldoorn in the Netherlands. There are many travel possibilities to reach the location, including good connections by train to Germany and the International Airport of Schiphol near Amsterdam. Apeldoorn is situated in one of the eastern provinces of the country and is surrounded by vast woods and moorlands. In the city, you will find the beautiful former Royal Palace (at the moment a museum) of the famous Queen Wilhelmina, who reigned over the Netherlands during 58 years (1890–1948)! The conference is held at a local hostel named *De Grote Beer*, i.e., the "Great Bear." The organization and preparation is done by members of the Meteor Section of the Dutch Association for Meteorology and Astronomy, abbreviated *NVWS*.

The Meteor Section celebrates its 50th anniversary this year. In 1946, the Section originated in the "Astro Club," a small group of enthusiastic young students, who began with stargazing, and especially meteor observations, during the Second World War. In that period, the nights were very dark as a result of the black-out of all buildings and street-lighting. Fifty years later, there are many active meteor observers in the Netherlands, who are engaged in all methods of meteor observation, including the modern video and computer technology. Due to the close position of the *IMC* location to several other active groups and individual observers, we can expect another well-attended and very interesting meeting.

As usual, we start the meeting on Thursday evening (September 19, 1996). The conference lasts until Sunday (September 22). Details about the registration procedure can be found on the Registration Form accompanying this article. As usual, the fee includes lodging and a copy of the Proceedings.

New Organization of the Photographic Commission

Jürgen Rendtel

For the last two years, I acted as interim director of the Photographic Commission. In this period, we had a regular column of photographic observers' hints in *WGN*, and the number of photographs received for the *PMDB* has increased as well. However, the major conclusions from photographs are to be expected from double-station observations, which also require another analysis. Therefore, I am happy that Marc de Lignie, who gained a lot of experience with such observations and their investigation, agreed to become the director of the *IMO*'s Photographic Commission effective January 1, 1996. By the way, that was subject of one of the described "campfire talks" during the 1995 *IMC*.

Nevertheless, we think that still a substantial amount of meteor photographs will be single-station images, requiring a different treatment and analysis. Therefore, we decided to organize the work as follows:

- single-station photographs should be sent to me, as before;
- general and technical enquiries as well as all items regarding double-station work should be sent to Marc de Lignie.

Both addresses are given on the inside back cover of *WGN*. If you cannot decide whom to ask in a particular case, please do not hesitate to contact one of us. We will arrange the work according to the possibilities we have.

Frequently Asked Questions on Observing Methods

compiled by Rainer Arlt

As last year, a conversion table of dates to solar longitudes may be helpful for planning observations and for the quick reduction of the times of maxima in any analysis to the actual date and time (Table 1). Remember that the longitudes given are only valid for 1996. Again, the algorithm described in [1] was used to determine the solar longitudes at 0^h UT with a precision of $0\overset{\circ}{.}001$—two decimals are given here. A change of $0\overset{\circ}{.}01$ in solar longitude corresponds to 15 min on average, slightly varying over the year. If you want to calculate the solar longitude $\lambda_\odot$ of a specific time of the day, you may use a linear interpolation between two dates. Suppose you have a certain *Date* and the *Time* in hours (UT), you get the solar longitude from $\lambda_\odot = \lambda_{\odot,\mathrm{Date}} + (\lambda_{\odot,\mathrm{NextDay}} - \lambda_{\odot,\mathrm{Date}}) \times \mathrm{Time} / 24^h$. Alternatively, if you want to convert a certain solar longitude $\lambda_\odot$ in a time of the day, look up the *Date* with the next-smaller solar longitude in the table and calculate $\mathrm{Time} = 24^h \times (\lambda_\odot - \lambda_{\odot,\mathrm{Date}}) / (\lambda_{\odot,\mathrm{NextDay}} - \lambda_{\odot,\mathrm{Date}})$.

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

Table 1 – Solar longitudes 1996 (eq. 2000.0). Dates refer to 0^h UT.

Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$
Jan 1	279.90	Mar 1	340.74	May 1	40.96	Jul 1	99.49	Sep 1	158.88	Nov 1	218.89
Jan 2	280.92	Mar 2	341.75	May 2	41.93	Jul 2	100.44	Sep 2	159.85	Nov 2	219.89
Jan 3	281.93	Mar 3	342.75	May 3	42.89	Jul 3	101.40	Sep 3	160.82	Nov 3	220.89
Jan 4	282.95	Mar 4	343.75	May 4	43.86	Jul 4	102.35	Sep 4	161.79	Nov 4	221.90
Jan 5	283.97	Mar 5	344.75	May 5	44.83	Jul 5	103.30	Sep 5	162.76	Nov 5	222.90
Jan 6	284.99	Mar 6	345.76	May 6	45.80	Jul 6	104.26	Sep 6	163.73	Nov 6	223.90
Jan 7	286.01	Mar 7	346.76	May 7	46.77	Jul 7	105.21	Sep 7	164.70	Nov 7	224.90
Jan 8	287.03	Mar 8	347.76	May 8	47.74	Jul 8	106.16	Sep 8	165.67	Nov 8	225.91
Jan 9	288.05	Mar 9	348.76	May 9	48.70	Jul 9	107.12	Sep 9	166.64	Nov 9	226.91
Jan 10	289.07	Mar 10	349.75	May 10	49.67	Jul 10	108.07	Sep 10	167.61	Nov 10	227.92
Jan 11	290.09	Mar 11	350.75	May 11	50.63	Jul 11	109.02	Sep 11	168.58	Nov 11	228.92
Jan 12	291.10	Mar 12	351.75	May 12	51.60	Jul 12	109.98	Sep 12	169.56	Nov 12	229.93
Jan 13	292.12	Mar 13	352.75	May 13	52.57	Jul 13	110.93	Sep 13	170.53	Nov 13	230.94
Jan 14	293.14	Mar 14	353.75	May 14	53.53	Jul 14	111.88	Sep 14	171.51	Nov 14	231.94
Jan 15	294.16	Mar 15	354.74	May 15	54.50	Jul 15	112.84	Sep 15	172.48	Nov 15	232.95
Jan 16	295.18	Mar 16	355.74	May 16	55.46	Jul 16	113.79	Sep 16	173.46	Nov 16	233.96
Jan 17	296.20	Mar 17	356.73	May 17	56.42	Jul 17	114.75	Sep 17	174.43	Nov 17	234.97
Jan 18	297.22	Mar 18	357.73	May 18	57.39	Jul 18	115.70	Sep 18	175.41	Nov 18	235.98
Jan 19	298.24	Mar 19	358.72	May 19	58.35	Jul 19	116.66	Sep 19	176.38	Nov 19	236.98
Jan 20	299.25	Mar 20	359.72	May 20	59.31	Jul 20	117.61	Sep 20	177.36	Nov 20	237.99
Jan 21	300.27	Mar 21	0.71	May 21	60.28	Jul 21	118.57	Sep 21	178.34	Nov 21	239.00
Jan 22	301.29	Mar 22	1.71	May 22	61.24	Jul 22	119.52	Sep 22	179.32	Nov 22	240.01
Jan 23	302.31	Mar 23	2.70	May 23	62.20	Jul 23	120.48	Sep 23	180.29	Nov 23	241.02
Jan 24	303.33	Mar 24	3.69	May 24	63.16	Jul 24	121.43	Sep 24	181.27	Nov 24	242.03
Jan 25	304.34	Mar 25	4.68	May 25	64.12	Jul 25	122.39	Sep 25	182.25	Nov 25	243.05
Jan 26	305.36	Mar 26	5.67	May 26	65.08	Jul 26	123.34	Sep 26	183.23	Nov 26	244.06
Jan 27	306.38	Mar 27	6.66	May 27	66.04	Jul 27	124.30	Sep 27	184.21	Nov 27	245.07
Jan 28	307.39	Mar 28	7.65	May 28	67.00	Jul 28	125.25	Sep 28	185.19	Nov 28	246.08
Jan 29	308.41	Mar 29	8.64	May 29	67.96	Jul 29	126.21	Sep 29	186.18	Nov 29	247.09
Jan 30	309.43	Mar 30	9.63	May 30	68.92	Jul 30	127.16	Sep 30	187.16	Nov 30	248.11
Jan 31	310.44	Mar 31	10.62	May 31	69.88	Jul 31	128.12				
Feb 1	311.46	Apr 1	11.60	Jun 1	70.84	Aug 1	129.07	Oct 1	188.14	Dec 1	249.12
Feb 2	312.47	Apr 2	12.59	Jun 2	71.79	Aug 2	130.03	Oct 2	189.12	Dec 2	250.13
Feb 3	313.49	Apr 3	13.57	Jun 3	72.75	Aug 3	130.99	Oct 3	190.11	Dec 3	251.15
Feb 4	314.50	Apr 4	14.56	Jun 4	73.71	Aug 4	131.94	Oct 4	191.09	Dec 4	252.16
Feb 5	315.51	Apr 5	15.54	Jun 5	74.66	Aug 5	132.90	Oct 5	192.08	Dec 5	253.18
Feb 6	316.53	Apr 6	16.53	Jun 6	75.62	Aug 6	133.86	Oct 6	193.06	Dec 6	254.19
Feb 7	317.54	Apr 7	17.51	Jun 7	76.58	Aug 7	134.82	Oct 7	194.05	Dec 7	255.21
Feb 8	318.55	Apr 8	18.49	Jun 8	77.53	Aug 8	135.78	Oct 8	195.04	Dec 8	256.22
Feb 9	319.57	Apr 9	19.48	Jun 9	78.49	Aug 9	136.74	Oct 9	196.02	Dec 9	257.24
Feb 10	320.58	Apr 10	20.46	Jun 10	79.45	Aug 10	137.69	Oct 10	197.01	Dec 10	258.26
Feb 11	321.59	Apr 11	21.44	Jun 11	80.40	Aug 11	138.65	Oct 11	198.00	Dec 11	259.27
Feb 12	322.60	Apr 12	22.42	Jun 12	81.36	Aug 12	139.61	Oct 12	198.99	Dec 12	260.29
Feb 13	323.61	Apr 13	23.40	Jun 13	82.31	Aug 13	140.57	Oct 13	199.98	Dec 13	261.31
Feb 14	324.62	Apr 14	24.38	Jun 14	83.27	Aug 14	141.53	Oct 14	200.97	Dec 14	262.32
Feb 15	325.63	Apr 15	25.36	Jun 15	84.23	Aug 15	142.50	Oct 15	201.96	Dec 15	263.34
Feb 16	326.65	Apr 16	26.34	Jun 16	85.18	Aug 16	143.46	Oct 16	202.96	Dec 16	264.36
Feb 17	327.66	Apr 17	27.32	Jun 17	86.14	Aug 17	144.42	Oct 17	203.95	Dec 17	265.38
Feb 18	328.67	Apr 18	28.29	Jun 18	87.09	Aug 18	145.38	Oct 18	204.94	Dec 18	266.39
Feb 19	329.67	Apr 19	29.27	Jun 19	88.05	Aug 19	146.34	Oct 19	205.93	Dec 19	267.41
Feb 20	330.68	Apr 20	30.25	Jun 20	89.00	Aug 20	147.31	Oct 20	206.93	Dec 20	268.43
Feb 21	331.69	Apr 21	31.22	Jun 21	89.96	Aug 21	148.27	Oct 21	207.92	Dec 21	269.45
Feb 22	332.70	Apr 22	32.20	Jun 22	90.91	Aug 22	149.23	Oct 22	208.92	Dec 22	270.47
Feb 23	333.71	Apr 23	33.18	Jun 23	91.86	Aug 23	150.20	Oct 23	209.91	Dec 23	271.48
Feb 24	334.71	Apr 24	34.15	Jun 24	92.82	Aug 24	151.16	Oct 24	210.91	Dec 24	272.50
Feb 25	335.72	Apr 25	35.12	Jun 25	93.77	Aug 25	152.12	Oct 25	211.90	Dec 25	273.52
Feb 26	336.73	Apr 26	36.10	Jun 26	94.72	Aug 26	153.09	Oct 26	212.90	Dec 26	274.54
Feb 27	337.73	Apr 27	37.07	Jun 27	95.68	Aug 27	154.05	Oct 27	213.90	Dec 27	275.56
Feb 28	338.74	Apr 28	38.04	Jun 28	96.63	Aug 28	155.02	Oct 28	214.90	Dec 28	276.58
Feb 29	339.74	Apr 29	39.01	Jun 29	97.58	Aug 29	155.98	Oct 29	215.89	Dec 29	277.60
		Apr 30	39.98	Jun 30	98.54	Aug 30	156.95	Oct 30	216.89	Dec 30	278.61
						Aug 31	157.92	Oct 31	217.89	Dec 31	279.63

Practical Meteor Photography
Part I: Selecting a Camera

Marc de Lignie

Preface

The *IMO* Photographic Handbook provides a wealth of information, but in some parts additional practical hints would be useful. This series of short articles intends to fill this gap and to support beginning meteor photographers in deciding which materials to use, which methods to apply, etc. The information in this series originates from experienced meteor photographers and has proven its value in practice.

1. Introduction

The choice of a camera for meteor photography is often determined by the available budget. Therefore, suitable choices will be discussed for different budgets. Keep in mind, however, that in the long run the operational costs of a camera are determined mainly by the required films, chemicals, batteries and negative albums.

Although some types or brands of cameras are mentioned in the text below, this should not be considered as a "buying advice" from the author or from *WGN* and it does not imply that other cameras will not serve the job equally well.

2. Low-budget cameras

The most widely available low-budget cameras are made by Praktica and Zenit. Typical second-hand prices rate down to 20 USD. There are two reasons to prefer the Zenit camera over the Praktica: (*i*) the optics is superior, and (*ii*) time exposures can be made without using a cable release, which saves additional money. A third group of cheap cameras are the old cameras made before the mirror reflex era. One such camera, with $f/2.8$-50 mm optics from Zeiss and already 30 years of age, happens to be one of my most successful cameras.

3. Medium-budget cameras

Using low-budget cameras has some obvious disadvantages: the reliability of the manual film transport is poor and the quality of the optics often disappoints. I have often heard friends referring to them as "film-eating devices" or giving the advice to throw a particular objective in the glass recycling container.

If your budget allows it, you may want to use medium-budget cameras. Many of the major camera manufacturers have produced cameras for 35 mm film which can be operated without batteries. These cameras are still available on the second hand market for prices ranging from 80 to 200 USD (including the objective) and are an excellent choice for meteor photography.

Note that many medium-budget cameras need a battery to actively keep the shutter opened. Especially if such a camera uses a small type of battery, this will make it almost useless for astrophotography unless an external power supply is used. It is often hard to see whether a camera has a mechanically or an electronically operated shutter, because also the former usually requires a battery to measure the shutter speed during daylight photography. So be sure to try whether the shutter of the camera works without a battery before buying it.

4. Expensive cameras

There are only two improvements possible over the medium-budget camera: a larger film format and automated operation. Film formats larger than 35 mm are not an obvious choice and should only be considered for all-sky photography or for realizing a very high measuring accuracy. These motivations are not further discussed here, but could be a subject for later issues of this series. For automated operation of cameras, a motor winder is required. The best choice is a camera with an internal motor winder. External motor winders are often unreliable due to bad electronic contacts, and are therefore not recommended.

Because of its exceptional properties and wide use within meteor photography, one type of camera deserves mentioning: the Canon T70. Apart from an internal motor winder, this camera can be equipped with a command back that allows to program a series of time exposures for automatic operation during the entire night. Also without the command back, the camera can easily be automated because it has an electronic connection for remote operation of the shutter.

5. Availability of cameras

The types of cameras mentioned above are widely available in Europe. Supposedly, these cameras are also available in "western" countries on other continents (Japan, US, Australia). However, other types of cameras may be more attractive there. Some highly developed Asian countries (such as China) are likely to have designed their own cameras which may be equally suitable for meteor photography. If you have any information on availability of cameras in your country that could be valuable to other meteor workers, do not hesitate to inform me or the editor of *WGN*.

6. The objective

Most 35 mm cameras are equipped with an $f/1.8$, $f = 50$ mm lens. My personal advice is to use this lens for meteor photography! I even advise you to use the objective at an $f/2.8$ opening ratio. This will cost you hardly any meteors and you get rid of the coma and vignetting errors that all objectives have.

This advice may seem contradictory to the lens efficiencies provided in the Photographic Handbook. However, the theoretical values for lens efficiencies do not account for background illumination by stars and stray light. In order to exploit the four times higher efficiency of an $f/1.4$, $f = 50$ mm lens compared to an $f/2.8$, $f = 50$ mm lens, one also has to decrease the exposure time by a factor of four to have a comparable greyness of the negative. In addition, the values in the Photographic Handbook are valid for sporadic meteors, while for meteor streams the number of weak meteors is lower than for the sporadic background. Instead of using an expensive fast lens and lots of film one can better use additional cameras with normal objectives and apply longer exposure times (typically 15 to 30 minutes). The advantage is that you will catch more nice bright meteors with the additional cameras while the fast lens will rather give you some additional weak meteors.

By the way, the typical limiting magnitude for meteors of an $f/2.8$, $f = 50$ mm lens is about $+1$. The value of -0.6 mentioned in the Photographic Handbook is probably an absolute magnitude, i.e., valid at a distance of 100 km, while most meteors are photographed at a distance of 150 km. And what about the use of wide-angle lenses, such as $f/2.8$, $f = 35$ mm and $f/2.8$, $f = 28$ mm lenses? It turns out that the number of meteors photographed with such lenses is not larger than with an $f/2.8$, $f = 50$ mm lens (consistent with the efficiencies listed in the Photographic Handbook) and that the pictures from wide-angle lenses are often disappointing. Additionally, measurements from wide-angle lenses are less accurate. Therefore the use of a wide-angle lens is not specially recommended, but of course you can use it if you happen to possess one.

7. Conclusion

Finding the right camera within your budget should not be a problem if the pitfalls mentioned above are avoided (bad objective or unreliable film transport, electronic shutter, external winder, expensive fast lens).

By some fortunate coincidence, the widest available lense for 35 mm film cameras is just optimal for meteor photography. This has to do with the fact that the angular length of the typical photographic meteor fits well in the field of view of an objective with 50 mm focal length and that for reasonable exposure times the limiting magnitude of the $f/2.8$, $f = 50$ mm lens is just limited by background illumination.

A Dark Meteor Database

Alastair McBeath

1. Introduction

The response to the author's article on dark meteors [1], both in terms of letters in *WGN* [2–4] and in conversation at astronomical meetings, notably at the 1995 *IMC*, has been both gratifying and a little surprising. Many people have made the comment that they have seen such dark meteor-like streaks in the night sky on rare occasions for much of their visual meteor observing careers, but never dared report them before, for fear of ridicule. The comments Godfrey Baldacchino refers to in his letter [4] by those who wish to dismiss the phenomenon as irrelevant are regrettably all-too common examples of the appalling narrow-mindedness often displayed whenever any slightly unusual event is discussed. The additional notes he makes concerning the need to examine dark meteors further are well-made, since, like it or not, a sizable number of all visual meteor observers have seen these objects. As a result, it seems sensible to establish a database, as Godfrey suggests, so that we can derive some facts about dark meteors, such as the following:

- What is seen when a dark meteor occurs?
- Who sees them (regular observers, occasional observers, complete novices)?
- What factors influence their detection (fatigue, high alertness, very clear skies)?
- Why do some observers note dark meteors while others do not (age, eye health, use of optical aids)?
- When are they most likely to be seen (time of night, time of year, time during watch)?
- Where are they most often seen from (latitude/longitude/site altitude dependence, rural/urban sites)?
- How often are they seen (regularly, seldom, with potential periodicity, at random intervals)?
- Can dark meteors be observed by techniques not routinely employed by a visual watcher?

In fact, it seems sensible to establish a two-fold approach to this, firstly to establish what we can about previous sightings, which have mostly not been recorded with any real degree of accuracy due to the reception of this phenomenon outlined above and elsewhere, and secondly to propose a method by which future sightings can be recorded in the necessary detail. This second method needs to be flexible at present, until we are able to establish whether there are other questions that need to be looked into concerning dark meteors, so the proposed reporting method set out in Section 3 below should be regarded as a guide only at present.

2. Reporting previous observations

It would be useful to establish what proportion of observers have actually seen dark meteors during past watches, what people have perceived on witnessing such an event, and whether they can recall any particular features of the dark meteor(s) they saw. In order to discover these data, the following information needs to be provided by all meteor observers reading this:

1. Your name and address (we cannot guarantee to be able to reply to everyone who responds for cost and time reasons, but the information is useful in case any information needs re-checking).
2. How many years have you been observing meteors for and how many hours of observation have you carried out in that time?
3. Do you normally/predominantly carry out visual watching, telescopic/binocular watching or some other technique (please state)?
4. Have you ever seen a dark meteor?—Answer "Yes" or "No." If the answer is "No," no further information need be given. If it is "Yes," please provide the remaining data for each dark meteor seen, where possible.
5. When did you make your dark meteor sighting (preferably including the date and time in UT)?
6. Where did you make the observation from (give place name, country, latitude, longitude and height above sea level)?
7. What were the sky/weather conditions?
8. Describe as fully as possible what you saw.
9. Any further comments—e.g., were you alert/fatigued at the time, do you normally observe using glasses or contact lenses, etc.?

It is important that regular observers who have never knowingly seen a dark meteor should also contribute to this project, otherwise we will end up discovering that all meteor observers have seen a dark meteor, which we already know is not the case. If you do not respond, your data cannot be used!

For actual observations of dark meteors, it is unlikely that many people will have recorded accurately at the time what they saw, so not all the information asked for may be available. This is only to be expected, and it is equally likely that some information may be remembered only inaccurately or not at all, in which case, this should be clearly stated. At worst, this will enable us to gain an idea of just how many meteor observers have noticed dark meteors in the past, and provide some pointers for future researches.

3. Recording dark meteor sightings

A suggested report form for individual dark meteor sightings is provided with this article, and should be completed by anyone who sees such an event as fully as possible. The initial items to note are all fairly standard—date, name address, site location, observing conditions (which should also include an indication of the wind speed)—but it is also important to have some idea of whether a meteor watch was being carried out at the time, the alertness of the observer, and whether some optical problem was being corrected by glasses or contact lenses.

The initial dark meteor observation by each watcher should also contain further notes on potential eye problems which may influence whether or how dark meteors are perceived, which includes the observer's age, since various effects occur in the eye as it ages which can affect perception to some extent. It is also useful to know roughly how experienced the observer is, which gives an indication of how used the observer is to observing the various meteoric phenomena that occur far more commonly than dark meteors.

Non-visual sightings, such as photographs or video recordings, would be particularly interesting, and if a telescope or binoculars were employed, this space on the report form is also a suitable place to record the equipment used. So far, the author has only seen one video "dark meteor," that discovered by Sirko Molau [3] using the MOVIE system, and which appears to be a low-flying bat, but which had clearly recorded on video as a dark object despite being seen against the dark night sky. Several other potential dark meteors on video were reported by the Dutch observers at the 1995 *IMC*, however, and it will be useful to see and compare these with that caught by MOVIE.

Finally, space is set aside to note down the details of the dark meteors seen. It is difficult, and probably counter-productive, to say what details these should include, other than the time of the object's appearance, but a description in words or as a sketch would be appropriate, including how obvious the object was against the sky, and a rough measure of its apparent speed. If the object can be definitely identified as some kind of flying animal or windblown debris, that should be noted, although this may be very difficult to establish. It would also be helpful in this respect to know whether the object moved in the direction of the prevailing surface wind (if particularly noticeable) or not.

4. Conclusion

Completed forms should be returned to the author as soon as possible after the observation is made for analysis. Hopefully, the results of the initial survey of past sightings can be published in *WGN* quite soon, providing sufficient observers respond quickly. Future investigations of what the phenomenon may be are liable to require more time. Please remember, it is important in this initial phase that as many people respond as possible, not just those who have seen dark meteors. Thank you for your cooperation!

IMO DARK METEOR SURVEY REPORT FORM

Once completed, please return this form to:
Alastair McBeath,
12A Prior's Walk, Morpeth,
Northumberland, NE61 2RF, England, U.K.

Date (yy/mm/dd):__________ Name:____________________
Correspondence address:____________________________
Site location (town, country): __________________________
Longitude:__________ Latitude:__________ Altitude:__________
LM:_____ Other sky conditions: _________________________

Please circle as appropriate to answer:
Observed during meteor watch? Yes No - if "Yes", please give watch start and end times:____________________________
Your fatigue condition: very alert alert normal tired very tired
Were you observing in: glasses contact lenses neither

If you have never reported a dark meteor to this project before, please state
Your age: ______
Any known eye defects:____________________________
How many years have you been observing meteors for:____________
Do you consider yourself a regular occasional casual novice observer?
(Please circle one answer only)

If you did not make this sighting visually, please state equipment used:

____

For each dark meteor, give its appearance time in UT, and describe what you saw:

____

____

____

____

____

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____

____

References

[1] A. McBeath, "Dark Meteors", *WGN* 23:3, June 1995, pp. 91–96.
[2] M. Gyssens (comp.), "Letters to WGN", *WGN* 23:4, August 1995, pp. 101–102.
[3] M. Gyssens (comp.), "Letters to WGN", *WGN* 23:5, October 1995, pp. 162–163.
[4] M. Gyssens (comp.), "Letters to WGN", *WGN* 23:6, December 1995, pp. 186–188.

Updating Daylight Radio Shower Details

Alastair McBeath

Rainer Arlt has drawn to my attention several notes he has received from forward-scatter radio observers concerning details they are interested in seeing in future editions of the *IMO*'s annual *Meteor Shower Calendar*. Chief among these is the actual time in UT of the maxima for the major showers, whether Moon-affected or not, and we will endeavor to accommodate this in the 1997 Calendar, which is under preparation.

However, it would also be interesting to see if there are sufficient data available to update the daylight radio shower list in the Calendar. In many cases, the information we publish there has not been monitored regularly (or certainly, the results have not been widely published) since the 1950s and 1960s, and it would be useful to establish just how accurate the data are, at least as far as forward-scatter results can tell us (i.e., we should be able to establish peak activity dates, although probably not specific radiant points). Reduced radio results have been published relatively infrequently in *WGN* in the last few years, and with little other than one or two national observers or groups collecting and analyzing the data that does appear, it is difficult to judge whether or not there are enough data available to make this a reality.

Consequently, if any radio observers have such data available in reduced form (*not* as just raw counts, since I do not have limitless time to devote to this task), I would be very interested to see it as soon as possible. The information cannot now be compiled in time for the Calendar's 1997 edition, but I would hope to introduce any new facets of the daylight radio showers into the 1998 edition. If sufficient response is generated, it would be my intention to prepare an article in *WGN* before the end of this year to identify what data are available, and what gaps there are in coverage. This means (*i*) please send your data now—do not wait until later in the year, and (*ii*) do not assume someone else will pass me your data—past experience suggests they almost certainly *will not*!

Meteor Shower Calendar: April–September 1996

compiled by Alastair McBeath

1. April to June

Meteor activity picks up around the April-May boundary, with showers like the Lyrids (detailed below), π-Puppids and η-Aquarids (their maximum is just after Full Moon this year, however), before switching to the daylight sky, for the most active radio showers of the year in May and June, showers like the o-Cetids, Arietids, ζ-Perseids and β-Taurids. The ecliptical complexes continue with some late Virginids and the best from the minor Sagittarids in May-June.

Lyrids

Active: April 16–25; Maximum: April 22, $21^{\rm h}$ UT ($\lambda_\odot = 32\overset{\circ}{.}1$); ZHR: variable—up to 90, usually 15;
Radiant: $\alpha = 271°$, $\delta = +34°$, $\Delta\alpha = +1\overset{\circ}{.}1$, $\Delta\delta = 0\overset{\circ}{.}0$; radius: 5°;
$V_\infty = 49$ km/s; $r = 2.9$
TFC: $\alpha = 262°$, $\delta = +16°$ and $\alpha = 282°$, $\delta = +19°$ ($\beta > 10°$ S)

The Lyrids are best viewed from the northern hemisphere, but they are observable from most sites either north or south of the equator, and are suitable for all forms of observation. Maximum rates are attained for only about an hour or two at best, and can be rather erratic at times. In recent years, activity of around 15 meteors per hour has been seen, but on some occasions much higher rates have been noted. The most recent such event was in 1982 when American observers recorded a very short-lived peak ZHR of 90. This unpredictability means the Lyrids are always a shower to watch, since we cannot tell when another unusual return may happen.

As the shower's radiant rises during the night, watches can be usefully carried out from about $22^{\rm h}30^{\rm m}$ local time onwards. This year, their peak falls with a thin waxing crescent Moon which will have set from most sites by the time the radiant is at a useful elevation above the horizon. The predicted peak should favor Asian sites if correct, but variations in the stream could mean this is not the case in actuality.

2. July to September

Minor shower activity continues from near-ecliptic sources throughout this quarter, first from the Sagittarids, then the Aquarid and Capricornid showers (the best of which, the Southern δ-Aquarids and α-Capricornids, lose out to Full Moon near their maxima towards the end of July this year. The Northern δ- and ι-Aquarid peaks are better in this regard, with maxima around August 9 and 20 respectively), and finally the Piscids into September. Other low activity showers are apparent too, such as the κ-Cygnids, and the Aurigid showers from late August through to October (the δ-Aurigid peak around September 9 is best-placed of these in 1996). The major northern hemisphere event is always the Perseids in August, of course, although before we cover that, we highlight two other minor streams first.

Pegasids

Active: July 7–13; Maximum: July 11 ($\lambda_\odot = 108°$); ZHR = 3;
Radiant: $\alpha = 340°$, $\delta = +15°$; $\Delta\alpha = +0\overset{\circ}{.}8$, $\Delta\delta = +0\overset{\circ}{.}2$; radius: 5°; $V_\infty = 70$ km/s; $r = 3.0$;
TFC: $\alpha = 320°$, $\delta = +10°$ and $\alpha = 332°$, $\delta = +33°$ ($\beta > 40°$ N); $\alpha = 357°$, $\delta = +02°$ ($\beta < 40°$ N)

Watching this very short-lived minor shower is not easy, as a few cloudy nights mean its loss for visual observers, but with the Moon a slim waning crescent for its peak this year, everyone—particularly those in the northern hemisphere—should attempt to cover it. The shower is best-seen in the second half of the night, and the maximum ZHR is generally low. With its swift, faint meteors, telescopic observers should be in action too.

July Phoenicids

Active: July 10–16; Maximum: July 14 ($\lambda_\odot = 111°$); ZHR: variable, 3–10;
Radiant: $\alpha = 32°$, $\delta = -48°$; $\Delta\alpha = +1\overset{\circ}{.}0$, $\Delta\delta = +0\overset{\circ}{.}2$; radius: 7°; $V_\infty = 47$ km/s; $r = 3.0$;
TFC: $\alpha = 041°$, $\delta = -39°$ and $\alpha = 066°$, $\delta = -62°$ ($\beta < 10°$ N)

This minor shower can only be seen from the southern hemisphere, from where it only attains a reasonable elevation above the horizon after midnight. This means there will be some slight interference in covering it this year from the waning Moon, but the Moon is only four days from new at the shower's maximum. Activity is quite variable visually, and indeed observations show it is a richer radio meteor source (possibly also telescopically too, but more results are needed). Recent years have brought ZHRs of 3–5, when the winter weather has allowed any coverage at all. Perhaps 1995 will be a good year for them?

Perseids

Active: July 17–August 24; Maxima: August 12, 0^h UT ($\lambda_\odot = 139\overset{\circ}{.}6$) and 12^h UT ($\lambda_\odot = 140\overset{\circ}{.}1$)
ZHR: primary peak: variable, 200–400; secondary peak: 100;
Radiant: $\alpha = 46°$, $\delta = +58°$; $\Delta\alpha = +1\overset{\circ}{.}4$, $\Delta\delta = +0\overset{\circ}{.}2$: radius: 5°; $V_\infty = 59$ km/s; $r = 2.6$;
TFC: $\alpha = 019°$, $\delta = +38°$ and $\alpha = 348°$, $\delta = +74°$ before 2^h local time;
$\alpha = 43°$, $\delta = +38°$ and $\alpha = 73°$, $\delta = +66°$ after 2^h local time ($\beta > 20°$ N)
$\alpha = 300°$, $\delta = +40°$, $\alpha = 000°$, $\delta = +20°$, or
$\alpha = 240°$, $\delta = +70°$ ($\beta > 20°$ N)

The Perseids have become the single-most exciting and dynamic meteor shower in recent times, with outbursts producing ZHRs over 400 in both 1991 and 1992, around 300 in 1993, and 220 in 1994 at the shower's primary maximum, which this year is expected to fall around, or possibly before, midnight UT on August 12. The return of the Perseids' parent comet P/Swift-Tuttle in late 1992 was almost certainly responsible for producing these outbursts, although the material was probably laid down at the comet's previous perihelion passage, in 1862. It is difficult to assess whether the moonlight-affected return of 1995 agrees with the decreasing trend in the primary maximum's rates, but with New Moon just two days after both Perseid maxima in 1996, conditions are ideal for European observers to record what occurs. The "traditional" maximum is expected around 12^h UT on August 12 this year, which should be good news for watchers in Northern and Central America. The time of primary maximum has proved variable by up to several hours in the last few years, and its short-lived nature means that observers must be alert throughout the northern hemisphere right over the expected peak times.

Visual and photographic observers should need little encouragement to cover this stream, but telescopic watching near the main peak would be valuable in confirming or clarifying the possible multiple nature of the Perseid radiant, something not detectable visually. Video observations would be very helpful in this respect too, the Perseids being a particularly good shower to test new equipment set-ups on, with plenty of meteors expected for several nights over the peaks. Radio data would naturally enable early confirmation, or detection, of a perhaps otherwise unobserved outburst if the timing proves unsuitable for land-based sites. The only negative aspect to the shower is the impossibility of covering it from the bulk of the southern hemisphere.

κ-Cygnids

Active: August 3–25; Maximum: August 18 ($\lambda_\odot = 145°$); ZHR = 3;
Radiant: $\alpha = 286°$, $\delta = +59°$; $\Delta\alpha$ = +)°.2, $\Delta\delta$ = +0°.1; radius: 6° V_∞ = 25 km/s; r = 3.0;
PFC: $\alpha = 330°$, $\delta = +60°$ and $\alpha = 300°$, $\delta = +30°$

New Moon on August 14 almost ideally favors this minor shower this year, although it can be considered accessible only to watchers north of the equator. Its r-value suggests telescopic observers may benefit from its presence, though visual and photographic workers should note that occasional slow fireballs from this source have been reported too. Its apparently stationary radiant results from its close proximity to the ecliptic north pole in Draco. There has been some suggestion of a variation in its activity at times, perhaps coupled with a periodicity in fireball sightings, but we are a long way from even beginning to understand all the nuances of this stream—provide us with more data, please!

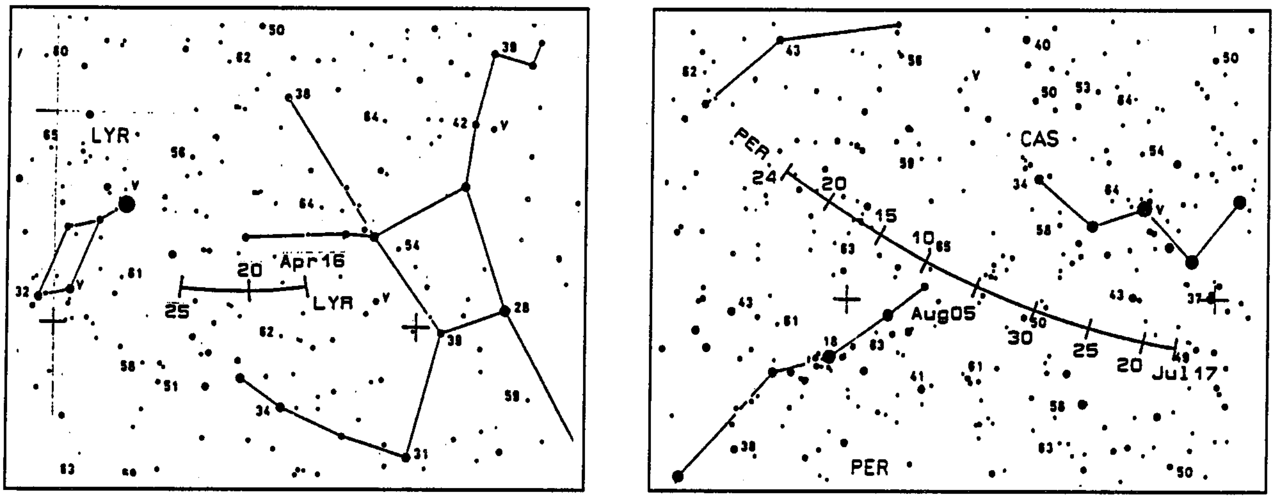

Figure 1 – Radiant positions of the Lyrids (*left*) and the Perseids (*right*).

3. Working list of meteor showers

Table 1 – Working list of meteor showers for the period April–September 1996. Streams marked with an asterisk are periodically or occasionally active, and therefore no ZHR is cited.

Shower	Activity	Maximum Date	$\lambda_\odot$	Radiant α	δ	Radius	V_∞ (*km/s*)	r	ZHR
Virginids (VIR)	Jan 25–Apr 15	Mar 25	4°	195°	−04°	15°/10°	30	3.0	5
Lyrids (LYR)	Apr 16–Apr 25	Apr 22	32.°1	271°	+34°	5°	49	2.9	15
π-Puppids* (PPU)	Apr 15–Apr 28	Apr 24	33.°5	110°	−45°	5°	18	2.0	
η-Aquarids	Apr 19–May 28	May 06	45.°5	339°	−01°	4°	66	2.7	60
Sagittarids (SAG)	Apr 15–Jul 15	May 20	59°	247°	−22°	15°/10°	30	2.3	5
Jul Pegasids (JPE)	Jul 07–Jul 13	Jul 11	108°	340°	+15°	5°	70	3.0	3
Jul Phoenicids* (PHE)	Jul 10–Jul 16	Jul 14	111°	32°	−48°	7°	47	3.0	
Piscis Austrinids	Jul 15–Aug 10	Jul 28	125°	339°	−16°	5°	35	3.2	5
Southern δ-Aquarids (SDA)	Jul 12–Aug 19	Jul 28	125°	341°	−30°	5°	41	3.2	20
α-Capricornids (CAP)	Jul 03–Aug 15	Jul 30	127°	307°	−10°	8°	25	2.5	4
Southern ι-Aquarids (SIA)	Jul 25–Aug 25	Aug 05	132°	334°	−15°	5°	34	2.9	2
Northern δ-Aquarids (NDA)	Jul 15–Aug 25	Aug 09	136°	335°	−05°	5°	42	3.4	4
Perseids (PER)	Jul 17–Aug 24	Aug 12	140.°1	46°	+58°	5°	59	2.6	100
κ-Cygnids (KCG)	Aug 03–Aug 25	Aug 18	145°	286°	+59°	6°	25	3.0	3
Northern ι-Aquarids (NIA)	Aug 11–Aug 31	Aug 20	147°	327°	−06°	5°	31	3.2	3
α-Aurigids (AUR)	Aug 25–Sep 05	Sep 01	158.°6	84°	+42°	5°	66	2.5	10
δ-Aurigids (DAU)	Sep 05–Oct 10	Sep 09	166°	60°	+47°	5°	64	3.0	6
Piscids (SPI)	Sep 01–Sep 30	Sep 20	177°	5°	−01°	5°	26	3.0	3

Table 2 – Radiant positions during 1996 in α and δ.

					VIR			
Apr 10	**SAG**	**LYR**	**PPU**		203° −7°			
Apr 15	224° −17°	263° +34°	106° −44°	**ETA**	205° −8°			
Apr 20	227° −18°	269° +34°	109° −45°	323° −7°				
Apr 25	230° −19°	274° +34°	111° −45°	328° −5°				
Apr 30	233° −19°							
May 5	236° −20°							
May 10	240° −21°							
May 20	247° −22°							
May 30	256° −23°							
Jun 10	265° −23°							
Jun 15	270° −23°							
Jun 20	275° −23°							
Jun 25	280° −23°							
Jun 30	284° −23°	**JPE**	**CAP**					
Jul 5	289° −22°	338° +14°	285° −16°	**SDA**				
Jul 10	293° −22°	341° +15°	289° −15°	325° −19°	**NDA**	**SIA**	**PER**	**PAU**
Jul 15	298° −21°		294° −14°	329° −19°	316° −10°	311° −18°	12° +51°	330° −34°
Jul 20			299° −12°	333° −18°	319° −9°	317° −17°	18° +52°	334° −33°
Jul 25			303° −11°	337° −17°	323° −9°	322° −17°	23° +54°	338° −31°
Jul 30	**KCG**		308° −10°	340° −16°	327° −8°	328° −16°	29° +55°	343° −29°
Aug 5	283° +58°	**NIA**	313° −8°	345° −14°	332° −6°	334° −15°	37° +57°	348° −27°
Aug 10	284° +58°	317° −7°	318° −6°	349° −13°	335° −5°	339° −14°	43° +58°	352° −26°
Aug 15	285° +59°	322° −7°		352° −12°	339° −4°	345° −13°	50° +59°	
Aug 20	286° +59°	327° −6°	**AUR**	356° −11°	343° −3°	350° −12°	57° +59°	
Aug 25	288° +60°	332° −5°	76° +42°		347° −2°	355° −11°	65° +60°	
Aug 30	289° +60°	337° −5°	82° +42°	**DAU**				
Sep 5			88° +42°	55° +46°	**SPI**			
Sep 10				60° +47°	357° −5°			
Sep 15				66° +48°	1° −3°			
Sep 20				71° +48°	5° −1°			
Sep 25				77° +49°	9° 0°			
Sep 30				83° +49°	13° +2°			

4. Daytime radio meter streams

Table 3 – Working list of daytime radio meteor streams. The "Best Observed" columns give the approximate local mean times between which a four-element antenna at an elevation of 45° receiving a signal from a 30-kW transmitter 1000 km away should record at least 85% of any suitably positioned radio-reflecting meteor trails for the appropriate latitudes. Note that this is often heavily dependent on the compass direction in which the antenna is pointing, however, and applies only to dates near the shower's maximum.

Shower	Activity	Max	$\lambda_\odot$	Radiant		Best Observed		ZHR
		Date	2000.0	α	δ	50° N	35° S	
Piscids (Apr)	Apr 08–Apr 29	Apr 20	30.°3	7°	+07°	07^h–14^h	08^h–13^h	
δ-Piscids	Apr 24–Apr 24	Apr 24	34.°2	11°	+12°	07^h–14^h	08^h–13^h	
ε-Arietids	Apr 24–May 27	May 08	48.°7	44°	+21°	08^h–15^h	10^h–14^h	
Arietids (May)	May 04–Jun 06	May 16	55.°5	37°	+18°	08^h–15^h	09^h–13^h	
o-Cetids	May 05–Jun 02	May 19	59.°3	28°	−04°	07^h–13^h	07^h–13^h	15
Arietids	May 22–Jul 02	Jun 07	76.°7	44°	+24°	06^h–14^h	08^h–12^h	60
ζ-Perseids	May 20–Jul 05	Jun 09	78.°6	62°	+23°	07^h–15^h	09^h–13^h	40
β-Taurids	Jun 05–Jul 17	Jun 28	96.°7	86°	+19°	08^h–15^h	09^h–13^h	25
γ-Leonids	Aug 14–Sep 12	Aug 25	152.°2	155°	+20°	08^h–16^h	10^h–14^h	
Sextantids*	Sep 09–Oct 09	Sep 27	184.°3	152°	00°	06^h–12^h	06^h–13^h	30

5. Lunar phases

Table 4 – Lunar phases for April–September 1996.

New Moon	Mar 19	Apr 17	May 17	Jun 16	Jul 15	Aug 14	Sep 12
First Quarter	Mar 27	Apr 25	May 25	Jun 24	Jul 23	Aug 22	Sep 20
Full Moon	Apr 04	May 03	Jun 01	Jul 01	Jul 30	Aug 28	Sep 27
Last Quarter	Apr 10	May 10	Jun 08	Jul 07	Aug 06	Sep 04	Oct 04

Hints for Telescopic Observers: April–June 1996

Malcolm J. Currie

The main target for the period is the *Lyrid* shower. As the moon is effectively absent until the last couple of nights' activity and the maximum falls at a weekend, this year affords a good opportunity to study this major shower telescopically. Hitherto telescopic data have been scarcer than a series win for the England cricket team. The former I attribute to reliable weather (it's almost always cloudy) and because the shower can only be seen well after midnight. Unanswered questions include the following: does the telescopic activity peak before the visual, what is the radiant size, are there subradiants as Prentice concluded, and what is the luminosity function at faint magnitudes? As major showers go, the Lyrids have a high population index. What this means in practice is better observed telescopic rates; so for instance, the Lyrids are normally much weaker than the Perseids for naked-eye meteors, but extrapolating to telescopic magnitudes there will be more Lyrids than Perseids. Another feature of the Lyrids, is the occasional short-lived outburst of faint visual meteors, along the lines of the α-Monocerotids last November. The data suggest a twelve-year period (which indicates some connection to Jupiter), though this is far from conclusive, and the Lyrids need to be observed around the globe every year so we do not miss an outburst. Suggested charts are 67, 69, and 109 before about 1^{h} local time, and supplement with 87 and 111 after that. As ever, spend about thirty minutes on a field before switching.

These same charts, and 67 and 109 in particular, will also permit you to detect the occasional slow-moving *α-Bootid*. Visually the radiant is extended, but its properties below the naked-eye threshold are unknown.

During May and June, it is well worth looking for minor showers, as this period has historically not been well observed. Such showers might only last for a day and so are easily missed. One set of charts for this project could be 106, 108, 109, 111, and 113. Those south of latitude 40° N, where twilight is not a nuisance, are encouraged to try 148–151, 160 (and possibly 161 and 162) because they will let them simultaneously follow the *Ophiuchids* in May, and the weak *Scorpius-Sagittarid Complex* throughout the period. Try to use at least three charts per night if you intend following these ecliptic showers. If you spot a potential minor shower you might want to add fields further north to determine the radiant's location more accurately. Please then concentrate on the putative shower for the rest of the night.

No Meteors from Comet 1996 B2 Hyakutake

Rainer Arlt

Recently, Comet Hyakutake passed our planet in a distance of about 0.1 AU. It has been argued whether we may see meteors from this comet. Although the distance of 0.1 AU is small when observing comets, it is rather large when considering a meteoroid stream. The particles ejected from the comet's nucleus have to drift out of the orbit of the comet if they are to hit the Earth. A particle has a maximum drift speed if it is ejected perpendicularly to the comet's direction of motion. Ejection velocities of particles are supposed to be between 0.3 and 1.0 km/s. Let us assume 1 km/s as the upper limit. The minimum distance between Earth and comet was 15 million km, hence, it takes the particle at least 15 million seconds or 170 days to drift far enough to hit the Earth. However, 170 days ago the comet was at a distance of some 3.8 AU from the Sun, i.e., beyond the asteroid belt. The ejection rate of particles is very low at this distance. Harris et al. [1] assume a r^{-2}-dependence of the emission rate on the distance r to the Sun for Comet 109P/Swift-Tuttle and the Perseids, and they further assume that the ejection rate is zero for distances greater than 2.9 AU. Additionally, recent studies indicate that dust particles are ejected from the comet's nucleus mainly after its perihelion passage when a large amount of the volatile substances have sublimated, further decreasing the expected flux of meteoroids from the comet.

[1] N.W. Harris, K.K.C. Yau, D.W. Hughes, "The true extent of the nodal distribution of the Perseid meteoroid stream", *Mon. Not. Roy. Astron. Soc.* 273, 1995, pp. 999–1015.

Progress in Meteor Science

Articles in this section have been formally refereed by at least one professional and one experienced, knowledgeable amateur meteor worker, and deal with global analyses of meteor data, methods for meteor observing and data reduction, observations with professional equipment, or theoretical studies.

Double-Station Video Observations of the 1995 Quadrantids

Marc de Lignie and Klaas Jobse

After some years of experimenting and development of reduction methods, amateurs are now able to routinely produce meteor orbits from double-station observations with intensified video cameras. This article describes observations during the 1995 Quadrantid maximum as well as our data reduction procedures. Accurate orbits and atmospheric trajectories of 20 sporadic and 29 Quadrantid meteors were obtained, which is a significant contribution to the existing knowledge on the Quadrantid stream. The average orbit of small Quadrantid meteoroids, as observed with intensified video cameras, is shown to be equal to the orbit in the photographic mass range.

1. Introduction

Although intensified video cameras have been used for meteor observations during several decades, they have not been an instrument for systematic observations of meteor showers. Reasons for this have been a lack of funding for large professional observation programs and the technical complexity associated with the reduction of video material. Recent developments in both video and computer technology have torn down the technological barrier to a level where amateurs can afford the equipment required for video observations and the data reduction. The present article is another indication that we are entering an era in which amateurs will provide video observations of meteor showers on a regular basis.

After similar reports on the 1990 and 1991 Taurids in [1] and the 1993 Orionids in [2], this article discusses double station video observations of the 1995 Quadrantids. Such observations are valuable because video observations cover a different mass range of particles (0.0003–0.1 g) than photographic observations (0.1–50 g). This is particularly interesting for the Quadrantids, because this stream is reported to have a mass separation along its node [3]. Furthermore, double-station observations of the Quadrantids are scarce. The database of the *IAU* Data Center in Lund only contains 15 high-precision Quadrantid orbits from photographic observations; six additional photographic Quadrantid orbits were reported in [4].

2. The observations

Many observers in Western Europe experienced clear moonless skies during the Quadrantid maximum of 1995. As a result, this event was covered very well by both visual and photographic observations. At two Dutch locations, Bosschenhoofd and Oostkapelle, also intensified video cameras were stationed. During seven hours of observing, these cameras recorded 69 meteors simultaneously, of which 49 could be fully reduced.

The camera in Oostkapelle ($\lambda = 3°32'15''\!.9$ E, $\varphi = 51°34'21''\!.7$ N) consists of a microchannel plate (MCP) image intensifier with a 48 mm photocathode (XX 1332), an $f/2.0$, $f = 135$ mm objective and a Video 8 camcorder. The camera in Bosschenhoofd ($\lambda = 4°32'32''\!.6$ E, $\varphi = 51°34'14''\!.2$ N) is very similar and consists of an MCP image intensifier with a 25 mm photocathode (XX 1400), an $f/1.2$, $f = 85$ mm objective and a Hi 8 camcorder. Both cameras have a field of view of about 20° and a star limiting magnitude of +8.5.

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The distance between the two stations was about 70 km. The cameras were aimed at a position in the atmosphere 100 km above the Earth's surface. This point was selected such that the expected angle between the trails of a double-station event is large in case of a meteor from the Quadrantid shower.

3. Data reduction

The first step in the data reduction is visually inspecting the video tapes for the occurrence of meteors. After that, the lists of meteors from both stations are compared to find the double-station events. In most cases, the time of appearance indicates whether a meteor trail is part of a double station event or not (the timing precision is about 1 second). When there is still doubt, also the other characteristics of the meteor, such as its brightness, are taken into account. In this stage, also a selection is made which events are worth further reduction. Very weak trails that are visible in just a few video frames are discarded. Also trails that move closely along the edge of the image are not further reduced. However, bright trails that are only slightly truncated pass the selection.

The second step is digitizing all meteor trails. We use a frame grabber that can digitize in a resolution of 384×288 pixels, 256 grey levels, and at a frame rate of 25 images per second (Miro DC1 Clip). We digitize about 3 seconds of video material per meteor trail, which makes the digitization a quite straightforward process (it is not necessary to "time" the start of the digitizing process). The frame grabber applies Motion-JPEG compression on the fly, which allows to store a large number of meteor trails on a standard PC hard disk (one trail takes about 1.2 Mbyte of storage). Given the fact that the meteor images are obtained from a video source with a limited resolution, the image compression does not further limit the image resolution.

In the third step the position of the meteor trail and of a number of surrounding reference stars is measured. We use a computer program that was originally developed for doing astrometric measurements of digitized photographic images (called ASTRO RECORD [5]). It is now adapted to also accept a sequence of digitized video images in the Microsoft Video for Windows format. For the positional measurements of the reference stars, eight video frames are averaged to obtain an image with better noise characteristics. We measure about 25 reference stars around the meteor, around the center of the image, and everywhere in between. With a third-order polynomial fit we obtain a positional accuracy of about $45''$, which is a quarter of the width of a pixel of the digitized image.

The final step is calculating the atmospheric trajectory and heliocentric orbit of the meteor in a standard way [6]. One tricky point is to determine the pre-atmospheric velocity (VINF) of the meteor. The standard procedures to do this appear not to work well for video meteors: due to the poor dynamic range of video images, there is a tendency to measure the position of the meteor at its brightest point too far down the trail while the true position of the meteor is obtained at its weaker parts. This measurement artifact introduces an artificial deceleration in the measured motion of the meteor as it becomes brighter and then weaker again. This deceleration makes the calculation of pre-atmospheric velocities impossible. Instead, the calculated average velocities have been corrected by adding a value of 0.2 km/s at $\langle V \rangle = 60$ km/s and 0.4 km/s at $\langle V \rangle = 20$ km/s; for other values of $\langle V \rangle$, one can interpolate. These values of the correction term were roughly determined from photographic data on the Perseid and Geminid meteor showers [2]. Once video data on more meteor showers are available, it may be attempted to derive a better-founded value for the deceleration of video meteors by integrating the equation of motion and mass loss equation using ablation coefficients and meteoroid densities obtained from photographic observations. Anyway, the applied correction does add little uncertainty to the pre-atmospheric velocity of individual meteors; however it influences the average value of a statistically significant sample. Note that also for velocities determined from photographs of shower meteors, the pre-atmospheric correction is not very precise.

The results of the calculations are listed in Tables 1 and 2.

Table 1 – Orbital elements (2000.0) of 29 Quadrantid (Qua) and 20 sporadic meteors (spo) observed on January 3 and 4, 1995.

code	day	str	Mv	q	tol	a	1/a	tol	e	tol	i	tol	w	tol	node	pi	tol
95001	3.7993	Qua	3	0.979	0.001	3.3	0.303	0.03	0.704	0.032	73.4	0.5	171.6	0.7	283.0	94.7	0.7
95002	3.9368	Qua	2	0.964	0.002	2.8	0.356	0.03	0.657	0.029	69.8	0.5	161.9	0.9	283.2	85.0	0.9
95004	3.9660	Qua	4	0.977	0.001	2.8	0.356	0.03	0.652	0.030	72.1	0.5	169.8	0.7	283.2	93.0	0.7
95008	3.9882	Qua	3	0.978	0.001	3.2	0.311	0.03	0.696	0.030	71.2	0.5	170.7	0.6	283.2	94.0	0.6
95009	3.9910	Qua	6	0.970	0.003	2.2	0.453	0.11	0.560	0.105	69.6	2.1	164.3	2.4	283.2	87.5	2.4
95012	4.0139	Qua	4	0.981	0.001	2.9	0.346	0.03	0.661	0.030	73.1	0.5	173.6	0.6	283.2	96.9	0.6
95014	4.0181	Qua	3	0.970	0.003	4.4	0.227	0.09	0.780	0.090	71.7	1.4	165.7	1.9	283.2	89.0	1.9
95015	4.0181	Qua	3	0.981	0.001	3.4	0.298	0.05	0.708	0.048	71.9	0.8	173.7	0.8	283.2	96.9	0.8
95016	4.0229	Qua	3	0.978	0.001	2.7	0.375	0.03	0.633	0.029	71.6	0.5	170.2	0.7	283.2	93.4	0.7
95017	4.0236	Qua	1	0.983	0.000	3.3	0.304	0.04	0.702	0.035	73.2	0.6	176.8	0.6	283.2	100.1	0.6
95018	4.0257	Qua	4	0.981	0.001	3.7	0.273	0.08	0.732	0.082	72.0	1.3	173.5	1.3	283.2	96.7	1.3
95019	4.0299	Qua	3	0.977	0.001	2.4	0.414	0.03	0.595	0.029	71.5	0.5	169.6	0.8	283.2	92.9	0.8
95023	4.0528	Qua	2	0.978	0.001	2.7	0.374	0.03	0.634	0.029	71.2	0.5	170.1	0.7	283.3	93.3	0.7
95026	4.0639	Qua	5	0.977	0.001	3.2	0.315	0.07	0.692	0.067	71.5	1.1	169.5	0.9	283.3	92.8	0.9
95027	4.0653	Qua	3	0.975	0.001	2.9	0.348	0.03	0.661	0.029	69.4	0.5	167.8	0.6	283.3	91.1	0.6
95033	4.0833	Qua	4	0.974	0.001	2.6	0.378	0.03	0.632	0.028	69.5	0.5	166.9	0.6	283.3	90.2	0.6
95037	4.1111	Qua	3	0.961	0.002	3.2	0.309	0.10	0.703	0.093	68.9	1.7	160.8	1.6	283.3	84.2	1.6
95041	4.1243	Qua	-1	0.980	0.001	3.5	0.287	0.03	0.719	0.031	73.3	0.5	172.4	0.6	283.3	95.8	0.6
95043	4.1319	Qua	2	0.978	0.001	2.6	0.382	0.03	0.626	0.028	70.4	0.5	170.1	0.6	283.4	93.5	0.6
95045	4.1403	Qua	3	0.978	0.001	3.1	0.322	0.10	0.685	0.098	73.1	1.6	170.8	1.3	283.4	94.2	1.3
95047	4.1493	Qua	3	0.979	0.001	2.7	0.366	0.03	0.641	0.029	71.2	0.5	171.4	0.6	283.4	94.8	0.6
95051	4.1785	Qua	3	0.978	0.001	2.4	0.414	0.04	0.595	0.040	68.6	0.8	169.9	0.7	283.4	93.3	0.7
95052	4.1799	Qua	6	0.980	0.001	3.5	0.289	0.04	0.717	0.043	74.1	0.7	172.3	1.2	283.4	95.7	1.2
95053	4.1833	Qua	5	0.974	0.001	2.9	0.347	0.03	0.662	0.031	71.9	0.5	167.5	0.6	283.4	91.0	0.6
95056	4.1882	Qua	2	0.978	0.001	3.6	0.275	0.03	0.731	0.032	74.0	0.5	171.1	0.6	283.4	94.5	0.6
95058	4.1910	Qua	5	0.979	0.001	4.2	0.238	0.06	0.767	0.062	73.0	1.0	171.9	0.7	283.4	95.3	0.7
95061	4.2035	Qua	4	0.978	0.001	2.5	0.400	0.05	0.609	0.049	70.3	0.9	170.5	0.7	283.4	93.9	0.7
95065	4.2111	Qua	4	0.978	0.001	2.1	0.488	0.03	0.523	0.028	68.0	0.6	170.0	0.7	283.4	93.5	0.7
95067	4.2181	Qua	5	0.978	0.001	3.3	0.304	0.05	0.703	0.045	68.7	0.8	170.6	0.7	283.4	94.1	0.7
average	4.08		3.3	0.977		3.0	0.340		0.668		71.3		169.8		283.3	93.1	
st. dev	0.10		1.5	0.005		0.5	0.060		0.059		1.7		3.4		0.1	3.4	
st. error	0.02			0.001		0.1	0.011		0.011		0.3		0.6		0.0	0.6	

code	day	str	Mv	q	tol	a	1/a	tol	e	tol	i	tol	w	tol	node	pi	tol
95006	3.9813	Spo	6	0.718	0.007	2.9	0.349	0.08	0.749	0.055	32.0	1.4	248.2	1.4	283.2	171.4	1.4
95010	4.0111	Spo	6	0.298	0.004	2.8	0.362	0.03	0.892	0.009	57.1	0.8	118.6	0.7	103.2	221.9	0.7
95020	4.0326	Spo	4	0.726	0.004	2.4	0.411	0.03	0.702	0.020	17.0	0.4	248.6	0.4	283.3	171.8	0.4
95021	4.0438	Spo	5	0.928	0.004	2.6	0.390	0.03	0.638	0.031	3.7	0.2	211.1	0.9	283.3	134.3	0.9
95030	4.0764	Spo	4	0.983	0.000	5.3	0.187	0.23	0.816	0.222	45.1	4.1	183.2	0.6	283.3	106.4	0.6
95031	4.0826	Spo	5	0.980	0.001	5.6	0.178	0.05	0.826	0.051	82.1	0.7	172.5	1.0	283.3	95.8	1.0
95032	4.0826	Spo	3	0.983	0.000	5.6	0.178	0.07	0.825	0.071	75.6	1.0	183.1	1.1	283.3	106.4	1.1
95035	4.1014	Spo	5	0.903	0.021	2.8	0.358	0.24	0.677	0.212	156.7	1.1	217.1	8.4	283.3	140.4	8.4
95038	4.1174	Spo	4	0.943	0.006	11.1	0.090	0.07	0.915	0.065	110.3	0.8	156.1	1.9	283.3	79.5	1.9
95039	4.1188	Spo	4	0.921	0.021	1.5	0.652	0.06	0.400	0.054	109.7	1.1	219.0	7.4	283.3	142.3	7.4
95040	4.1201	Spo	3	0.973	0.001	5.1	0.194	0.10	0.811	0.096	88.5	1.2	167.6	1.1	283.3	90.9	1.1
95044	4.1361	Spo	3	0.722	0.006	6.6	0.152	0.05	0.890	0.032	75.5	0.7	64.2	1.3	103.4	167.5	1.3
95049	4.1625	Spo	5	0.308	0.010	6.1	0.164	0.05	0.949	0.013	118.7	0.8	114.2	1.8	103.4	217.6	1.8
95054	4.1861	Spo	5	0.300	0.013	3.4	0.297	0.05	0.911	0.012	160.6	0.7	117.3	2.3	103.4	220.7	2.3
95059	4.1986	Spo	5	0.937	0.009	14.4	0.069	0.26	0.935	0.248	166.5	0.6	205.4	4.2	283.4	128.8	4.2
95060	4.2000	Spo	6	0.098	0.041	7.4	0.135	0.37	0.987	0.031	132.6	8.0	324.4	11.1	283.4	247.8	11.1
95063	4.2090	Spo	5	0.969	0.000	5.3	0.188	0.03	0.818	0.027	41.5	0.5	165.6	0.3	283.4	89.0	0.3
95064	4.2097	Spo	6	0.869	0.024	1.5	0.674	0.11	0.415	0.082	136.4	1.0	232.8	9.8	283.4	156.3	9.8
95068	4.2181	Spo	6	0.525	0.013	18.8	0.053	0.06	0.972	0.031	145.2	0.5	266.8	2.3	283.4	190.3	2.3
95069	4.2194	Spo	6	0.951	0.021	1.7	0.578	0.37	0.450	0.338	154.1	1.5	206.4	15.6	283.4	129.9	15.6

The estimated error in the radiant coordinates is derived from the astrometric accuracy and the particular geometry of the trails (a short trail or a small angle between the trails results in a large estimated error). The estimated error in the velocity is derived from the quality of the linear fit to calculate the average velocity and from the difference in the velocities as measured at both stations. A minimum error in the radiant of 0°3 and in the velocity of 1% is applied if the algorithms for the error prediction specify a lower value (these are typical values for "unexplained" errors known from meteors that are photographed from more than two stations). The errors in the orbital elements directly originate from the predicted errors in the radiant and velocity.

Table 2 – Trajectory data (2000.0) of 29 Quadrantid and 20 sporadic meteors. The suffix "G" (in VG and the radiant coordinates RAG and DEG) means geocentric, indicating that a correction for zenith attraction has been applied. Begin and end heights (HB and HE) are in km. The zenith distance of the radiant at the time of appearance of the meteor is denoted by Z and the angle between the trails from both stations is denoted by Qmax.

code	VG	VH	VINF	<V>	tol	HB	HE	RA	tol	DE	tol	RAG	DEG	cos Z	Qmax
95001	42.1	39.2	43.6	43.3	0.5	107.2	100.8	229.03	0.17	50.54	0.28	229.23	48.91	0.217	35
95002	40.1	38.6	41.7	41.4	0.5	101.1	92.9	233.58	0.22	48.94	0.27	234.93	47.49	0.234	36
95004	41.1	38.6	42.7	42.4	0.5	99.0	89.1	228.74	0.28	49.81	0.24	230.23	48.72	0.316	35
95008	41.0	39.1	42.7	42.4	0.5	103.0	94.4	229.69	0.34	50.58	0.21	231.23	49.64	0.364	32
95009	39.2	37.4	40.9	40.6	1.8	98.8	93.7	230.78	0.43	48.98	0.37	232.41	47.89	0.343	33
95012	41.7	38.7	43.3	43.0	0.5	104.7	94.4	226.61	0.36	49.91	0.19	228.08	49.20	0.430	30
95014	42.0	40.0	43.6	43.4	1.3	106.3	101.7	232.74	1.30	49.09	0.58	234.20	48.29	0.390	29
95015	41.5	39.2	43.1	42.8	0.7	103.1	95.7	228.12	0.55	50.85	0.23	229.62	50.15	0.441	30
95016	40.7	38.4	42.4	42.1	0.5	101.3	89.6	228.68	0.37	49.64	0.18	230.20	48.91	0.435	32
95017	42.0	39.2	43.7	43.4	0.5	103.7	88.7	225.72	0.39	50.85	0.18	227.16	50.25	0.469	31
95018	41.7	39.5	43.4	43.1	1.3	103.1	97.1	228.49	0.91	50.86	0.34	229.96	50.22	0.456	29
95019	40.4	37.9	42.1	41.8	0.5	96.3	90.7	228.30	0.40	49.25	0.23	229.81	48.54	0.451	33
95023	40.5	38.4	42.2	41.9	0.5	100.5	86.6	229.11	0.39	49.62	0.17	230.56	49.06	0.504	32
95026	41.2	39.0	42.9	42.6	1.1	100.5	89.9	230.08	0.44	49.56	0.14	231.44	49.07	0.526	32
95027	39.9	38.7	41.6	41.3	0.5	102.0	87.4	231.79	0.41	49.96	0.15	233.26	49.42	0.520	31
95033	39.7	38.3	41.5	41.2	0.5	101.7	90.6	231.59	0.42	49.41	0.12	232.98	48.96	0.562	30
95037	40.1	39.1	41.8	41.5	1.6	102.3	91.2	235.78	0.49	48.01	0.16	237.02	47.62	0.591	28
95041	42.2	39.4	43.9	43.6	0.5	105.9	80.8	228.43	0.45	49.35	0.08	229.37	49.18	0.688	31
95043	40.1	38.3	41.8	41.5	0.5	103.0	85.8	229.98	0.44	49.55	0.10	230.99	49.37	0.699	32
95045	41.9	39.0	43.5	43.2	1.6	102.8	92.5	228.83	0.81	48.75	0.12	229.66	48.62	0.721	29
95047	40.6	38.5	42.3	42.0	0.5	101.8	86.3	229.29	0.44	49.52	0.10	230.13	49.41	0.746	34
95051	39.0	37.9	40.7	40.4	0.7	99.9	84.2	231.18	0.41	49.99	0.14	231.90	49.95	0.803	44
95052	42.6	39.3	44.2	43.9	0.6	106.1	95.8	228.36	0.99	48.74	0.14	228.86	48.72	0.816	29
95053	41.1	38.7	42.8	42.5	0.5	103.2	89.5	230.93	0.41	48.21	0.12	231.50	48.16	0.807	40
95056	42.6	39.5	44.2	44.0	0.5	103.3	84.7	229.17	0.39	48.56	0.16	229.63	48.55	0.828	39
95058	42.5	39.9	44.1	43.8	0.9	105.0	91.0	230.04	0.52	49.46	0.11	230.50	49.46	0.833	33
95061	39.9	38.1	41.6	41.3	0.8	100.7	85.3	230.26	0.41	49.40	0.14	230.71	49.41	0.857	39
95065	38.1	37.0	39.8	39.5	0.5	94.1	84.6	230.52	0.37	49.73	0.18	230.96	49.75	0.872	52
95067	39.9	39.2	41.6	41.3	0.7	102.5	87.9	233.01	0.49	50.69	0.17	233.41	50.74	0.874	43
average	40.9	38.8	42.5	42.2		102.2	90.4	229.96		49.58		231.03	49.09		
st. dev	1.2	0.7	1.1	1.1		2.9	5.0	2.10		0.77		2.11	0.79		
st. error	0.2	0.1	0.2	0.2		0.5	0.9	0.39		0.14		0.39	0.15		

code	VG	VH	VINF	<V>	tol	HB	HE	RA	tol	DE	tol	RAG	DEG	cos Z	Qmax
95006	25.8	38.7	28.2	27.8	1.4	99.0	93.0	122.22	0.56	64.89	0.52	122.22	65.60	0.953	64
95010	40.6	38.5	42.2	42.0	0.5	96.2	90.4	128.02	0.13	-8.81	0.27	127.89	-10.05	0.470	47
95020	20.2	37.9	23.0	22.6	0.5	95.8	83.2	102.51	0.33	52.55	0.22	100.13	52.37	0.984	79
95021	10.9	38.2	15.4	15.0	0.5	86.0	74.7	65.16	1.00	38.91	0.09	56.86	33.25	0.748	25
95030	28.7	40.5	30.9	30.6	3.8	96.1	89.9	255.73	0.58	68.47	0.22	260.01	67.39	0.609	43
95031	47.2	40.6	48.7	48.4	0.7	105.0	97.3	223.94	0.67	45.71	0.15	224.79	45.44	0.583	29
95032	44.2	40.6	45.8	45.5	1.0	103.1	92.9	222.66	0.81	51.71	0.16	223.71	51.51	0.640	28
95035	66.9	38.6	68.1	67.9	2.8	108.7	98.6	189.29	0.34	10.17	0.49	189.34	9.85	0.570	22
95038	59.1	41.5	60.4	60.2	0.8	109.4	99.6	217.39	0.81	28.26	0.33	217.69	28.02	0.579	11
95039	53.4	35.0	54.7	54.5	0.9	104.7	93.4	200.39	1.36	32.35	0.52	200.55	32.17	0.756	8
95040	49.9	40.4	51.3	51.1	1.4	96.0	86.8	222.45	0.43	41.13	0.10	222.98	40.95	0.662	28
95044	45.3	40.9	46.5	46.3	0.7	97.1	95.3	133.97	0.17	-32.79	0.27	133.11	-34.26	0.061	39
95049	57.1	40.7	58.1	57.9	0.6	110.8	101.6	149.31	0.15	-9.29	0.26	148.89	-9.92	0.465	44
95054	61.4	39.3	62.3	62.1	0.6	109.9	103.6	160.91	0.14	0.96	0.28	160.56	0.51	0.619	50
95059	71.2	41.7	72.1	72.0	2.8	114.8	105.2	188.93	0.16	4.89	0.26	188.74	4.59	0.681	62
95060	56.1	41.0	57.1	56.9	4.7	99.1	88.2	155.17	0.17	21.68	0.26	154.71	21.32	0.817	53
95063	27.0	40.5	29.4	29.1	0.4	100.4	91.9	270.41	0.80	57.53	0.13	273.48	56.93	0.671	34
95064	60.0	34.7	61.1	60.9	1.5	109.6	101.3	193.42	0.19	19.37	0.24	193.20	19.11	0.838	76
95068	64.9	41.9	65.8	65.6	0.7	111.7	98.9	174.23	0.26	20.06	0.18	173.90	19.80	0.843	75
95069	64.4	35.9	65.4	65.2	4.6	117.4	107.1	193.82	0.18	9.68	0.24	193.60	9.37	0.743	72

The brightness of a meteor was estimated by comparing the meteor with the surrounding reference stars as it moves across the screen. This procedure may somewhat underestimate the brightness of the meteor compared to its true photometric magnitude [7]. Since the video cameras were pointed at high elevations and the meteors appeared near the 100 km height level, no distance corrections were required to obtain absolute magnitudes. The specified beginning (HB) and end heights (HE) are true heights, i.e., each meteor trail was recorded entirely by at least one of the cameras.

4. Discussion

A first inspection of Tables 1 and 2 learns that almost one out of every two meteors is sporadic, even though the observations were made during the Quadrantid maximum. This has to do with the detection limit of video double-station events, which is about one magnitude higher than the visual detection limit, and the smaller population index of shower meteors compared to sporadic meteors. In addition, the same field of view applies to both Quadrantid and sporadic meteors, while for visual observers the effective field of view increases with an increasing brightness of meteors. These two effects lower the shower-to-sporadic ratio from about 5 for visual observers to hardly more than 1 for these video observations.

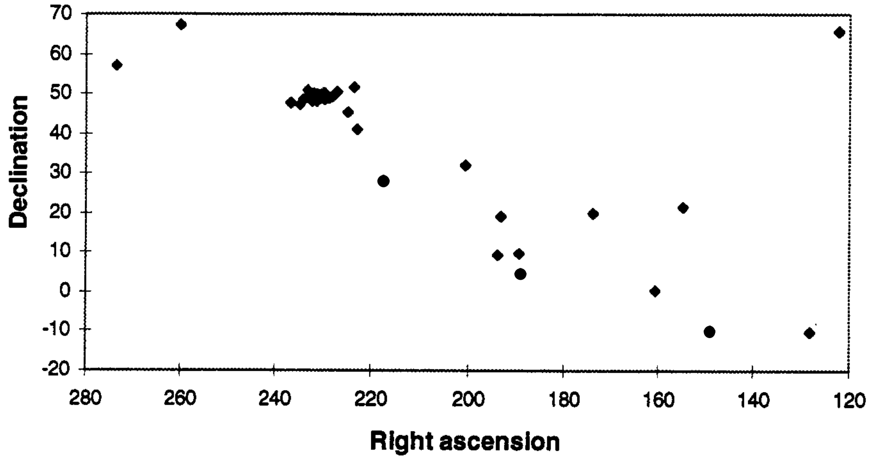

Figure 1 – Geocentric radiants (2000.0) of most of the observed meteors.

Figure 1 displays most of the radiant points obtained during the night of January 3-4, 1995. This figure clearly shows the advantage of double-station over single-station observations: now at least some information is gained from the sporadic background. Note that the selectivity of the observations even increases when also the precisely measured velocity is taken into account. As soon as we have a clustering of 4 or 5 radiant points for which the corresponding velocities are similar, this is likely to be a minor stream. Of course, this requires more observations than shown in Figure 1.

Apart from the strongly concentrated Quadrantid radiant, there is little order in the distribution of radiants. The meteor with a radiant at $\alpha = 193°$ and $\delta = 19°$ (no. 95064) seems to belong to the Coma Berenicid stream; however, its velocity is too low, resulting in a quite different orbit than the average orbit of the Coma Berenicids. The meteors 95035 and 95069 have quite similar characteristics, but for these meteors a known stream does not exist. The δ-Cancrid stream, reported during video observations in [8], is absent from this sample.

The radiants of the Quadrantid meteors are drawn in greater detail in Figure 2. This figure also contains the radiant points of the *IAU* database of precision photographic orbits [9]. One can see that the radiant area has a dense, almost circular core. However, the "outliers" have a preference for the southwest and northeast parts of the radiant area. The data from the present sample and from the *IAU* database agree very well. Apart from the position of the radiant, this also holds for the velocities. Within the standard errors in the averages indicated in Tables 1 and 2, there is no significant difference between the two samples. On the one hand, this is stimulating when considering the reliability of double-station video observations. On the other hand, this is disappointing, because mass separation effects have been reported for the Quadrantid stream [3]. With a difference of 4.5 magnitudes in brightness between the photographic and the video sample, it would have been nice to see some mass-dependent effects in the orbits, such as for the Geminid stream [10].

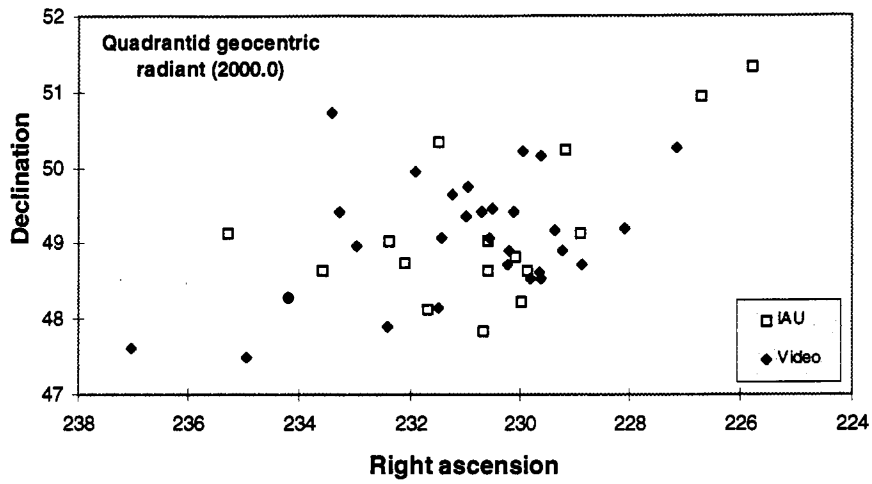

Figure 2 – Geocentric radiants (2000.0) of the observed Quadrantid meteors. Quadrantids from the *IAU* database [9] are also indicated.

5. Conclusions

With our present tools and procedures for the reduction of double-station video observations, we are able to obtain significant numbers of meteor orbits on a routine basis. With the use of high quality image intensifiers and an accurate frame grabber, the uncertainty in our positional measurements is only 45″. As a result, reasonably accurate meteor orbits can be produced.

This article shows that, in a single night of observing, several tens of orbits can be obtained. In this case, the sample contained 29 orbits of the Quadrantid stream. It was shown that the average of the Quadrantid orbit from our video observations agrees very well with the average orbit as known from photographic observations. This suggests that any mass separation effects in the Quadrantid stream are not visible in other orbital elements than the ascending node.

Acknowledgments

Jaap van 't Leven did a perfect job in operating the video camera in Bosschenhoofd and inspecting the video tapes for meteor occurrences. Hans Betlem kindly provided some essential input for the orbital calculations.

We gratefully acknowledge the use of computer source code provided by Dr. Z. Ceplecha of the Ondřejov Observatory, Czech Republic.

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Ongoing Meteor Work

Photographic Analysis of the 1992 Quadrantids

Josep M. Trigo

This paper analyzes the photographs taken by members of *SOMYCE* during January 3–4, 1992, from several sites in the València, Granada and Barcelona provinces. During this night, two meteor showers were detectable: Quadrantids and Coma Berenicids. In total, the inspection of the negatives revealed over 80 meteors, more than 50 of which are Quadrantids. The obtained astrometric positions of each meteor were analyzed using the software RADIANT, version 1.4, developed by Rainer Arlt. The obtained radiant position suggests that the investigated meteoroids were not perturbed by Jupiter recently.

1. Introduction: previous analyses

The Quadrantids' evolution has revealed many surprises in recent years. Possibly the most notable of them was the discovery of a difference in the radiant position of $-3°$ in right ascension, yielding differences of $4°$ to $5°$ in the argument of perihelion [1]. The most probable cause is the Jovian impulse effect in the Quadrantids' 1987 meteoroids that encountered Jupiter within 0.2 AU in August 1984.

During 1992, the *SOMYCE* members prepared a photographic and visual campaign. The main aims were as follows:

- Determining the radiant position and diameter, and verifying if the cloud of perturbed meteoroids encountered the Earth in 1992.
- Investigating the existence of multiple radiants during the few hours around peak activity and estimating the radiant size changes through the maximum.
- Checking for evidence of active radiants during this night.

2. Data and methodology

All analyzed meteors appeared during the period 1^h–6^h UT of January 4, 1992. This corresponds to solar longitudes $\lambda_{\odot} = 283\overset{\circ}{.}023$–$283\overset{\circ}{.}235$ (2000.0). The following observers participated in the photographic program:

L. Bellot, C. Estevez, M. Marín, A. Román, S. Torrell, and J. Trigo.

In order to obtain a large number of meteor photographs, it is necessary to locate the camera's field center at the point of maximum meteor probability of appearance from a given radiant. The method is described in [2,3]. We chose the following rules:

- the distance of the camera field in azimuth from the shower radiant to capture most meteors is $40°$–$50°$;
- the elevation of the camera fields were variable during the period depending on radiant elevation; and
- the camera was directed with the long side of the negative parallel to the horizon.

Our photographic work needs a high-quality emulsion with high sensitivity, even at the cost of image quality. Therefore we used TMAX P3200 developed to ISO 1600/33°.

3. Radiant analysis

The Cartesian coordinates of the beginning and end points of each photographed meteor were measured in the *Brno Gnomonic Star Atlas 2000.0* and converted to equatorial positions using standard astrometric conversions of this atlas. The typical measuring error converted to angular distance was negligible compared with typical plotting errors. In several photographs, the problem was the unknown time of the meteor's appearance which introduced an additional error. Consequently, the size of the radiant generated by the software is larger than the real radiant size.

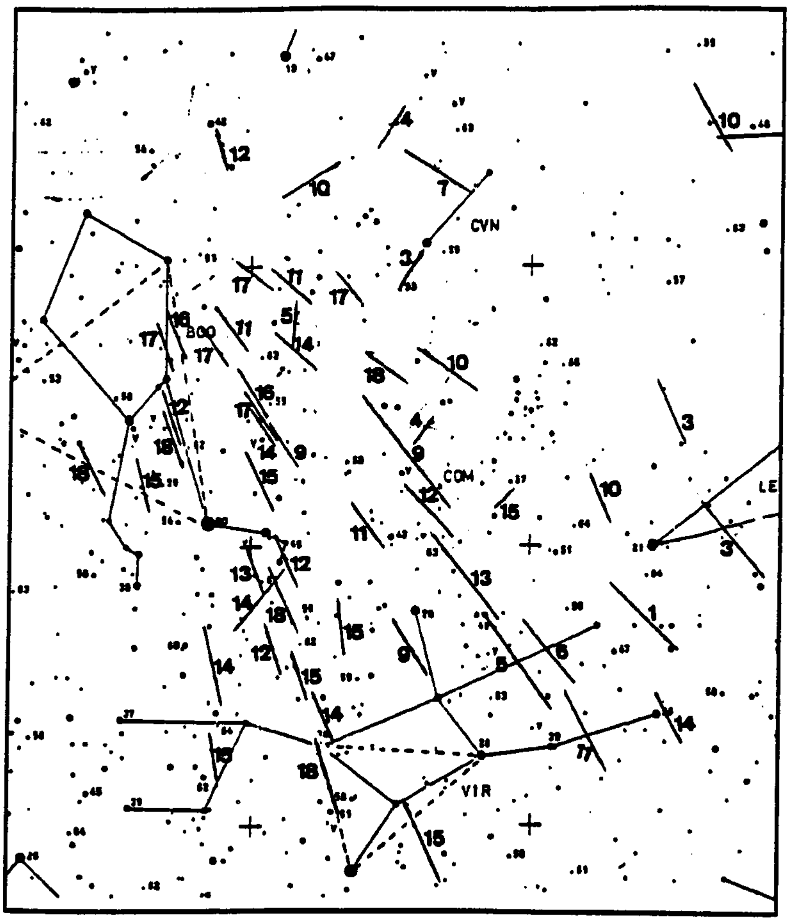

Figure 1 – Large part of the meteors photographed by the author with a standard f = 24 mm lens in Aras de Alpuente (València) during 4 hours on January 4, 1992. The number of each meteor indicates the negative number of the film.

To analyze the radiant from equatorial coordinates of the meteor trails, we used the RADIANT 1.4 software [4]. This program offers three methods to determine radiant positions. We chose the intersection method because no rotating shutters have been used and therefore no angular velocity is measured. In the intersection method, every meteor trail is checked for intersection with each other meteor resulting in $n(n-1)/2$ intersections, with n the total number of plotted meteors. The results are shown in Figure 2.

4. Quadrantid results

The analysis using the intersection method shows an apparent radiant position at $\alpha = 229° \pm 1°$ and $\delta = +49° \pm 1°$. To estimate the radiant diameter, the region with major density of intersections was considered. This leads to a radiant diameter of about 4°. As a consequence of the particular meteor distribution in the sky, the radiant appears somewhat elongated.

5. Other radiants

During the Quadrantid analysis, the RADIANT program showed two more photographic radiants, the most defined one in the Coma Berenices region, and the other one (very diffuse) in Crater. The first radiant mentioned is that of the Coma Berenicids. Approximately 10 meteors radiate from this radiant, and the expected and observed apparent radiant positions differ not more than two degrees in declination: the expected radiant is at $\alpha = 189°$ and $\delta = +29°$, and the determined radiant is at $\alpha = 189°$ and $\delta \doteq +31°$. The second radiant is determined from four meteors and gives the apparent position $\alpha = 164°$ and $\delta = -5°$.

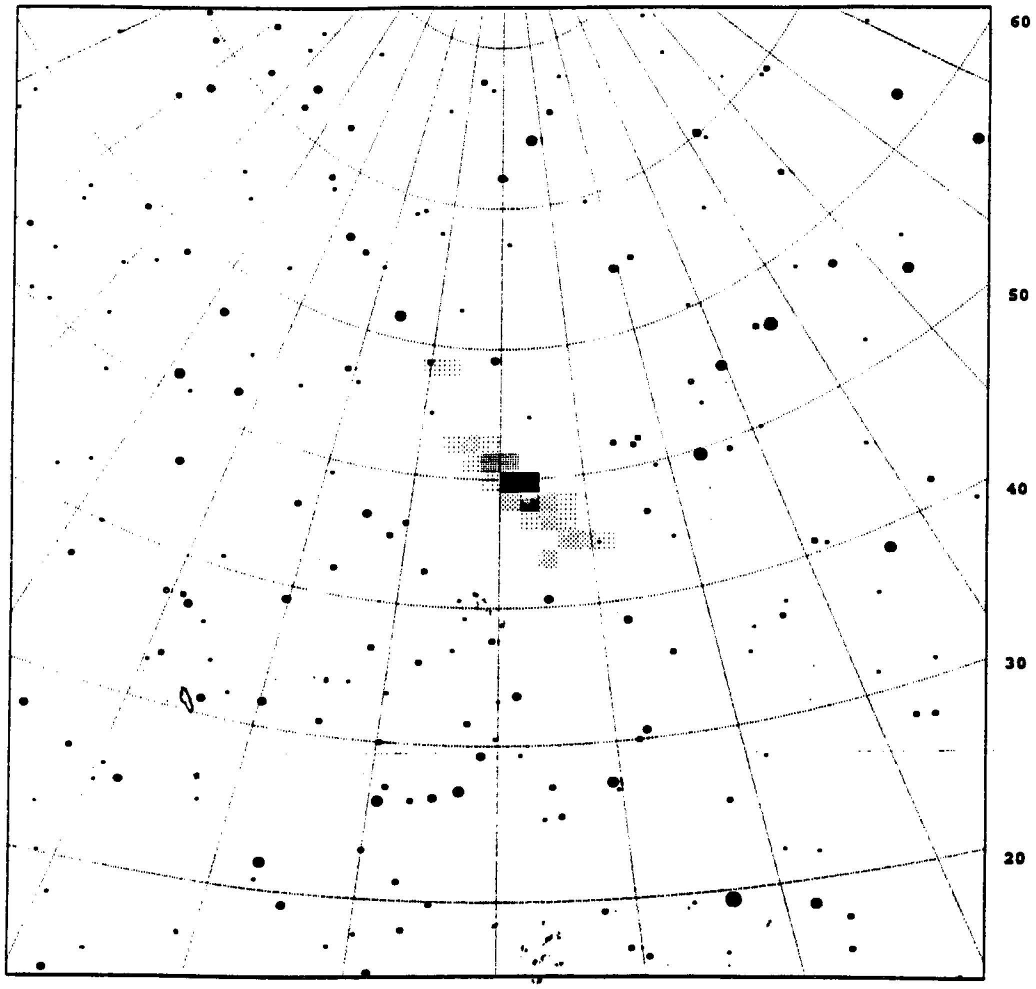

Figure 2 – Radiant position obtained from the described observations.

6. Conclusions

The analysis of photographic Quadrantid meteors applying the intersection method of the RADIANT 1.4 software showed a well-defined and undisturbed radiant of the 1992 Quadrantids very close to the expected position. Apparently, there were no perturbed Quadrantids in our sample. A possible explanation is that the meteoroids appearing in the 1992 Quadrantid shower have not been perturbed by Jupiter because of the relatively large distance to this planet during the 1984 stream-planet encounter.

7. Acknowledgments

The author wishes to thank Luis Bellot for his invaluable ideas and for the analysis of eight accurate meteor positions. He also wishes to thank Sebastià Torrell, who prepared the photographic prints of the Barcelona group.

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An α-Capricornid Meteor Spectrum

Jiří Borovička, Ondřejov Observatory, and Miloš Weber

A spectrum of a meteor which was very probably an α-Capricornid was photographed using an objective prism camera. The identification of spectral lines is given and the temperature of 3600 K is derived for the radiating gas. No anomaly in chemical composition was detected.

A meteor spectrum was photographed at the private observing site Chouzavá, Czech Republic ($\lambda = 14°13'$ E, $\varphi = 49°50'$ N) on August 2, 1995, $21^{h}48^{m}01^{s}$ UT. This is the second spectrum obtained within the observing program started by one of us (M.W.) in 1994. An $f/3.5$, $f =$ 150 mm lens and 30° objective prism are used together with a 9×12 cm, 100 ASA flat film. The first recorded spectrum was of the bright fireball "Kouřim." On average, 61 hours of exposure time were needed to obtain one meteor spectrum.

An enlargement of the spectrum reported here is presented in Figure 1. The brightest part of the meteor, with two flares toward the end of the trajectory, is shown. Unfortunately, the meteor was to faint to be recorded by the cameras of the European Fireball Network and precise data on meteor trajectory are therefore unavailable. However, the meteor was seen and plotted by five visual observers at a remote station (Skalky) and an approximate trajectory could be computed using the plots and the spectral photograph. This computation resulted in the radiant position of $\alpha = 307° \pm 2°$ and $\delta = -10° \pm 4°$, which is fully consistent with the radiant of the α-Capricornid meteor shower. The meteor was therefore very probably a member of this shower. The brightest flare occurred at a height of about 84 km above the surface. The visual observers gave the meteor a magnitude of about -2. However, the spectral photograph shows that a *visual* magnitude of about -5 was reached for a very short time interval (0.02 s) in the flare.

The spectrum was measured with a microdensitometer and calibrated roughly using the spectrum of α Lyr recorded in the same frame. The spectrum of the meteor flare is plotted in Figure 2, where the prominent emission lines are also identified. The brightest lines are the iron lines in the violet region (hardly visible by the human eye) which is not unusual for meteors of similar brightness [1]. Sodium, magnesium, and calcium (both neutral and ionized) are also detected. Chromium and manganese lines are blended with iron.

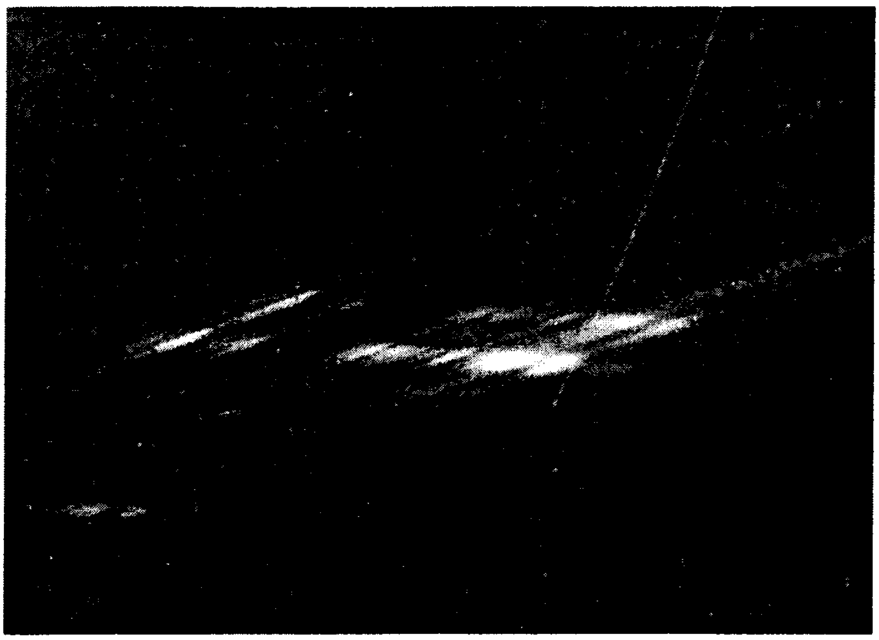

Figure 1 – The spectrum of the brightest part of the meteor of August 2, 1995. The meteor moved from top left to bottom right. The wavelengths in the spectrum increase from top to bottom.

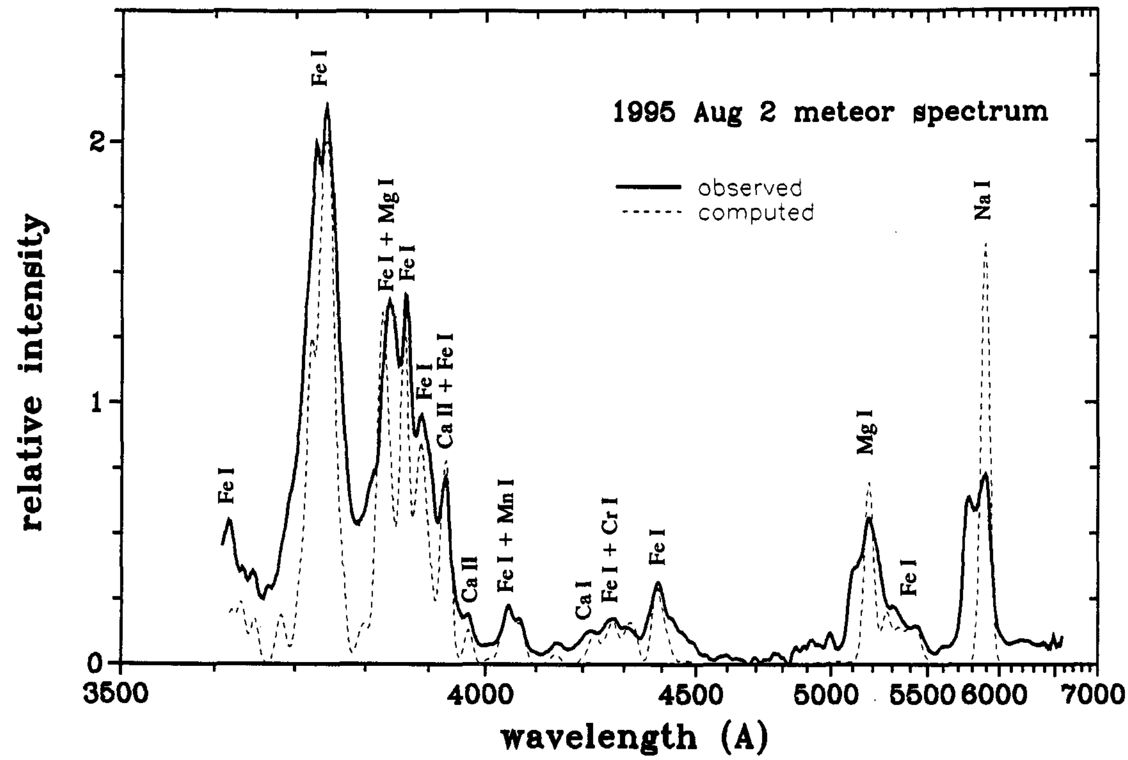

Figure 2 – The tracing of the spectrum at the brightest flare. Important emissions are identified by the atom/ion designation. A synthetic spectrum computed with the parameters given in the text is also shown. Note that the observed spectrum is out of focus above 5000 Å. The wavelength scale is nonlinear due to the dispersion of prism.

The physical parameters of the radiating gas corresponding to the observed spectrum were computed using the method described in [2]. The best estimate of temperature is 3600 K, and the column density of Fe I atoms was about 6×10^{13} cm^{-2}. Taking this number as Fe I = 1, the following relative abundances of other atoms were found: Na I = 8×10^{-4}, Mg I = 3, Ca I = 2×10^{-4}, Ca II = 10^{-3}, Cr I = 10^{-3}, and Mn I = 3×10^{-3}. The theoretical synthetic spectrum computed using these values is shown also in Figure 2 for comparison. It can be seen that all main features of the observed spectrum are explained.

Using the Ca II/Ca I ratio and the Saha equation, a free electron density of 6×10^{11} cm^{-3} was obtained. With this value, the ionization degrees of other elements were computed resulting in the following relative abundances (by number) of chemical elements in the radiating gas: Fe = 1, Na = 0.04, Mg = 3, Ca = 10^{-3}, Cr = 10^{-3}, and Mn = 3×10^{-3}. Although these values must rather be taken as order of magnitude estimates owing to the quality of the spectrum, they are in accordance with the results for other meteors [2]. The abundances of some elements (especially Ca) are lower than in meteorites (chondrites), but this is due to the incomplete evaporation of the meteoric material [3]. The spectrum is fully consistent with the meteoroid having normal chemical composition, i.e., the composition of both chondrites and cometary material.

Also the temperature of 3600 K is quite typical for meteors. It is worth noting that there is no trace of the high temperature component of $\approx$ 10 000 K observed in fast fireballs [3]. All lines including Ca II are explained by the 3600 K. This is consistent with a relatively slow (23 km/s for α-Capricornids) and not very bright meteor. We therefore conclude that the present spectrum does not show any peculiarities.

Acknowledgments

We thank V. Znojil for his careful search in the database of visual observations which enabled the trajectory of the meteor to be determined.

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Orbital Elements of Three Photographic 1991 Perseids

Josep M. Trigo and Jordi Artés

This paper shows results obtained for three photographic Perseids captured from three stations by *SOMYCE* members during the 1991 Perseids Campaign in the province of Teruel (Spain). The ORBIMET software allowed to obtain the apparent and corrected radiants and the geocentric velocity of each meteor. Knowing the orbital energy of each particle, we determined the orbital elements of the three meteoroids, which according to their values of the *D*-criteria (Southworth and Hawkins) are very similar to those of 109P/Swift-Tuttle.

1. Introduction: Perseid meteor campaign in Spain

On August 12, 1991 a strong Perseid shower observed from Japan indicated the vicinity of the parent comet 109P/Swift-Tuttle [1]. Analyses of observations made by members of the *IMO* during 1988 and 1989 gave hints on an activity maximum before the regular time of maximum [2,3] near the position of the descending node of the comet's orbit. In this context, the Valencia and Barcelona meteor research groups of *SOMYCE* (Spanish Meteor and Cometary Society) prepared a photographic Perseid program aiming at the determination of orbital elements of particles of the "new maximum."

Comet 109P/Swift-Tuttle was re-discovered on September 26, 1992, and underlined that "fresh" meteoroids formed the "new peak" of the Perseids. In the light of this discovery, the interest of our photographic work is obvious: to contribute to the analysis of possible differences between the orbital elements of "new" and "old" particles. At this moment, we have analyzed two double-station Perseids and one photographed from three stations. Some more meteor data are in the phase of analysis, including one more Perseid.

2. Data and results

During August 11-12, 1991, between solar longitudes $\lambda_\odot = 139\overset{\circ}{.}7$ and $\lambda_\odot = 140\overset{\circ}{.}1$ (2000.0), three stations participated in the photographic program. The cameras have been operated by the following observers:

> Xavier Bayona, Miguel Camarasa, Francesc Campos, Vicenç Castellote, Manel Marin, Sebastià Torrell, and Josep Trigo.

Two other stations of this campaign were established in the Valencia province by Oscar Cervera, Raúl Fernández and José Ponce. The locations are listed in Table 1. Several cameras with lenses of $f = 24-50$ mm were used. In total, about hundred meteors have been recorded. Four double- or triple-station Perseids have been identified. The sites of the photographic three-station Perseid program are as follows:

Prox. of Peñarroya Peak (Teruel)	0°38′02″ W	40°23′37″ N	1940 m
Prox. of Cedrillas (Teruel)	0°54′45″ W	40°27′11″ N	1620 m
La Muela de Jorcas (Teruel)	0°45′08″ W	40°32′31″ N	1335 m

The astrometric measurements are based on the use of a microscope and a vernier scale. Measuring the Cartesian coordinates of the begin and end points of the stars and meteors and conversion to equatorial coordinates using the astrometric method of the ASTFMX software and DBASE 3 applications. This program developed by Christian Steyaert in 1990 is based on the dependencies method [4] to determinate the exact meteor position. It also uses an iterative method to estimate the center of the plate.

The standard deviation obtained with the described measurement scheme from our photographic positions vary between 10′ and 1′. Generally, the data of the trajectory including the longitude and latitude determination of beginning and terminal points of each meteor deviates by no more than one to three hundred meters from the real position.

Meteors were photographed using a rotating shutter (31.75 breaks per second). This frequency was controlled by a stroboscopic method using a red LED. The orbital elements are calculated using the ORBIMET program developed by Jordi Artés especially for this work. This program determines the following data from photographic meteors: apparent radiant and radiant corrected for zenital attraction and diurnal aberration, beginning and end points projected onto the Earth's surface, length of the trajectory, geocentric velocity, and the orbital elements.

Another related problem arose from analyzing the geocentric velocity from the meteor path. The position of the beginning and end points is not very accurate because the relative proximity of the stations. To solve this problem we used the following formula [5]:

$$\omega = \frac{L}{\sin L} \times \frac{V_\infty \sin D_e \sin h_b}{H_b},$$

where ω is the angular velocity L its angular length, V_∞ its geocentric velocity, D_e the distance between the radiant and the meteor end, h_b the angular height of the meteor beginning, and H_b the linear height of the meteor above the Earth's surface. The formula relates the geocentric velocity V_∞ obtained from the meteor's distance to the radiant D_e and its angular velocity ω. The geocentric velocity values are found from this formula.

Tables 1–3 list the results obtained for three photographed Perseids, and Figure 1 shows a photograph of SOMYCE91-01.

Table 1 – Trajectory data of the three photographed Perseid meteors. SOMYCE91-01 was a spectacular -6^m fireball recorded at 2^h27^m from the stations at Cedrillas and Peñarroya. SOMYCE91-02 was photographed at 2^h58^m from the Cedrillas and Peñarroya stations, while SOMYCE91-04 at 3^h25^m has been found on images taken from the stations Cedrillas, Jorcas, and Peñarroya.

Trajectory	SOMYCE91-01		SOMYCE91-02		SOMYCE91-04	
	Begin	End (cut)	Begin	End	Begin	End
V_∞ (km/s)	59.9 ± 0.1		59.9		60	
h (km)	111.3 ± 0.1	98.6 ± 0.1	100.1 ± 0.1	92.3 ± 0.1	111.0 ± 0.1	93.0 ± 0.1
λ (° W)	0.267 ± 0.001	0.128 ± 0.001	0.127 ± 0.001	0.143 ± 0.001	0.300 ± 0.001	0.266 ± 0.001
φ (° N)	40.303 ± 0.001	40.242 ± 0.001	41.107 ± 0.001	41.102 ± 0.001	40.556 ± 0.001	40.502 ± 0.001
Abs. m.	0 ± 1	−7 ± 1	−3 ± 1	−5 ± 1	−2 ± 1	−5 ± 1

Table 2 – Radiant positions (2000.0) for the meteors in Table 1.

Radiant	SOMYCE91-01		SOMYCE91-02		SOMYCE91-04	
	Observed	Corrected	Observed	Corrected	Observed	Corrected
α	50°.8 ± 0°.5	51°.8 ± 0°.5	52°.5 ± 0°.5	54°.7 ± 0°.5	49°.8 ± 0°.5	50°.8 ± 0°.5
δ	+58°.7 ± 0°.5	+59°.3 ± 0°.5	+56°.1 ± 0°.5	+56°.3 ± 0°.5	+56°.0 ± 0°.5	+56°.1 ± 0°.5

Figure 1 – Meteor SOMYCE91-01.

Table 3 – Orbital elements (2000.0) for the meteors in Table 1.

Orbit	SOMYCE91-01	SOMYCE91-02	SOMYCE91-04
a (AU)	54.06 ± 0.02	7.07 ± 0.02	6.60 ± 0.02
e	0.983 ± 0.005	0.874 ± 0.005	0.860 ± 0.005
q (AU)	0.923 ± 0.001	0.892 ± 0.001	0.927 ± 0.001
i	111°5 ± 0°1	115°6 ± 0°1	115°8 ± 0°1
Ω	139°9475 ± 0°0001	140°008 ± 0°001	140°0262 ± 0°0006
ω	145°1 ± 0°5	137°97 ± 0°5	144°7 ± 0°5
T	1991-07-20.2946	1991-07-15.4955	1991-07-19.2151

The values obtained for the D-criterion of Southworth and Hawkins to compare the orbits of the meteoroids with that of 109P/Swift-Tuttle are 1, 0.8, and 1, respectively, for the three meteors. This indicates their certain association with the comet's orbit.

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Characteristics of the New Perseid Peak

Andrey Grishchenyuk

The composite structure of the Perseids is discussed. It is argued that the "new" peak of the shower at solar longitude $\lambda_\odot = 139\overset{\circ}{.}5$ is caused by meteoroids recently ejected from Comet 109P/Swift-Tuttle, most probably during the previous return of the comet. It is possible that the new peak is going to disappear soon, especially if the ejection of matter from the comet was isotropic.

The Perseids continue to attract the attention of meteor workers. It is interesting to look at past attempts to model this shower [1–3]. First, though, we consider the observations.

Comet 109P/Swift-Tuttle was observed in 1862, and a period of about 119 years was derived from the observations. Therefore, the comet was expected to return to perihelion in 1981–1982. Of course, increased Perseid activity was anticipated. For a while, it seemed as if these expectations were founded. The hourly rates of Perseids during 1974–1978 were quite low [4], but in 1979–1981 the activity of the shower jumped upward by about an order of magnitude, and we became witnesses of meteor "rains" that lasted a whole night. In 1982, the activity decreased again to the "normal" level, and there was a general impression that nothing interesting would occur anymore. However, the comet was not discovered during that period. Then, in 1985, the shower presented a new surprise to us: the activity profile revealed a bi-modal structure. In 1988, this characteristic was confirmed, and, in 1989, the "new" peak (we will refer to it as "first" peak, because it is observed before the "normal" peak) had already the same strength as the regular maximum. During 1991–1994, the first peak was observed as a short-lived meteor outburst with a ZHR about 300 at solar longitude $\lambda_\odot = 139\overset{\circ}{.}5$ (eq. 2000.0) [5]. During these years, the second, regular, maximum was observed at solar longitude $\lambda_\odot = 140\overset{\circ}{.}05 \pm 0\overset{\circ}{.}10$ with a ZHR around 110. The value of the population index r shows that at the time of new maximum mainly large particles were observed [5]. The unexpected discovery of Comet 109P/Swift-Tuttle in 1992 is important, particularly for the future modeling of orbits.

Obviously, the Perseids clearly exhibited a composite structure since 1988. Observations show that the "new" stream could not be detected before 1985. Thus the "new" stream must be very young: according to Plavec [6], a stream with a major axis around 20 AU needs 6 to 8 revolutions to be closed. The comet passed perihelion in December 1992, and the meteor shower connected with the "new" stream was first observed in 1985, seven years earlier. Assuming that the ejection process which produced the "new" stream was isotropic, and that the distribution of the meteoroids is therefore symmetrical relative to the comet, one may conclude that the "new" stream will cease to be observable by 1999. Moreover, the last outburst may occur in 1996 or 1997. However, asymmetrical values of hourly rates relative to the comet are observed. ZHRs over 250 were observed only one year before the comet's perihelion passage, but already 3 years afterwards. One can interpret these findings as being caused by an anisotropic ejection process. As a result, the "new" stream might remain observable for a longer period.

Let us next consider the possible age of this condensation. We will use Plavec's formula [7]

$$\Delta M = 3 \times s \times P \times V \times C_t \times a,$$

with ΔM the difference between the anomalies of the stream and the comet; a the semi-major axis, s the number of revolution; P the period, V the velocity on the orbit; and C_t the tangential component of the velocity of ejection, all expressed in AU and years. We can take $\Delta M = 4.3$ years (1992–1988), $a = 20$ AU [8], $V = 40$ km/s (8 AU/year), and $C_t = 1$ m/s (0.00002 AU/year, corresponding to a velocity of ejection $C = 10$–15 m/s). Then $s \times P = 430$ years or $s < 4$ revolutions. If $C_t = 8$ m/s (0.00016 AU/years, corresponding to $C = 100$ m/s [9]) then we have $s \times P = 50$ years and $s < 1$ revolution.

For comparison, let us consider the age of the condensation that was observed during 1979–1981. For 1980, $\Delta M = 12.5$ years, and $s \times P = 1250$ years, $s = 10$ revolutions ($C_t = 1$ m/s), and $s \times P = 150$ years, $s = 1$ revolution ($C_t = 8$ m/s). Thus, $C_t = 1$ m/s is more likely.

We know that the ascending node of the comet's orbit is at $\Omega = 139^\circ\!.456$, and the peak of the shower's activity must in principle be observed precisely at this solar longitude. Table 1 gives the distance between the comet and the Earth's orbit, and also the difference between the longitude of the ascending node and solar longitude at the time of maximum for the period 1991–1994, taking into account an error margin for the determination of the shower maximum.

Table 1 – Differences between the longitude of the ascending node of Comet 109P/Swift-Tuttle and the solar longitude of the Perseid shower maximum in recent years

Year	Dist. comet-Earth (months)	Difference node-maximum
1991	16	0.119–0.129
1992	4	0.00 –0.08
1993	9	0.059–0.097
1994	21	0.134–0.198

One can see from Table 1 that with increasing distance between comet and Earth the difference between nodal longitude and solar longitude at the maximum of the shower also increases, and this on both sides from the comet. This may on the one hand indicate a high velocity of ejection, but may on the other confirm anisotropy of ejection.

Some studies have been dedicated to the modeling of the Perseids. Hamid [1] has studied the conditions under which Perseid meteoroids originate and found the probable speed of ejection to be 16.5 m/s ($C_t = 1$ m/s). Later, Southworth [3] using data from Guigay [10] found that ejection could have place at a distance of 1.5 AU of the Sun, 1.3 AU north of the ecliptic, with a velocity of 2.6 km/s. Katasyov and Kulikova [2] showed that the stream could be formed as a result of isotropic ejection near the descending node of the comet (true anomaly about 30°), with a velocity of about 100 m/s. In this case, however, the peak of activity would last only about 6 minutes! Apart from this, the model of Katasyov-Kulikova accounts for the differences between the orbits of stream and comet, calculated by Southworth [3]. It is known that the peak of activity lasts about 40 to 60 minutes.

Unfortunately, we do not have photographically determined orbits for Perseids belonging to the "new" peak. Therefore, obtaining such data should be a major goal for the Photographic Commission of the *IMO* in 1996!

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Double-Station TV Meteor Observations

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Double-station meteor observations were carried out using TV equipment on November 18, 1995. Orbital elements of 49 meteors have been determined, and associated with 13 streams.

1. Introduction

We started double station meteor observations with image intensifier and TV equipment on December 30, 1992. On November 18, 1995, we carried out the 15th observation. The observing period was from 17^h05^m to 20^h03^m UT. Forty-nine double station meteors were observed and analyzed.

If the cross angles are large, then errors of the radiant positions are small. However, there are also a lot of short meteor trails for which the errors of the velocities determination are large.

2. Observing system

A second generation micro channel plate type image intensifier (Hamamatsu Photonics V3287P) coupled with a CCD (Hitachi Electric KPM1) and an objective lens (Nikon $f/1.2$, $f = 50$ mm) and a macro lens (Nikon $f/2.8$, $f = 55$ mm) were used. Images of meteors and stars were recorded with a video tape recorder (SONY Hi8). A PC (NEC PC-9801) with an image processing bord (I/O DATA GV-98) was used to digitalize a video image into 640×400 pixels. We list the parameters of the equipment used at the two participating stations:

- objective lens: $f/1.2$, $f = 50$ mm;
- field size: $13° \times 17°$;
- limiting stellar magnitude: 9.2;
- average of the measurement errors: $111''$;
- average of the cross angles: 42°; and
- average radiant position errors: $0\overset{\circ}{.}51$.

The observing sites are as follows:

- P1: Nosaka Chiba, Japan, $\lambda = 140°35'14\overset{''}{.}0$ E, $\varphi = 35°38'35\overset{''}{.}8$ N, h =2 m; and
- P2: Mikado Chiba, Japan, $\lambda = 140°22'18\overset{''}{.}2$ E, $\varphi = 35°16'22\overset{''}{.}5$ N, h =17 m.

The baseline was 45.5 km.

3. Association with meteor showers

We have begun to understand the distribution of orbits of the Leonids by these observations. The Leonids do not only depend on Comet 55P/Tempel-Tuttle, but also on perturbations, causing spread-out streams.

The November χ-Orionids have been observed. This stream differs from the χ-Orionids close to the ecliptic in early December. It was observed in Japan since the 1970s [1]. The orbit of this stream has a small perihelion distance and large eccentricity like the δ-Aquarids. A northern component of this stream also seems to exist.

Table 1 shows a summary of the showers considered here, as well as the averages and standard deviations of 13 showers. All radiants of our sample are also plotted in a map shown as Figure 1. Table 2 lists the orbital elements of 49 meteors.

Next, we give some details about the 13 meteoroid streams mentioned above. The numbers in the last column of Table 1 and the first column of Table 2 refer to the following summary. The identifications (abbreviated as ID) refer to the last character of the ID column of Table 2.

Table 1 – Averages and standard deviations of the streams.

Str	Date (UT) (yyyymmdd.ddd)	α (2000.0)	δ (2000.0)	SD	V_G (km/s)	a (AU)	e	q (AU)
1	19951118.760	154.°2	+21.°9	0.°4	71.0	16.6	0.941	0.985
	SD ± 0.013	0.°0	0.°5	0.°0	1.2	–	0.117	0.001
2	19951118.791	156.°6	+25.°9	0.°4	67.2	3.38	0.711	0.978
	SD ± 0.031	2.°4	1.°3	0.°1	3.7	–	0.309	0.017
3	19951118.811	150.°4	+15.°9	0.°5	67.0	2.11	0.536	0.980
	SD ± 0.002	4.°2	1.°1	0.°1	0.8	–	0.083	0.004
4	19951118.762	127.°7	+ 9.°2	0.°3	63.8	2.24	0.716	0.637
	SD ± 0.004	1.°9	2.°7	0.°2	0.7	–	0.038	0.082
5	19951118.756	116.°6	– 3.°2	0.°6	58.5	2.73	0.804	0.533
6	19951118.751	79.°5	+14.°3	0.°5	41.4	5.16	0.974	0.132
	SD ± 0.050	5.°2	1.°9	0.°1	5.5	–	0.031	0.089
7	19951118.804	92.°3	+32.°2	0.°3	32.6	0.94	0.908	0.087
8	19951118.787	140.°7	+42.°9	1.°3	58.9	1.95	0.619	0.744
9	19951118.761	128.°8	– 4.°0	0.°8	63.3	3.01	0.727	0.821
	SD ± 0.032	1.°6	3.°6	0.°2	1.1	–	0.090	0.065
10	19951118.772	133.°2	+26.°5	0.°4	60.3	1.68	0.682	0.534
	SD ± 0.047	3.°5	6.°0	0.°2	5.9	–	0.108	0.168
11	19951118.802	119.°0	+22.°4	0.°5	60.1	2.18	0.865	0.294
	SD ± 0.037	0.°8	1.°6	0.°2	1.2	–	0.024	0.028
12	19951118.779	154.°8	– 4.°4	0.°7	64.6	2.24	0.637	0.815
	SD ± 0.025	2.°6	2.°2	0.°4	3.3	–	0.172	0.077
13	19951118.787	130.°9	–21.°6	1.8	54.6	1.86	0.482	0.962
	SD ± 0.000	3.°0	0.°5	1.°6	1.3	–	0.033	0.028

(1) Leonids (ID: 4, F, P). The main component of the Leonids. Is the northern branch more active than the main stream?

(2) Northern branch of Leonids (ID: 6, T, e, h, k, o). The boundary of the main stream and this stream is not distinct. The inclination of the orbits is slightly lower than that of the main stream.

(3) Southern branch of Leonids (ID: j, l). The inclination of the orbits is slightly higher than that of the main stream.

(4) ε-Hydrids (ID: I, K, O). Possibly these meteors belong to the main stream of the ε-Hydrids.

(5) α-Monocerotids (ID: G). An activity outburst was observed from Europe on November 22, 1995.

(6) Southern November χ-Orionids (ID: 1, W). The χ-Orionids in November are different from the ecliptic stream.

(7) Northern November χ-Orionids (ID: g). This is not a branch of the November χ-Orionids.

(8) December Leo Minorids (ID: Z). The Leo Minorids of December.

(9) Provisional ζ-Monocerotids (ID: 5, N, d). The Monocerotids of October.

(10) Provisional ι-Cancrids (ID: 3, B, f, r). First detection. The orbits have a large spread.

(11) Provisional μ-Cancrids (ID: J, s, t). First detection. The orbits are concentrated and very close to the ecliptic plane.

(12) Provisional δ-Sextantids (ID: D, L, S, a, n). First detection. Several concentrations of the radiants were observed.

(13) Provisional η-Pyxids (ID: X, Y). First detection. Meteors appeared within only 23 seconds.

Table 1 – continued.

Str	Date (yyyymmdd.ddd)	ω	Ω	i	Obs Mag	H_b (km)	H_e (km)
1	19951118.760	173°4	236°0	162°1	3.8	113.9	92.7
	SD ± 0.013	1°2	0°1	0°5	2.5	12.8	–
2	19951118.791	169°3	236°0	153°2	5.6	113.0	97.4
	SD ± 0.031	10°2	0°0	2°5	1.2	3.3	4.6
3	19951118.811	178°0	236°0	173°6	6.3	113.9	98.9
	SD ± 0.002	17°6	0°0	4°3	0.7	0.8	2.1
4	19951118.762	81°4	56°0	160°6	6.8	111.4	97.5
	SD ± 0.004	10°6	0°0	3°8	0.3	6.8	7.2
5	19951118.756	91°9	56°0	126°6	5.0	114.7	101.3
6	19951118.751	140°0	56°0	26°2	5.8	102.4	92.7
	SD ± 0.050	13°7	0°1	8°7	1.4	1.1	–
7	19951118.804	336°5	236°0	23°9	1.0	101.1	78.2
8	19951118.787	249°4	236°0	128°3	4.0	111.3	98.4
9	19951118.761	53°0	56°0	138°9	6.3	112.8	100.3
	SD ± 0.032	13°4	0°0	5°1	1.0	4.6	2.9
10	19951118.772	282°1	236°0	160°5	6.1	113.2	100.2
	SD ± 0.047	34°6	0°1	12°0	1.0	3.7	3.0
11	19951118.802	301°0	236°0	175°7	6.4	103.6	93.9
	SD ± 0.037	4°6	0°1	4°0	0.4	2.7	4.4
12	19951118.779	302°8	56°0	153°5	6.3	106.8	98.8
	SD ± 0.025	17°8	0°0	5°0	0.9	5.2	4.2
13	19951118.787	21°7	56°0	110°5	6.3	110.2	89.9
	SD ± 0.000	14°1	0°0	2°0	0.4	–	–

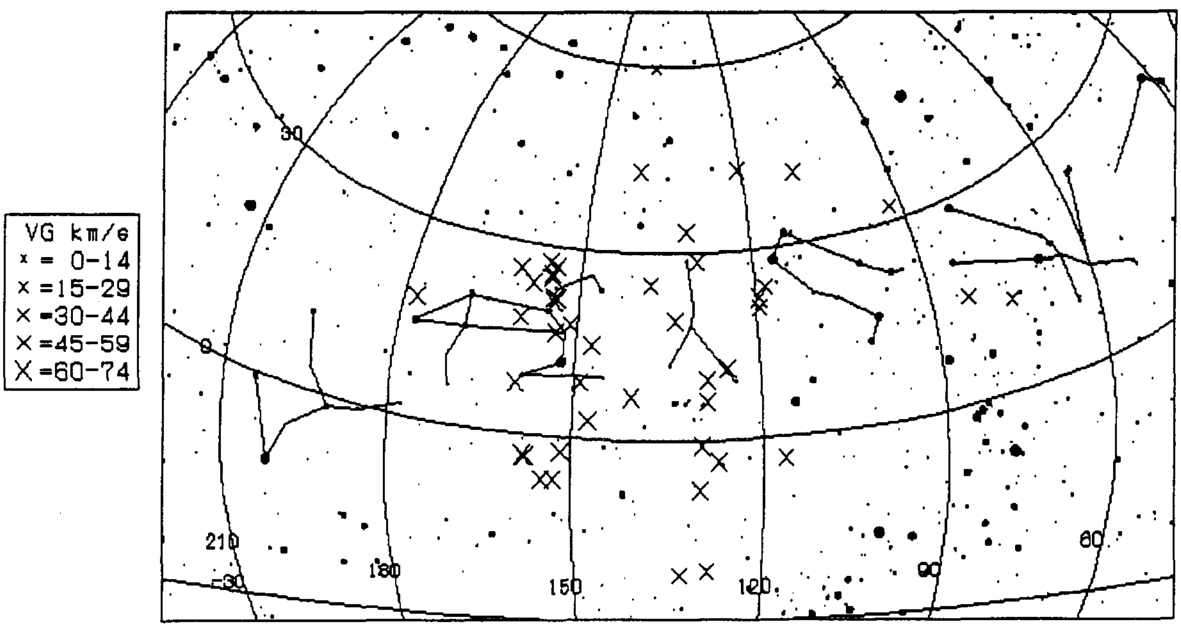

Figure 1 – Map showing the corrected radiants (2000.0) of the meteors for which the orbits are given.

Table 2 – Orbital elements (eq. 2000.0).

ID	1995 Nov 18 (UT)	α	δ	SD	V_G (km/s)	a (AU)	e	q (AU)
MSSIFx	$20^h01^m13^s$	28°.2	+62°.7	0°.4	23.2	2.98	0.738	0.782
MSSIF1	$17^h09^m43^s$	75°.8	+13°.0	0°.5	37.6	4.13	0.953	0.195
MSSIFW	$18^h52^m21^s$	83°.2	+15°.7	0°.6	45.3	17.2	0.996	0.070
MSSIFv	$19^h53^m11^s$	90°.9	+52°.1	0°.6	29.6	1.00	0.720	0.282
MSSIFg	$19^h18^m17^s$	92°.3	+32°.2	0°.3	32.6	0.940	0.908	0.087
MSSIFV	$18^h45^m11^s$	109°.0	+41°.0	0°.5	48.3	1.44	0.897	0.148
MSSIFG	$18^h09^m08^s$	116°.6	− 3°.2	0°.6	58.5	2.73	0.804	0.533
MSSIFs	$19^h40^m45^s$	118°.1	+24°.0	0°.6	59.7	2.24	0.879	0.271
MSSIFt	$19^h49^m39^s$	119°.4	+22°.4	0°.6	61.4	2.69	0.879	0.325
MSSIFJ	$18^h13^m45^s$	119°.6	+20°.8	0°.2	59.1	1.76	0.838	0.285
MSSIFc	$18^h57^m25^s$	120°.8	+42°.6	0°.6	57.3	2.96	0.866	0.398
MSSIFI	$18^h12^m10^s$	125°.4	+11°.5	0°.3	63.2	2.23	0.753	0.550
MSSIFN	$18^h21^m10^s$	127°.0	− 3°.4	0°.6	62.3	2.51	0.692	0.772
MSSIFO	$18^h23^m23^s$	128°.7	+ 9°.7	0°.2	63.6	2.00	0.677	0.647
MSSIFK	$18^h15^m20^s$	128°.8	+ 6°.3	0°.5	64.6	2.53	0.718	0.712
MSSIFX	$18^h52^m52^s$	128°.8	−21°.3	0°.7	53.7	1.74	0.458	0.942
MSSIFd	$18^h59^m08^s$	129°.6	− 0°.8	1°.0	63.3	2.35	0.661	0.797
MSSIFr	$19^h40^m08^s$	129°.7	+28°.6	0°.3	59.5	1.43	0.677	0.461
MSSIF5	$17^h28^m16^s$	129°.9	− 7°.9	0°.7	64.4	5.24	0.829	0.895
MSSIFB	$17^h52^m37^s$	131°.6	+33°.4	0°.4	61.3	1.98	0.714	0.566
MSSIFY	$18^h53^m15^s$	133°.0	−21°.9	3°.0	55.5	1.98	0.505	0.982
MSSIFf	$19^h14^m44^s$	133°.7	+19°.2	0°.3	67.5	3.71	0.797	0.751
MSSIF3	$17^h17^m41^s$	137°.9	+24°.9	0°.7	53.1	0.775	0.539	0.357
MSSIFH	$18^h10^m28^s$	138°.9	+59°.6	5°.0	22.6	0.685	0.540	0.315
MSSIF7	$17^h40^m47^s$	140°.7	+ 6°.9	0°.3	68.6	3.46	0.723	0.957
MSSIFZ	$18^h53^m43^s$	140°.7	+42°.9	1°.3	58.9	1.95	0.619	0.744
MSSIFj	$19^h26^m34^s$	147°.4	+15°.1	0°.4	66.4	1.88	0.477	0.983
MSSIFu	$19^h50^m29^s$	147°.5	+ 2°.9	0°.5	64.4	1.58	0.380	0.979
MSSIF9	$17^h47^m18^s$	148°.9	+ 9°.0	0°.2	70.7	6.24	0.842	0.986
MSSIFM	$18^h20^m56^s$	151°.1	+18°.1	0°.6	56.6	0.823	0.201	0.657
MSSIFn	$19^h34^m45^s$	151°.6	− 2°.1	0°.5	67.8	3.78	0.755	0.925
MSSIFD	$17^h58^m39^s$	152°.8	− 6°.6	1°.3	62.4	1.66	0.498	0.831
MSSIFl	$19^h30^m00^s$	153°.4	+16°.6	0°.5	67.6	2.41	0.595	0.977
MSSIF4	$17^h28^m02^s$	153°.8	+22°.0	0°.4	73.1	− 7.14	1.138	0.987
MSSIFF	$18^h00^m41^s$	154°.2	+21°.5	0°.3	70.1	6.94	0.858	0.985
MSSIFP	$18^h28^m00^s$	154°.2	+22°.2	0°.4	71.8	−42.5	1.023	0.986
MSSIFe	$19^h07^m26^s$	154°.4	+26°.9	0°.4	71.8	− 9.97	1.099	0.988
MSSIFL	$18^h20^m27^s$	154°.7	− 6°.8	0°.4	61.8	1.58	0.509	0.774
MSSIFT	$18^h43^m26^s$	155°.1	+25°.8	0°.5	66.0	2.32	0.575	0.987
MSSIFh	$19^h19^m13^s$	155°.2	+25°.3	0°.3	62.5	1.40	0.294	0.984
MSSIF6	$17^h36^m23^s$	155°.9	+27°.6	0°.6	67.5	3.76	0.738	0.987
MSSIFa	$18^h53^m59^s$	157°.2	− 3°.2	0°.5	68.5	6.96	0.881	0.827
MSSIFS	$18^h42^m05^s$	157°.6	− 3°.1	0°.7	62.4	1.56	0.539	0.718
MSSIFk	$19^h28^m57^s$	158°.2	+24°.0	0°.6	71.2	−31.9	1.031	0.973
MSSIFC	$17^h53^m24^s$	159°.2	+ 8°.2	0°.6	65.6	1.91	0.575	0.812
MSSIFR	$18^h41^m35^s$	159°.6	+18°.4	1°.1	52.5	0.724	0.459	0.391
MSSIFo	$19^h36^m50^s$	160°.8	+26°.1	0°.3	64.4	2.01	0.530	0.946
MSSIFA	$17^h47^m35^s$	177°.9	+18°.2	0°.3	66.7	−28.0	1.022	0.613
MSSIF8	$17^h43^m05^s$	254°.9	+84°.3	0°.8	30.2	2.74	0.657	0.939

Table 2 – continued.

ID	ω	Ω	i	Obs Mag	H_b (km)	H_e (km)	Str
MSSIFx	239°5	236°1	28°8	5.5	99.8	92.2	–
MSSIF1	130°2	55°9	20°1	6.8	103.2	92.7	6
MSSIFW	149°7	56°0	32°4	4.8	101.7	88–	6
MSSIFv	315°1	236°1	42°6	6.5	100.7	91.2	–
MSSIFg	336°5	236°0	23°9	1.0	101.1	78.2	7
MSSIFV	322°9	236°0	106°3	6.5	103.9	92.4	–
MSSIFG	91°9	56°0	126°6	5.0	114.7	101.3	5
MSSIFs	303°5	236°0	171°7	6.8	102.6	97.0	11
MSSIFt	295°7	236°0	175°6	6.5	106.7	95.8	11
MSSIFJ	303°9	235°8	179°7	6.0	101.6	88.8	11
MSSIFc	286°7	236°0	125°4	5.8	99.7	88.1	–
MSSIFI	91°9	56°0	163°3	7.0	111.8	98.3	4
MSSIFN	62°3	56°0	137°9	7.3	109.9	98.2	9
MSSIFO	81°7	56°0	162°1	6.8	104.4	89.9	4
MSSIFK	70°6	56°0	156°3	6.5	117.9	104.2	4
MSSIFX	31°6	56°0	109°0	6.0	101+	89.9	13
MSSIFd	59°2	56°0	144°4	6.5	110.5	102.3	9
MSSIFr	288°8	236°0	157°4	6.0	116.6	98.0	10
MSSIF5	37°7	56°0	134°3	5.3	118.1	104–	9
MSSIFB	271°5	236°0	148°0	4.8	115.7	101–	10
MSSIFY	11°7	56°0	111°9	6.5	110.2	106–	13
MSSIFf	242°6	236°0	176°7	7.0	112.1	102.3	10
MSSIF3	325°5	235°9	160°0	6.8	108.5	102–	10
MSSIFH	340°6	236°0	45°2	7.0	99.0	92.4	–
MSSIF7	22°5	56°0	165°7	4.5	114.7	101.3	–
MSSIFZ	249°4	236°0	128°3	4.0	111.3	98.4	8
MSSIFj	190°5	236°0	176°6	5.8	114.5	100.4	3
MSSIFu	344°6	56°1	162°0	6.0	112.7	101.9	–
MSSIF9	353°7	56°0	174°1	1.0	120+	94.8	–
MSSIFM	3°1	236°0	167°5	6.8	110.8	102.0	–
MSSIFn	328°3	56°0	156°8	6.8	113.3	100.8	12
MSSIFD	301°4	56°0	148°0	7.0	108.4	104.5	12
MSSIFl	165°6	236°0	170°5	6.8	113.4	97.4	3
MSSIF4	175°3	236°0	162°5	6.3	103.7	91.7	1
MSSIFF	172°6	236°0	162°4	5.5	104.9	92.7	1
MSSIFP	174°3	236°0	161°7	2.0	123.0	109–	1
MSSIFe	179°6	236°0	154°4	6.0	112.5	98.4	2
MSSIFL	290°9	56°0	148°2	7.0	101.5	93.2	12
MSSIFT	174°7	236°0	154°1	7.0	111.6	101.3	2
MSSIFh	169°1	236°0	153°7	6.3	111.7	94.5	2
MSSIF6	175°4	236°0	151°3	5.5	110.4	100.2	2
MSSIFa	310°6	56°0	158°1	5.0	112+	98.6	12
MSSIFS	282°6	56°0	156°7	6.0	103.8	96.9	12
MSSIFk	165°6	236°0	156°4	3.5	106+	89.5	2
MSSIFC	300°8	56°0	179°0	6.3	109.9	101.1	–
MSSIFR	23°1	236°0	158°6	6.8	108.9	101.3	–
MSSIFo	151°1	236°0	149°3	5.5	118.7	100.6	2
MSSIFA	104°4	236°0	147°1	2.0	116.6	100–	–
MSSIF8	209°1	236°0	49°7	6.0	100+	85.3	–

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Problems of Limiting Magnitude Determination in Meteor Observations

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The *IMO* method for determining the visual limiting magnitude is critically examined.

1. Introduction

The accurate determination of a limiting magnitude is one of the most important data at a visual meteor observation. The limiting magnitude determination that was used had been derived from a direct visual estimate according to a star map. There were chosen stars of early spectral classes with their well-specified visual magnitudes. The *IMO* recommended to experienced observers the *AAVSO* maps [1] which were, however, hard to survey for a quick orientation. This was because there was an insufficient number of comparison stars and they were sometime necessary to be found far from your field of view.

Due to this reason, a new method in the *IMO* has been introduced. This is based on counting stars in chosen areas bounded by three or four relative bright stars. The number of stars in an area can be transformed directly [2,3] into the limiting magnitude. The purpose has been to objectify and make easier the determination of limiting magnitudes.

2. Deficiencies of the IMO method

Some criticisms can be made with respect to the *IMO* method:

1. The method cannot be applied in bad observing conditions owing to the great differences between a previous and a next star's magnitude in the *IMO* tables when the limiting magnitude is less than 5.0 (Table 1).

   Solution: Estimating in two or three areas roughly at the same time [4]. The time difference between the estimations that should be done at the same time should not be more than 10 minutes [5]. The highest value is regarded as a limiting magnitude.

2. In very good observing conditions when the limiting magnitude is more than 6.5, a lot of stars can be seen, especially near the galactic equator, and some might be left out or included twice when counting. The properties of the eye causes two or more stars, whose angular separation is small, to be seen as one star, which reduces the number of observed stars in the area. However, the magnitude of the "composed" star equals the object's total brightness. Hence, brighter stars are brightened by dimmer stars and those star "pairs" whose angular distance is small and which normally are under the limit of visibility might be registered as a visible object.

Solution: When choosing the areas to determine the limiting magnitude, one should avoid the areas with high star density.

3. If the limiting magnitude is more than 6.0, the number of stars in areas near the galactic equator is high, and their counting decreases the concentration upon the meteors. The observer easily overlooks meteors while counting, which depreciates the ZHR.

   Solution: Estimating the limiting magnitude should be done during individual breaks.

4. Stars situated too close to the edges may or may not be included into the area. The question stands from what angular distance between the star and the line we can safely say whether or not the star is in the area.

   Solution: Determining the limiting magnitude by determining the least-magnitude star number (see further). The stars belonging to the area are marked on the map, allowing for $0^{\circ}\!.1$ tolerance.

5. There are variable stars in the areas which have an influence on the determination of the limiting magnitude. Moreover, we must state that it is practically impossible to find a sufficiently large area without variable stars. However, the variable stars in the chosen areas—apart from some exceptions such as P Cyg (3.0–6.0) in area 14 and W Boo (4.7–5.4) in area 11—have only small variations in magnitudes [6] and thus do not affect the determination of the limiting magnitude too much.

6. The method does not take into account color (effect of Purkyně). We are less sensitive to red light than to blue light. In an area which contains many faint red stars, we shall see fewer stars than in a similar area with many faint blue stars. On variable star observations [7], a correction for this phenomenon is applied, using $m = m_0 + 0.18 \times (B - V)$, where m_0 is the catalogue value and $B - V$ is the color index of the star. This equation, however, does not hold near the limiting magnitude.

7. The magnitudes of the stars used in *IMO* tables [2,3] are determined from the SAO catalogue [8], which is not sufficiently accurate for this aim. It is likely that the most reliable visual magnitudes can be found in BSC [9]. This catalogue is sufficiently homogeneous for stars up to magnitude 6.5, which is mostly sufficient. For fainter stars however, it is inevitable to use *IMO* tables taken from SAO. The magnitudes of the stars in the *IMO* areas published in BSC have been controlled according to [11,12] and are sufficiently accurate for visual observations. The differences are smaller than $0^{m}\!.05$.

Table 1 – Uncertainties in the determination of the limiting magnitudes using the *IMO* tables larger than 0.3 for limiting magnitudes at least 5.0.

Area	Nr. of stars	Lm	Area	Nr. of stars	Lm
1	10–11	5.3–6.0	12	13–14	5.8–6.4
2	7– 8	5.1–5.4	13	6– 7	5.0–5.5
3	9–11	5.4–5.7	14	8–11	5.2–5.5
4	8– 9	5.3–5.6	15	5– 6	5.1–5.5
5	7– 8	5.4–6.0		6– 8	5.5–5.8
6	6– 7	5.4–5.7	16	5– 6	5.1–5.7
	8– 9	5.9–6.2	17	9–10	5.1–5.5
7	12–13	5.5–5.9		10–11	5.5–5.9
8	09–10	5.5–5.9	18	9–10	5.2–5.5
9	08–11	5.0–5.6	19	3– 4	3.9–5.2
10	4– 5	4.5–5.8		5– 6	5.4–5.7
	11–12	6.1–6.4		6– 8	5.7–6.1
11	10–11	5.0–5.3		8–11	6.1–6.4
	11–13	5.3–5.7	20	5– 6	5.0–5.4
12	5– 6	3.7–5.2		6– 7	5.4–5.7

3. Results

We compared all 20 *IMO* areas to data obtained from the BSC [9], SAO [8], and GCVS [6] catalogues.

The coordinates of the stars were transformed into gnomonic projection, to ensure correct area boundaries. We compared data up to magnitude 6.5. To reduce large differences between *IMO* numbers of stars and our numbers of stars, stars which are close to the boundary were included. Thus, the edges were effectively moved outward by $0\overset{\circ}{.}1$.

As an example, we show a comparison of the *IMO* values with the catalogue values for area 2 (β Per-δ Per-ζ Per) up to magnitude 6.6. The stars which are closer to the boundary than $0\overset{\circ}{.}1$ are marked with "+." It is obvious that the *IMO* table includes these stars. Nevertheless, the differences in magnitude between *IMO* values and BSC values (including near-boundary stars) can be larger than 0.2 (Table 2).

The difference between the *IMO* table and the SAO+ table is caused by the missing star SAO 56646 (magnitude 5.0), which is $0\overset{\circ}{.}39$ outside the area's boundary! Such a large tolerance, however, would cause extending the table by two other stars: SAO 39085 (5.6) and SAO 56635 (6.0), so the table would not be applicable again. These differences are obviously caused by using unsuitable projection methods when the *IMO* areas have been processed.

Table 2 – Comparison of the *IMO* table for area 2 with catalogue data up to magnitude 6.6. Here, N represents the number of stars; IMO the magnitude according to the *IMO* tables; SAO the magnitude according to the SAO Catalogue; SAO+ the same, but including near-boundary stars; BSC the magnitude according to the BSC Catalogue; BSC+ the same, but including near-boundary stars; and GCVS indicates variable stars in the area according to the GCVS Catalogue. Plusses indicate where extending the boundaries effectively resulted in including more stars.

N	IMO	SAO	SAO+	BSC	BSC+	GCVS
1		2.9	2.9	2.12	2.12	2.12–3.39
2	2.9	2.9	2.9	2.85	2.85	
3	3.1	3.1	3.1	3.01	3.01	2.99–3.04
4	3.9	3.9	3.9	3.77	3.77	
5		5.0	5.0	4.95	4.95	
6	5.0	5.1	5.1	5.11	5.11	5.05–5.18
7	5.1	5.6	5.4+	5.57	5.31+	
8	5.4	5.6	5.6	5.59	5.57	
9		5.7	5.6	5.77	5.59	
10	5.6	5.8	5.7	5.81	5.77	
11	5.7	6.3	5.8	6.41	5.81	5.79–5.84
12	5.8	6.3	6.0+	6.42	5.96+	
13	6.0	6.4	6.1+	6.45	6.07+	
14	6.1	6.4	6.2+	6.51	6.11+	
15	6.2	6.4	6.3	6.57	6.41	6.37–6.51
16		6.6	6.3		6.42	
17	6.3	6.6	6.4		6.45	
18		6.6	6.4		6.51	
19			6.4		6.57	
20	6.4		6.6			
21			6.6			
22			6.6			
23	6.6					

			B S C		
1	936	38592	212	2.12	3.39
2	1203	56799	285		
3	1122	39053	301	2.99	3.04
4	1135	39078	377		
5	1002	38750	495		
6	1177	56727	511	5.05	5.18
7	1069	38924	531		
8	1113	56628	557		
9	1133	56675	559		
10	1191	56761	577		
11	1078	56538	581	5.79	5.84
12	986	56322	596		
13	966	38674	607		
14	1130	39071	611		
15	1072	38927	641	6.37	0.14
16	1097	38999	642		
17	979	38700	645		
18	1026	38809	651		
19	1163	56709	657		

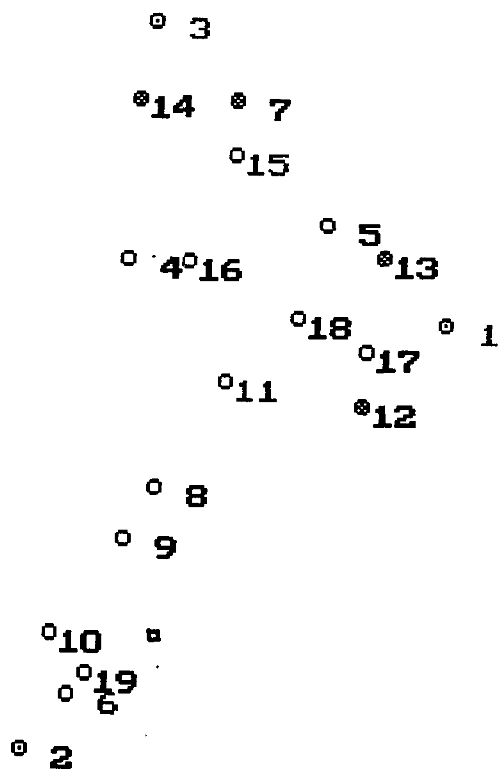

Figure 1 – The stars are sorted according to decreasing magnitude. Here, BS = HR star identification, SAO star identification, visual magnitude, and magnitude range for variable stars are given. Variable stars are grey, dotted circles indicate corner stars, and full circles mark near-boundary stars. The square represents the star SAO 56646, included in the *IMO* tables despite its being 0°.39 outside the area's boundary.

4. Conclusion

It is necessary that the determination of the limiting magnitude is done with great care, since, otherwise, the observation suffers from large errors.

According to our knowledge and experiences, the optimum solution of this problem is using maps with a sequence of numbered stars and a transformation table, as in Figure 1. It is sufficient that the number of the faintest visible star is taken when determining the limiting this way (the possible variability of the star has to be taken into account).

More detailed information about this subject has been published in [13,14] by the authors.

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The Leonids

On the 1993 Leonid Meteor Activity

Marco Langbroek

In the period of November 16–20, 1993, five experienced observers in the *Dutch Meteor Society* (*DMS*) observed 58 Leonid meteors and 121 sporadic meteors in 16.52 effective observational hours. Analysis of their data result in ZHRs that are comparable to the normal annual Leonid activity in "off season" years. These results are at odds with results by Bel'kovich et al. [1], who claim that in 1993 activity was a factor 2.5 higher than usual. I support the opinion expressed by Jenniskens [2,3] that 1994 was the year that marked the first sign of enhanced activity of the Leonid meteor stream connected to the perihelion-passage of the parent comet P/Tempel-Tuttle in 1998.

1. Introduction

As the late 90s of the 20th century are approaching, expectations run high among meteor astronomers. It is widely anticipated (e.g., [3–7]) that the perihelion passage of the short period comet P/Tempel-Tuttle, the parent comet of the meteoroids in the Leonid meteor stream, in 1998 will give rise to impressive meteor storms in either 1998, 1999, or both years.

In 1994, a broad outburst of the Leonid stream, lasting 0.8 days, was observed centered on November 18, 9^h UT [8,9]. An "outburst" is defined as any activity significantly raised above the normal annual activity of the stream in question (cfr. [5]). The outburst of 1994 was welcomed with enthusiasm as the long awaited herald of the exciting events to come next years.

But was it truly the first herald, or did comet P/Tempel-Tuttle already send an earlier messenger announcing its coming return and had it gone unnoticed? Recently, Bel'kovich et al. decided to check. As a result, they report that their research shows that the Leonids already returned with significantly higher rates than usual in 1992 and 1993 [1]. According to Bel'kovich and his co-workers, the Leonid activity has been a factor 2.5 higher in 1993.

The results of Bel'kovich et al. are challenged by Jenniskens [2,3], who has analyzed the same body of data (!) by a different method and has found no significant enhancement of rates in 1993 over normal annual "off season" activity and maintains that 1994 was the first in a new series of Leonid outbursts connected to perihelion passage of the parent comet in 1998.

This report presents observational results by five experienced observers of the *Dutch Meteor Society* (*DMS*), obtained during the Leonid activity period of 1993 and partly covering the very same solar longitudes for which Bel'kovich et al. report enhanced activity. Though a relatively small body of data is involved, they stem from experienced observers and therefore the results should have some relevance.

2. The 1993 Leonids from the Netherlands

Usually, the Leonid stream remains hidden behind rain-loaded clouds for observers in the Netherlands. The year 1993, however, has been one of those rare exceptions, since clear skies provided the opportunity to observe the stream during the period of November 16 until 20, 1993, though only from a few fortunate parts of the country.

During the night of November 16-17, Michiel van Vliet at the meteor observatory "Cyclops," Oostkapelle, and Carl Johannink and the author at Lattrop Public Observatory obtained several hours of Leonid observations. An attempt for multi-station photography failed because the photographic stations at Harderwijk and Leiden were clouded out by fog and Lattrop and Oostkapelle are at too far a distance from each other for successful multi-station photography. The hourly rates of Leonids were found to be quite low and, for example, evidently lower than the activity of the Orionid stream near October 22. A few hours earlier, Alex Scholten had spent some time observing Leonids during a touristic visit to Indonesia. On the nights of November 17-18, 18-19 and 19-20, Koen Miskotte of the observational team "Delphinus" at Harderwijk managed to obtain a good sample of the descending slope of the Leonid activity profile. All together, these five experienced observers obtained 58 Leonid meteors and 121 sporadic meteors in 16.52 effective observational hours.

3. Reduction procedure

The data have been reduced according to the procedure outlined in [9]. The equation for obtaining corrected ZHRs reads as follows:

$$\mathrm{ZHR} = (N_{\mathrm{Leo}}/T_{\mathrm{eff}}) \times r^{6.5-\mathrm{lm}} \times \sin^{-\gamma} h_r \times C_p^{-1}.$$

Correction factors involved include the effective observational time (T_{eff}), a correction for deviating sky limiting magnitudes ($r^{6.5-\mathrm{lm}}$), radiant altitude dilution ($\sin^{-\gamma} h_r$) and personal perception differences between individual observers (C_p^{-1}, obtained from calibration on the sporadic background). Following Jenniskens [3,5,9], I adopted $\gamma = 1.4$. The personal perception factors (C_p) as derived from recent observational campaigns have been used for all observers, since these have been calculated from larger samples of sporadic meteors and therefore are believed to be more reliable.

From the meteor magnitude estimates by the observers, I obtained the population index r by applying a probability function $P(m)$ to the observed magnitude distribution $N(m)$. The values for $P(m)$ as given by Jenniskens [9] have been used, allowing for a shift in the curve proportional to the deviation of the observed sky limiting magnitudes from the "standard" limiting magnitude of +6.5.

4. Results

For the observations of November 17–20, I find an average population index $r = 2.7 \pm 0.2$. This does not differ significantly from the r-value of 3.0 as given for the annual "off season" Leonid activity by Jenniskens [3,9], taking into account that a relatively low number of estimates is involved. Therefore, I have used $r = 3.0$ in further calculations. The observation that the observed population index does not differ significantly from the normal population index for the annual Leonid stream is noteworthy, because during the 1994 outburst the meteors were on average much brighter with an r-value near 2.1 [9]. The same is true for the 1995 outburst ($r \approx 1.8$, preliminary result from observations by the author).

The calculated ZHRs for November 16–20, 1993, are shown by the larger black squares in Figure 1, which is the normal annual "off season" Leonid activity curve taken from Jenniskens ([3]: this is a revised activity curve replacing the curve presented in [9]). Each data point depicts the average of ZHR-determinations during a period no longer than 2.5 hours. Error bars show the one-sigma statistical error (i.e., $\sigma_{\mathrm{ZHR}} = \mathrm{ZHR}/\sqrt{N}$, with N the total number of meteors).

The ZHRs calculated from the 1993 observations are evidently compatible with normal annual "off season" rates. There is no evidence of a significant increase in rates compared to the standard annual profile. Certainly, the data exclude a broad structured enhancement of the Leonid activity by a factor 2.5 for the solar longitudes covered by the observations. Actually, in the opinion of the observers involved, the 1993 return did not compare at all to the recent 1995 return, which for European observers saw an activity about a factor 3 higher than the annual "off season" activity. During the night of November 17-18, 1995, the author alone for example obtained 85 Leonids during 3.76 hours of effective observational time with limiting magnitudes near +6.5: about 1.5 times a larger sample than the total sample of the five observers from 1993 (obtained in 16.52 hours effective observing time)!

Table 1 – Summary of visual observations by five members of the *Dutch Meteor Society* on the 1993 Leonid return. The table lists date, time, solar longitude (1950.0), effective observing time, sky limiting magnitude, radiant altitude, the calculated ZHR for the Leonids, number of observed Leonids, number of observed sporadics, number of meteors belonging to streams other than the Leonids (e.g., the Taurid stream), C_p of the observer and the observer's code: AS = A. Scholten, Tuk Tuk, Indonesia (2°30′ N, 98°50′ E); CJ = C. Johannink, Lattrop, the Netherlands (52°30′ N, 6°50′ E); KM = K. Miskotte, Harderwijk, the Netherlands (52°20′ N, 5°40′ E); ML = M. Langbroek, Lattrop, the Netherlands (52°30′ N, 6°50′ E); MV = M. van Vliet, Oostkapelle, the Netherlands (51°35′ N, 3°30′ E).

Nov 1993	UT	$\lambda_\odot$ (1950.0)	$T_{\rm eff}$ (h)	Lm	h_r (°)	ZHR	N_L	N_S	C_p	Obs
16	20.87	233°971	1.08	6.2	42	8.0 ± 3.6	5	8	1.4	AS
17	01.40	234°108	0.95	6.1	30	7.1 ± 5.0	2	2	1.2	ML
17	01.58	234°115	1.67	5.5	31	15.0 ± 7.6	4	8	1.2	CJ
17	01.71	234°121	0.90	6.2	33	21.7 ± 8.9	6	8	1.0	MV
17	02.40	234°150	0.57	6.2	39	9.3 ± 6.6	2	4	1.0	MVS
17	02.75	234°165	0.95	5.8	42	13.2 ± 6.6	4	2	1.2	ML
17	04.00	234°217	0.96	5.8	52	13.0 ± 5.8	5	9	1.2	ML
17	04.30	234°238	0.40	6.1	55	15.4 ± 8.9	3	2	1.0	MV
17	05.00	234°259	0.92	5.6	57	6.2 ± 4.4	2	10	1.2	ML
17	05.20	234°267	1.03	5.8	58	15.8 ± 6.5	6	2	1.0	MV
18	01.63	235°125	0.75	6.0	32	13.9 ± 8.0	3	10	1.2	KM
18	02.50	235°162	1.00	6.0	40	5.3 ± 3.8	2	8	1.2	KM
18	03.50	235°204	1.00	6.0	47	8.9 ± 4.5	4	10	1.2	KM
18	04.30	235°238	0.60	6.0	53	13.1 ± 6.6	4	7	1.2	KM
19	02.03	236°151	1.08	6.1	35	5.2 ± 3.6	2	6	1.2	KM
19	03.10	236°196	1.33	6.1	46	3.1 ± 2.2	2	14	1.2	KM
20	03.50	237°222	1.33	6.1	49	2.9 ± 2.0	2	11	1.2	KM
Total			16.52				58	121		5

Table 2 – Magnitude distributions for the Leonid meteors observed by the observers in Table 1.

Magnitude	−4	−3	−2	−1	0	+1	+2	+3	+4	+5
CJ	0	0	0	0.5	0.5	0	2.5	0.5	0	0
KM	0	0	0	0	2	2	3.5	5.5	5	1
ML	0	1	0	1	2	1	3	2	2	1
MV	1	1	0	0	2	0	1	7	6	0
Total	1	2	0	1.5	6.5	3	10	15	13	2

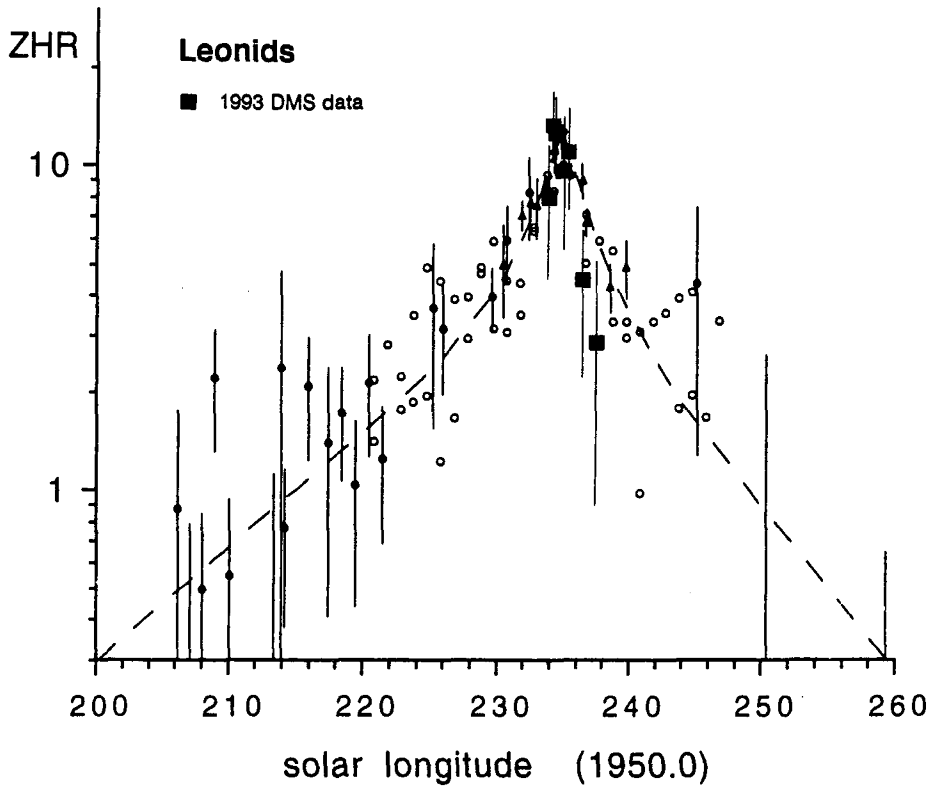

Figure 1 – The 1993 Leonid ZHRs as observed by the mentioned five experienced observers of the *Dutch Meteor Society* are shown here as the larger black squares, and are compared to the annual "off season" Leonid activity curve reproduced from Jenniskens [3]. Smaller symbols belong to this latter curve and show *DMS*, *IMO* and *NMS* data from the years prior to 1993.

5. Conclusions

For 1993, Leonid observations by five experienced observers of the *Dutch Meteor Society* result in ZHRs compatible with normal annual "off season" Leonid activity. The results do not allow for the existence of a broad outburst component comparable to the 1994 and 1995 components as presented for 1993 by Bel'kovich et al. [1]. Therefore, in support of Jenniskens [2,3], I cannot confirm the conclusion by Bel'kovich and co-workers and conclude that the 1994 Leonid outburst [3,8] was indeed the first herald of 55P/Tempel-Tuttle's coming return to perihelion.

Acknowledgments

I thank Carl Johannink, Koen Miskotte, Michiel van Vliet, and Alex Scholten for contributing their observational data to this study. The paper benefited from comments by Peter Jenniskens (NASA/Ames Research Center). Both Michiel van Vliet and Guus Docters van Leeuwen are thanked for maintaining the *DMS* visual archives from which the data were drawn. Carl Johannink and Casper ter Kuile proved good companions on the roof of Lattrop Public Observatory during that cold November night and on many other occasions.

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Enhanced 1994 Leonid Activity Also Seen in New Zealand

Graham W. Wolf

A mild enhancement of the 1994 Leonid meteor shower was widely reported in the December 1994 issue of *WGN*. A similar enhancement was observed by the author from New Zealand's capital city of Wellington, on November 18. Brief results are presented, and compared with overseas results.

Observations of the 1994 Leonid meteor shower from New Zealand by the author, on November 16, 18 and 21 are reported. Enhanced activity was noticed, with 11 Leonids in 48 minutes from 15^h08^m UT to 15^h56^m UT on November. Of these, 5 were observed in a 7 minute period. This seems to fit well with other overseas reports of enhanced Leonid activity, that were published in the December 1994 issue of *WGN*.

Table 1 – Comparison of magnitude distributions for November 18, 1994.

Obs	ZLm	−2	−1	0	+1	+2	+3	+4	Total
JENPE	5.2	1	2	4	1	2	3	5	18
WOLGR	3.5		4	2	2	3			11

JENPE is Peter Jenniskens, observing from the USA. WOLGR is the author, observing from Wellington, New Zealand, at a site called "Hine Road, Wainuiomata," on November 18, 1994. This is the residence of the married sister of the author. The geographical coordinates are 41°16′24″ S, 174°58′12″ E, at an elevation of 100 m above sea level.

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BAA Observations of the 1995 Leonids: A Preliminary Report

Neil Bone

Leonid observations reported to the *BAA Meteor Section* indicate enhanced activity, possibly peaking around a ZHR of 40, close to November 18, 1995, at 4^h UT. Many bright Leonids, and Leonids with persistent trains were recorded.

Following the reported upturn in Leonid activity seen despite moonlight interference in 1994 [1–3], the 1995 shower attracted a great deal of interest among the UK amateur observing community. As likely strong returns of the end of the century approach [4,5], this interest can be expected to grow in parallel with Leonid rates. It was hoped that the 1995 return might provide some indication of the solar longitude at which the richest part of the ortho-Leonid cloud might be encountered in later years. The report which follows is based on a total of 173^h01^m watch time submitted by the 75 individual observers and 6 local society groups listed below in the four weeks following the 1995 Leonids:

J. Abbott, L. Anslow, B. Beadell, S. Beaumont, D. Beesley, R. Billington, G. Bone, N. Bone, G. Boots, A. Bridson, P. Brierley, K. Brill, E. Britton (Ireland), R. Cooil, A. Drummond, D. Dunn, S. Evans, R. Fails, P. Fray, M. Gainsford, A. Cannon, D. Gavine, I. Gray, J. Green, M. Green, R. Grover, C. Hall, M. Harmer, M. Harris, T. Haymes, M. Herbert, B. Hitchings, P. Hitchings, P. Hughes, R. Johnson, B. Kelly, N. Kiernan, J. Lancashire, J. Lang, R. Livingstone, T. Lloyd Evans (South Africa), A. McBeath, T. McEwan, H. McGee, T. Markham, J. Martin, G. Mitchell, S. Moore, T. Moseley, B. O'Halloran (Ireland), M. Pace, H. Parkin, G. Parseley, G. Pointer, R. Polly, N. Quinn, J. Rogers, C. Rose, J. Shanklin, C. Sheldon, G. Spalding, J. Starling, C. Steele, D. Strachan, M. Taylor, A. Vincent, T. Wakefield, S. Warner, C. Watson, I. Wood, R. Wood, P. Yates, J. Youdale, J. Young, M. Young, Blackburn Leisure AS, Farnham AS, Isle of Man AS, Luton AS, Macclesfield AS, and South Downs AS.

A total of 1939 meteors (684 sporadics, 1127 Leonids, 101 Taurids and 27 others) was reported, representing the *BAA Meteor Section*'s most extensive Leonid coverage since 1974.

Weather conditions proved remarkably favorable over much of the British Isles during the 1995 Leonids. Best clear skies on November 16-17 were found over Scotland. Southern and central England enjoyed excellent clear conditions on the night of maximum, November 17-18, with a tongue of cold polar high pressure extending across the country: snow and hail showers were a problem for those further north and east. Not surprisingly, this night accounts for most of the coverage. November 18-19 was largely lost to a veil of high cloud which developed in late evening, but the following night was again excellent at many locations.

Table 1 provides a breakdown of hourly activity derived from visual observations, analyzed as for other showers to produce ZHRs [6]. Population index $r = 2.00$ has been used for the Leonids, $r = 3.42$ for the sporadics. Highest weight should naturally, be accorded to those intervals when the radiant elevation is greater than 30°.

As can be seen from Table 1, Leonid rates were already quite substantial by November 16-17, with ZHR around 25–30 in the immediate post-midnight hours. Activity seemed somewhat higher around 4^h UT, up to ZHR of 40 ± 3, with lower rates again towards dawn around 5^h30^m UT. Many observers have commented that the interval from about 3^h10^m–3^h50^m UT seemed particularly active. Whether this constitutes a significant peak remains to be seen, but it is quite clear that Leonid rates on maximum night were 2- to 3-fold higher than those found in the quiet-time years from 1974 to 1993 [7].

The few results from November 18-19 indicate lower activity than on the previous night. Enhanced activity seems to have been confined mainly to the interval around maximum, unlike the reported pattern in 1994. Leonid activity was still quite obvious on November 19-20.

Table 1 – 1995 Leonid data from the *BAA*.

Date	Time (UT)	$\lambda_\odot$ (2000.0)	$T_{\rm eff}$	$\overline{\rm Lm}$	F	Spor	HR	Leo	$h_{\rm rad}$	ZHR
Nov 17	00^h40^m	234°25	2.00	5.75	1.00	9	11.3 ± 3.7	6	20°	15.0 ± 6.1
Nov 17	01^h27^m	234°28	4.50	5.70	1.00	20	11.9 ± 2.7	10	27°	8.8 ± 2.8
Nov 17	03^h10^m	234°36	2.00	5.60	1.02	14	21.6 ± 5.8	10	42°	14.4 ± 4.6
Nov 17	04^h20^m	234°41	2.00	5.60	1.00	5	7.6 ± 3.4	12	50°	14.6 ± 4.2
Nov 17	05^h08^m	234°44	0.92	5.70	1.00	2	5.8 ± 4.1	11	53°	26.0 ± 7.8
Nov 18	00^h31^m	235°25	10.00	5.79	1.00	49	11.7 ± 1.7	49	19°	25.1 ± 3.6
Nov 18	01^h28^m	235°29	15.68	5.74	1.01	75	12.3 ± 1.4	117	28°	27.8 ± 2.6
Nov 18	02^h22^m	235°33	15.42	5.73	1.05	71	12.5 ± 1.5	118	36°	23.5 ± 2.2
Nov 18	03^h26^m	235°38	15.67	5.49	1.01	59	13.2 ± 1.7	180	45°	33.0 ± 2.5
Nov 18	04^h20^m	235°41	9.93	5.45	1.01	43	15.9 ± 2.4	152	52°	40.6 ± 3.3
Nov 18	05^h23^m	235°46	3.98	5.14	1.02	15	20.5 ± 5.3	30	57°	23.5 ± 4.3
Nov 19	00^h38^m	236°27	1.25	5.90	1.05	12	21.1 ± 6.1	1	21°	3.6 ± 3.6
Nov 19	01^h06^m	236°29	2.00	5.15	1.00	10	26.3 ± 8.3	4	25°	12.2 ± 6.1
Nov 19	02^h45^m	236°36	1.50	5.00	1.00	8	33.7 ± 11.9	6	40°	17.7 ± 7.2
Nov 19	05^h00^m	236°45	1.00	5.50	1.00	3	10.3 ± 5.9	4	57°	9.6 ± 4.8
Nov 20	00^h37^m	237°28	4.50	5.45	1.00	25	22.7 ± 4.5	11	21°	21.9 ± 6.6
Nov 20	01^h52^m	237°33	2.00	6.20	1.21	12	10.5 ± 3.0	10	32°	14.0 ± 4.4
Nov 20	02^h42^m	237°36	0.67	6.40	1.00	5	8.4 ± 3.8	4	40°	10.0 ± 5.0

A marked feature of the 1995 Leonids was the relative abundance of bright events, as shown in Figure 1, which summarizes observers' magnitude estimates. Overall mean Leonid magnitude was +1.56, mean sporadic magnitude +2.76; for November 17-18, the respective figures were +1.36 and +2.65. As usual, Leonid persistent trains were common.

Overall, 42.5% of Leonids had trains, compared with 6.3% of sporadics. Figures for November 17-18 were 41.5% and 7.4%, respectively.

Among the bright events, the single most outstanding meteor was a Leonid at 4^h39^m UT on November 17-18, reported by 11 observers from Sussex in the south to Manchester in the north, and Cambridge in the east to Ireland in the west.

Magnitude estimates range from −2 to −10, the meteor being brightest and most spectacular for those in the southwestern British Isles. From here, the meteor left a persistent train lasting at least 5 minutes, slowly distorting into a crescent in high-atmosphere winds. The development of the train was followed using a low-light video camera by Tim Haymes at Maidenhead.

Photographic results remain to be analyzed, but several good trails were recorded, notably by Joe Young at Bury St. Edmunds and Graham Boots at Worthing.

Also at Worthing, Nick Quinn recorded forward-scatter radio counts.

A fuller analysis of all these results, and of results obtained via the very successful public Leonid Watch 1995 organized by *BAA Meteor Section* Assistant Director John Mason in conjunction with BBC, will follow in the *Journal of the BAA*.

From this preliminary analysis, we would certainly conclude that Leonid activity on November 17-18, 1995, was much enhanced over its quiet-time levels, possibly showing a peak around 4^h UT. It is to be hoped that similarly extensive observations will be possible in 1996 and subsequent years. Thanks are expressed to all participating observers, who braved extremely cold conditions to collect the watch data.

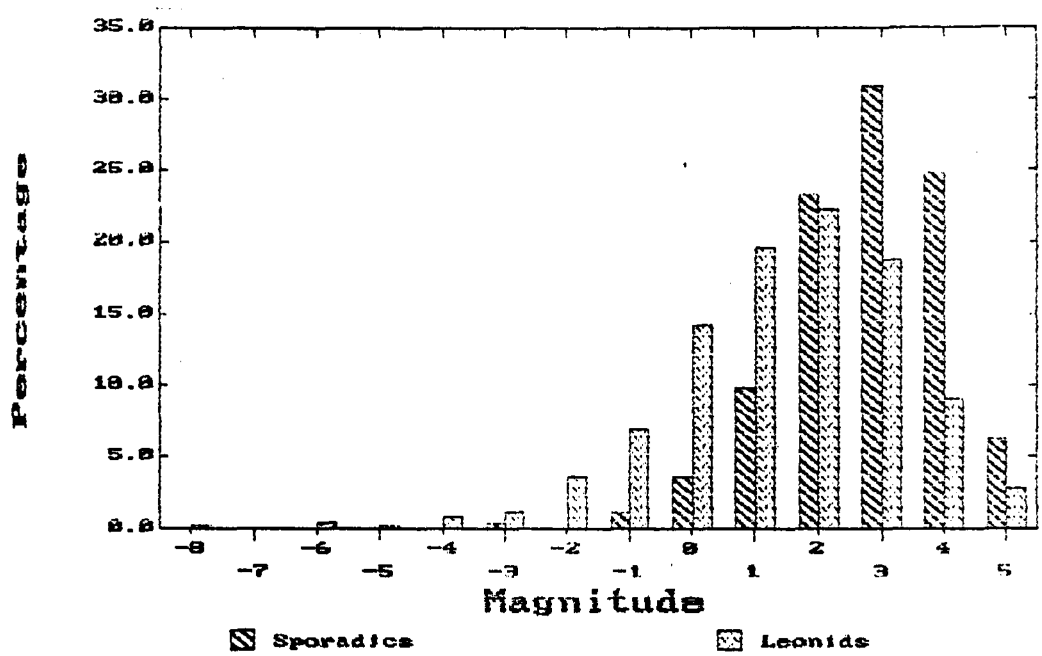

Figure 1 – Magnitude estimates for the 1995 *BAA* Leonid data.

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The 1995 Leonids from Brazil

Gilberto Klar Renner

An overview is given of Brazilian observations of the Leonids on November 18, 1995.

Our group observed the Leonids for the first time in 1995. Few Leonids were seen but they were bright. The radiant was 18° high and the Moon, 20% illuminated, was in the area of view. The author calculated the ZHR values assuming a population index r of 2.5 for all dates below.

The observers that participated in the Leonid observations in 1995 were Darlan Morais, Gilberto Klar Renner, Luís Antônio Reck de Araujo, and Luís Antônio da Silva Machado.

Tables 1 and 2 summarize our observations. Solar longitude are referred to equinoctium 2000.0.

Table 1 – The Leonids as observed in Brazil in 1995.

$\lambda_\odot$	Date	$T_{\rm eff}$	Obs	$\overline{\rm Lm}$	Leo	$\overline{m}_{\rm Leo}$	ZHR	Spor	$\overline{m}_{\rm Spor}$
235°50	Nov 18	$1^{\rm h}65$	2	+5.7	17	+1.11	34 ± 7	24	+2.79

Table 2 – Magnitude distribution of the Leonids and the sporadics on November 18, 1995, as seen from Brazil.

Shower	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot	$\overline{m}$
Leonids	0	1	5	5	3	3	0	0	0	17	+1.11
Sporadics	0	0	0	3	6	8	7	0	0	24	+2.79

Radar Observations of the 1995 Leonids in Italy

Giordano Cevolani and Luigi Foschini, FISBAT/CNR, Bologna

Continuous radar monitoring of the Leonid meteoroid stream during November 15–20, 1995, has been carried out by using the CNR forward-scatter radar. A significant number of high duration echoes (more than 16 seconds) was registered and also confirmed by visual and photographic observations. From data analysis results that echoes were distributed over three peaks at solar longitudes $\lambda_\odot = 234°649$, $\lambda_\odot = 234°775$, and $\lambda_\odot = 234°859$ (eq. 1950.0).

The forthcoming return of Comet 55P/Tempel-Tuttle, whose perihelion crossing is expected to occur on February 28, 1998, prospects for a Leonid storm and this has alerted meteor observers already during past years. In 1994, the Leonid shower was characterized by a significantly enhanced activity, as showed by many visual and radar observers [1,2]. Last year, even without an outburst, the registered activity was consistent.

Radar observations were carried out unbrokenly between November 15 and 20, 1995, by using the CNR forward-scatter meteor radar, with the transmitter in Budrio, near Bologna (latitude $\varphi = 44°6$ N), and the receiver in Lecce (latitude $\varphi = 40°3$ N) over a baseline of about 700 km [3]. The bi-static radar system utilizes a 42.7 MHz continuous wave with a fixed modulating tone at 1 kHz and 1 kW mean power.

Figure 1 shows the contour plot (*top*) of the three dimensional (*bottom*) variations of the hourly flux of overdense meteors with durations more than 16 seconds: time is referred to its solar longitude. These plots exhibit a remarkable activity on November 18 and distributed over three peaks at solar longitudes $\lambda_\odot = 234°649$, $\lambda_\odot = 234°775$, and $\lambda_\odot = 234°859$ (referred to the equinox of 1950.0), corresponding to $3^{\rm h}00^{\rm m}$, $6^{\rm h}00^{\rm m}$, and $8^{\rm h}00^{\rm m}$ UT, respectively. We also want to highlight that in these peaks there is an exceptional number of echoes with duration up to 128 seconds (6 echoes at $3^{\rm h}00^{\rm m}$ UT) and this is confirmed by visual observations carried out the same night.

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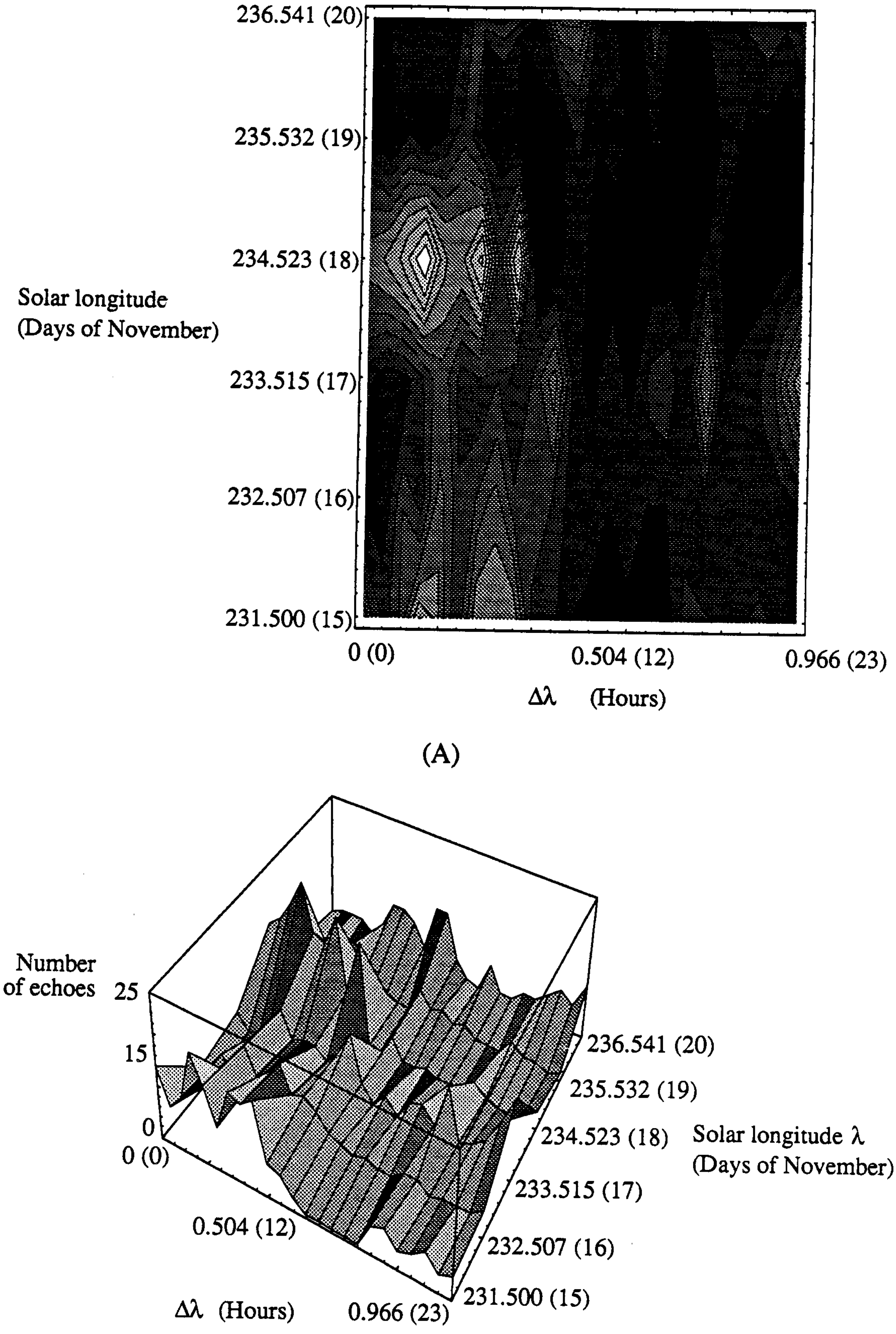

Figure 1 – Contour plot (*top*) of the 3D variations (*bottom*) of the hourly flux of overdense meteors with $T \geq 16$ s recorded with the CNR forward scatter meteor radar during November 15–20, 1995. Time is referred to its solar longitude (eq. 1950).

The Leonid Maximum of 1995 from Denmark

Gotfred Møbjerg Kristensen

The author's radio observations of the 1995 Leonids are presented.

Unfortunately, is was cloudy in Denmark on the night of the Leonid maximum. Only during a short period, there were a couple of small clear areas. It was very disappointing, because the radio showed an increase in the number of reflections (the transmission frequency was 100.50 MHz). Also during the night of November 18, I have received very bright signals. Visual observations were still not possible.

Figure 1 (*left*) shows up to 227 signals per hour, around 5^h00^m UT. It is significant over the background rates, averaged around 50 signals per hour. On the night of November 20, the radio meteor rate was falling to a nearly normal activity.

Figure 1 (*right*) shows the radio meteor observations from 1985 to 1995 of the Leonid maxima. Some oscillations in the rates are apparent, but there is a general increase in the rates.

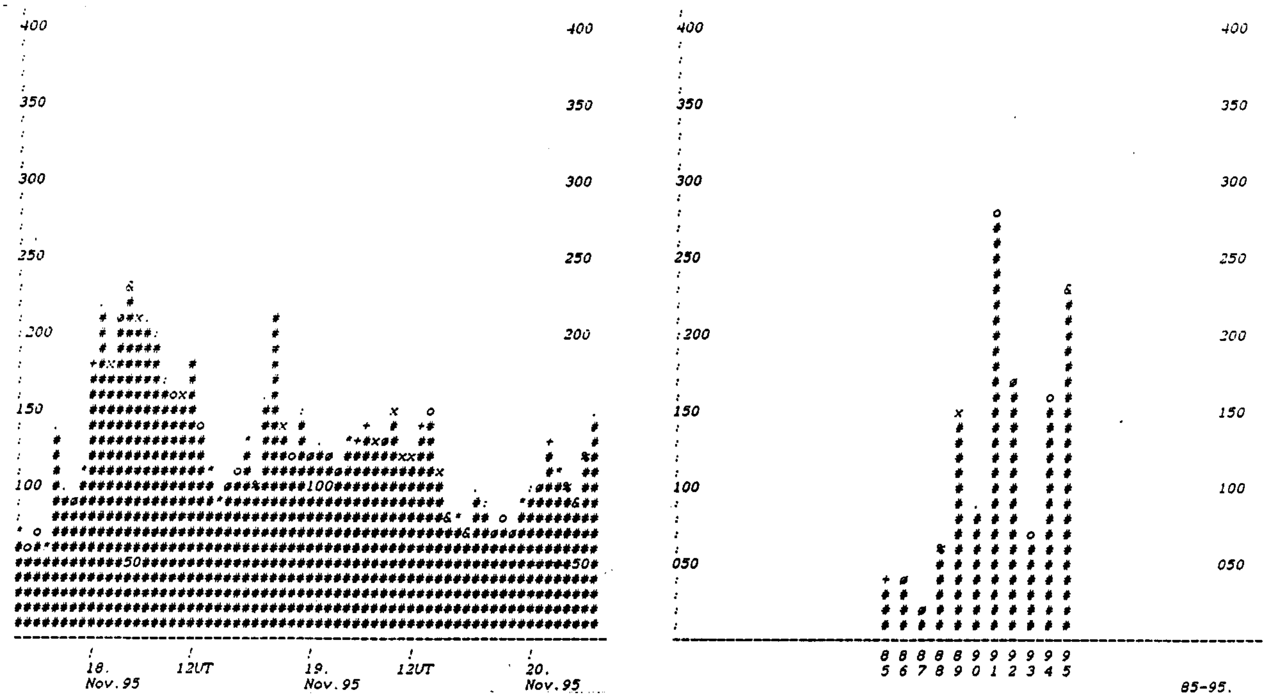

Figure 1 – *Left*: Real hourly radio rates observed by pen-recorder around the Leonid maximum in November 1995 (all observed signals). *Right*: Leonid maximum rates for the period 1985–1995 observed by pen-recorder (all observed signals).

The α-Monocerotids

Firework in the Romanian Sky: the α-Monocerotids

Valentin Grigore and Vasile Micu

A short-duration activity outburst of the α-Monocerotids has been observed on November 21-22, 1995, between 1^h15^m and 1^h48^m UT in two places in Romania.

Two persons watched the α-Monocerotid activity in Romania on November 21-22, 1995: Valentin Grigore (GRIVA) at Târgoviste, $\lambda = 25°29'00''$ E, $\varphi = 44°57'18''$ N, 350 m altitude and Vasile Micu (MICVA) at Bunila, $\lambda = 22°41'24''$ E, $\varphi = 45°41'42''$ N, 950 m altitude.

During the outburst, these persons observed the sky in a different way: GRIVA watched a very large area of the sky to perform an efficient counting, while MICVA concentrated his attention in a precise area to determine the radiant position. This can be the explanation for the fact that during some period (between 1^h17^m and 1^h42^m UT), GRIVA saw 71 α-Monocerotids in $0^h\!.38$ with a limiting magnitude of +6.5 and MICVA saw 42 α-Monocerotids in $0^h\!.35$ with a limiting magnitude of +7.5. Both persons made personal observations.

At Târgoviste, GRIVA started his watch at 23^h27^m UT. Till 1^h15^m the activity of the α-Monocerotids was very low, 3 possible shower members in $1^h\!.40$. The outburst occurred at 1^h15^m (1^h17^m at Bunila) when there appeared a magnitude +2 α-Monocerotid, followed after some tens of seconds by three α-Monocerotids of magnitude +0.5 in a 2.5 second interval, near the radiant area. During outburst, the activity was relatively constant, 8–9 meteors in a three-minute interval, compared to, e.g., the Perseid or Leonid outbursts, which presented a distinct fluctuation. However we can distinguish four more intense periods in the α-Monocerotid outburst (see Table 1).

Table 1 – α-Monocerotids per minute during the outburst on November 22, 1995. The effective observing time is given in minutes.

Interval (UT)	T_{eff}	AMO	AMO/min.	Interval (UT)	T_{eff}	AMO	AMO/min.
1^h16^m–1^h19^m	3	8	2.66	1^h34^m–1^h36^m	2	8	4.00
1^h19^m–1^h22^m	3	8	2.66	1^h36^m–1^h38^m	2	5	2.50
1^h22^m–1^h24^m	2	7	3.50	1^h38^m–1^h40^m	2	2	1.00
1^h24^m–1^h26^m	2	7	3.50	1^h40^m–1^h42^m	2	7	3.50
1^h26^m–1^h28^m	2	4	2.00	1^h42^m–1^h43^m	1	1	1.00
1^h28^m–1^h31^m	3	10	3.33	1^h43^m–1^h47^m	5	0	0.00
1^h31^m–1^h33^m	2	6	3.00	1^h47^m–1^h48^m	1	2	2.00
1^h33^m–1^h34^m	1	0	0.00	1^h48^m–1^h53^m	6	1	0.16

The end of the activity was as unexpected as the beginning, as if nothing had happened. Till 3^h36^m UT only two possible shower members appeared in $1^h\!.40$. During the outburst, the following characteristics of the α-Monocerotids were noticed by GRIVA and MICVA:

- although the α-Monocerotids are very fast, only few meteors left a persistent train: 5% seen by GRIVA and 11% seen by MICVA.
- over 70–80% of the meteors had a very short trail, 5–7° (GRIVA).
- the proportion of bright meteors was not higher than usual (see Table 2).
- GRIVA had the impression that the radiant was larger than 5°, maybe over 10°, with many meteors coming from a point near α Canis Minor.
- MICVA thinks there were two distinct radiants: one in the position given by the *IMO* and one, more active, to the north at 5–7° under Procyon, near ζ Canis Minor.
- MICVA made a color classification for 20 meteors (from 53 α-Monocerotids seen): 13 orange, 4 yellow, 1 red, 1 bluish and one orange-green meteor.

MICVA saw a −5 orange α-Monocerotid fireball at $1^h37^m34^s$ with a 20 seconds' persistent train having two breaks. At 1^h42^m there was a weak flash in GRIVA's N-NE direction (to his back)—a possible α-Monocerotid fireball. GRIVA saw 5 Leonids in $2^h\!.80$, and MICVA observed 4 Leonids in $2^h\!.39$.

The following night, the sky was covered. On November 23-24, 1995, GRIVA saw two possible α-Monocerotids and 9 sporadics in $1^h\!.17$, between 1^h51^m and 3^h00^m UT.

Although the α-Monocerotid outburst was very short and the meteors were not too spectacular, the show was fascinating. Thank God for these wonderful brilliants offered to our eyes!

Table 2 – Magnitude distribution for α-Monocerotids and sporadics seen by GRIVA and MICVA on November 21-22, 1995.

Show	Obs	−5	−2	−1	0	+1	+2	+3	+4	+5	+6	+7	Tot	$\bar{m}$
AMO	GRIVA			6	21	20	18.5	10.5	5.5	0.5			82	1.30
AMO	MICVA	1	1.5	6.5	11.5	6	6.5	6.5	3.5	4	3		50	1.52
SPO	GRIVA			2	4	10	6	4.5	4.5	1	1		33	1.89
SPO	MICVA			2.5	4	8	8	10.5	7.5	11.5	21	7	80	3.94

Radio Observations of the α-Monocerotids from Denmark

Gotfred Møbjerg Kristensen

The author's radio observations of the 1995 α-Monocerotids are presented.

I observed visually for 4 hours during the night of November 21-22, but unfortunately not during the α-Monocerotid outburst which occurred between approximately 1^h15^m and 1^h45^m UT. Upon the request of Rainer Arlt, I checked my pen-recorder paper for this period. I found 57 strong radio signals between 1^h21^m and 1^h44^m UT. Before and after that period, there was no unusual activity. Those 57 signals correspond with a frequency of 149 per hour. The average frequency on November 22 was 57 signals per hour. Most of these were rather weak.

Fireballs and Meteorites

Data Gathering for Meteorite Recovery

George Zay

It is estimated that about 24 000 meteorites will strike the earth each year ranging in size from 100 g to 10 kg. Three-fourths of these will be lost in the oceans, with 7 500 to fall on land [1]. If one is lucky enough to witness a meteorite-producing meteor, recording good data should be hot on one's mind for its recovery.

Unless the meteorite landed in an urban area, accurate fall data are needed for any chance of a meteorite to be recovered. Potential meteorite falls often occurs during the daylight hours. What I am about to suggest, however, could apply for major night time falls as well.

Meteors that are likely candidates to produce meteorites are the ones that are about as bright as a Full Moon (magnitude −12) or brighter and are accompanied by sonic booms and distant rumbling sounds. These sounds can occur very shortly after the meteor's passage or up to several minutes later. They also have a relatively slow velocity and do not produce a terminal burst.

In these cases, alt-azimuth measurements should be made. After a sighting, one seldomly has a compass or clinometer on hand to make altitude and azimuth readings. What is available is one's arm and hand. What the observer should do is carefully mark points on his hand with an outstretched arm for altitudes and note various landmarks on the horizon for the azimuths. Also, be sure you remember where you are at when making these measurements.

In addition, record the exact time to the closest second... even if you have to estimate. It is most important to record the point where the meteor's light is extinguished. This is the retardation point or where the meteor loses its cosmic velocities and becomes a falling rock under the Earth's gravitational force.

With hand measurements, note the beginning and ending of the meteor's path. Get both the altitude in relation to points on your hand and the azimuth in relation to distant horizon land marks.

After sighting a possible meteorite-producing meteor, be prepared for any sonic booms or rumblings to occur, by noting the time of their occurrence.

If you kept your wits about you and noted the positions, write them down as soon as possible along with a time. If a sonic boom soon follows, note its time right away too. Also note a rough estimate of the meteor's velocity. The key thing is to regain your composure after the initial sighting so that you can do all these important things that might help find any meteorites later.

After being satisfied about your preliminary data, you should then try to get an accurate compass reading for your distant horizon land marks for the azimuths (0°–360°). Next, you want to get a clinometer to convert your hand measurements into degrees for altitude. You can hang a weighted string from the center point of a protractor. Sight along the straight edge part to the corresponding area in the sky. Read the degrees (0°–90°) marked off by the string and subtract your reading from 90° and these will be your altitude readings with a simple protractor. The last thing you should do is find your exact position on a topographic map when the meteor made its appearance. Find your longitude and latitude in degrees, minutes, and seconds.

By themselves, if you have done the above, your efforts could be an important piece to the puzzle. After securing your data, you can make more gains by trying to find others who also sighted the same meteor from other locations. Several observations from various distances apart can be very helpful in determining a possible strewn field area. If you can find these individuals from the various news media, try to secure the same data from them as you have for yourself. Be sure to have them show you where they were when they saw the meteor. Use your compass and homemade clinometer to convert their arm gestures into degrees.

When you have secured all the data you can, mail them to André Knöfel at the *Fireball Data Center*. If the sighting becomes significant, he will be in contact with those who can make use of the data. Below is a simple summary of what is needed for daytime/or sonic boom producing meteors. If you can note additional fireball data not mentioned above, that is great. But the most important is what's listed below:

1. altitude for beginning and ending points of the meteor;
2. azimuth for beginning and ending points of the meteor;
3. longitude and latitude in degrees, minutes, and seconds for the position of each observer;
4. estimated velocity; and
5. times.

Reference

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A Perseid Fireball over the Adriatic Sea

August 13, 1994, $1^{h}31^{m}32^{s}$ UT

Alberto Latini

A summary of visual and photographic observations from Italy and Croatia is presented. Determination of its atmospheric track is outlined and a brief note on the present fireball's studies in Italy is made.

1. Introduction

In the night of August 12-13, 1994, at $1^{h}31^{m}32^{s}$ UT a brilliant Perseid fireball appeared over the Dalmatian Coast of the Adriatic Sea. It was probably the major fireball of the 1994 Perseids observed from Italy. The Meteor Section of *Unione Astrofili Italiani* (*UAI*) located its atmospheric track and added this fireball to previous ones already studied in the past [1–4]. In total, we collected three visual observations and three photographs from four different sites.

2. Observations from Pigra (Como, near Milan), Italy

Observer: Alberto Latini, visual and photographic.

Latitude: $\varphi = 45°57'24''$ N.

Longitude: $\lambda = 9°07'47''$ E.

Height: 870 m.

Time of fall: $1^{h}31^{m}35^{s} \pm 3$ s UT (stopwatch).

Magnitude: about -5.

Persistent train: 8 s duration to the naked eye.

Position: azimuth N 116° E, elevation 6° (principal flare).

Description: I was observing toward the north when my eye was attracted by a shine low in the ESE direction. I did not see the fireball directly, when I turned my head about a second after the flash, I saw only the persistent train. It appeared short and structured with some condensations, very low near the horizon some degrees below δ Eridani, the only star I saw in the vicinity. The persistent train lasted for about 8 s and I fixed it with reference to the horizon, timing the fireball with my stopwatch. The day after I measured the azimuth with a compass and elevation with a simple quadrant.

That night my all-sky camera was working regularly and captured the fireball too. But it was too low, distorted and out of focus, so the image is poor and not publishable. It was only used to check the visual position. Other amateurs at my site confirm this observation, which appeared near the geometrical limit of detection, taking into account that the fireball was about 500 km away from Pigra (Como).

3. Observation from Collepardo (Frosinone, near Rome), Italy

Observer: Ugo Tagliaferri, visual.

Latitude: $\varphi = 41\overset{\circ}{.}8$ N.

Longitude: $\lambda = 13\overset{\circ}{.}4$ E.

Height: 550 m.

Time of fall: $1^{h}33^{m}$ UT (stopwatch).

Magnitude: start -1, maximum -5, end -1.

Persistent train: 10 s duration to the naked eye.

Position: beginning azimuth S 207° W, elevation 16°; End azimuth 206° W, elevation 14°.

Description: the observer looked toward the north and saw a short trail since the fireball was near head-on sight. He noted a flare at about 2/3 of the track.

Figure 1 – The photograph of Cusercoli (Forlì, Italy) made with a 16 mm $f/2.8$ camera on Kodak Panther 1600.

4. Observation from Cusercoli (Forlì, near Bologna-Florence-S. Marino), Italy

Observer: Stefano Moretti (*Gruppo Astrofili Forlivesi "J. Hevelius"*), photographic.
Latitude: $\varphi = 44°02'26''$ N.
Longitude: $\lambda = 11°58'26''$ E.
Height: 365 m.
Time of fall: 1^h31^m UT (stopwatch).
Photo with a 16 mm $f/2.8$ on Kodak Panther 1600 film from Cà Bionda di Cusercoli-Civitella di Romagna-Forlì, Italy.
Start of exposure: 1^h27^m UT.
End of exposure: 1^h37^m UT.
The fireball traveled from α Tauri to Orion, low on the east horizon (Figure 1).

5. Observations from Prvić, Croatia

Observer: Drago Sirovica, visual and photographic.
Latitude: $\varphi = 43°43'52''$ N.
Longitude: $\lambda = 15°47'42''$ E.
Height: 20 m.
Time of fall: $1^h31^m30^s$ UT.
Magnitude: between -4 and -8.
Persistent train: 25 s duration to the naked eye.
Description: "I did not directly see the fireball since I was noting the observations. I suddenly saw a yellow flash one or two seconds long, brightening the landscape, to see the shadow of my head on the notes. The shadow was like that of the Moon at First Quarter. I turned my head and saw the persistent train sabre-shaped of magnitude -1 or -2 in Cygnus along the Milky Way. It was expanding and then it showed a wavy shape before it faded about 25 seconds later. Inexperienced observers (children) estimated the fireball magnitude to be -4 to -5. I think it was about -8, but I am not sure."

The drawings of visual observers from Prvić are collected in Figure 2. A camera view 2/53 with Jupiter-8M lens registered an excellent image, with all the fireball's details (see front cover of *WGN* 22:5, October 1994).

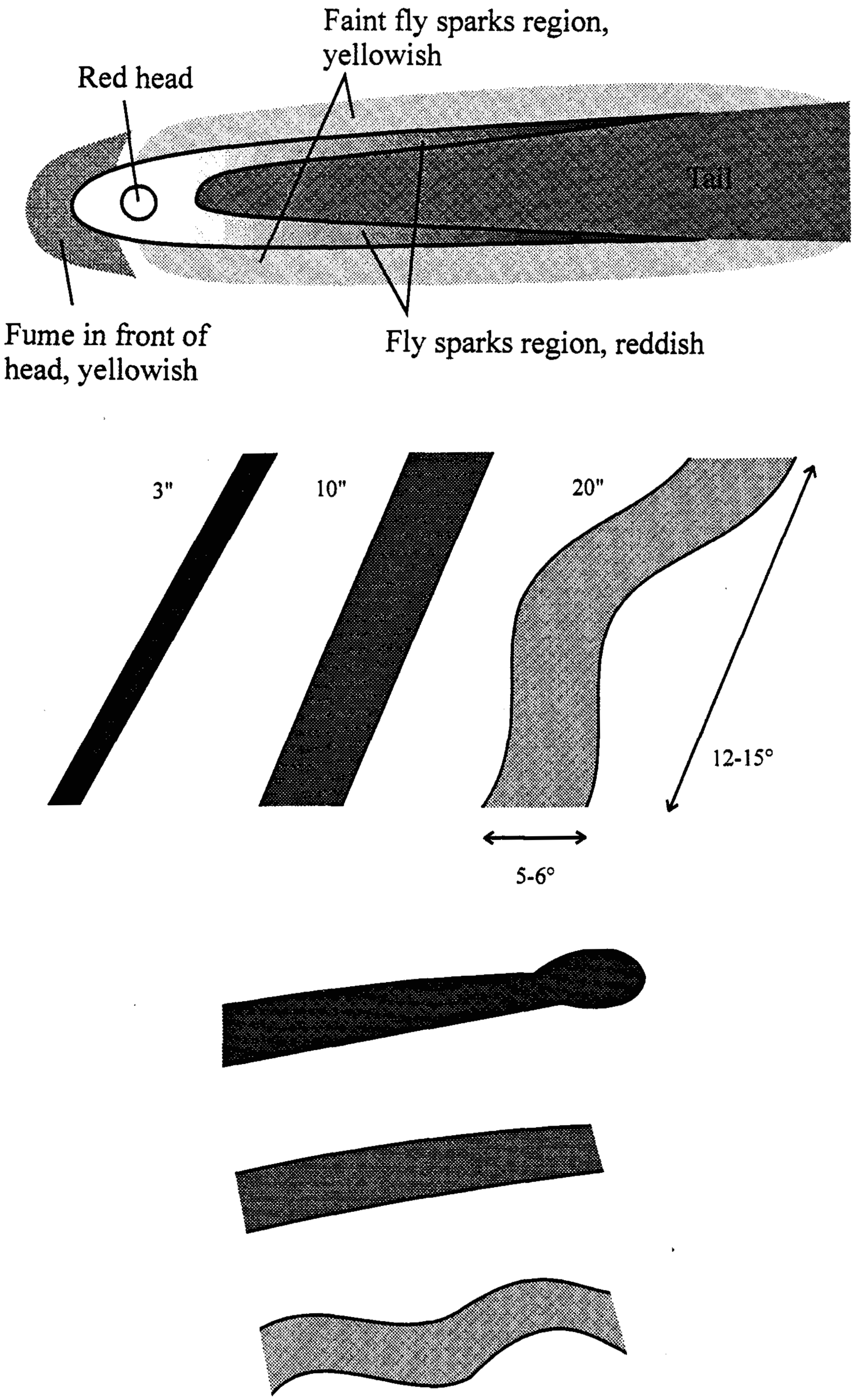

Figure 2 – Drawings of visual observers from Prvić. *Top*: Fireball details as seen by Jurica Matković. *Middle*: Evolution of the persistent train as seen by Drago Sirivica. *Bottom*: Observations of Iva Ivas, Ana Petković, and Daša Berić. (1) The fireball was yellow, long, and brilliant with a flash towards the end; (2) it left a persistent train expanding with time, with a feeble green color; (3) at the end, the persistent train became wavy and curved, and disappeared after about 25 s to the naked eye.

6. The astrometric measurements

To obtain the atmospheric track of the fireball, we used the two photographs, from Prvić and Cusercoli. The first step was to identify the same features on the two trails (homologous points), taking care of different scales and detail of the photos.

In Figure 4, some points on the trail are defined, using the same numbers for the homologous points 3, 5, and 6, then used for triangulation. As second step, we measured the position of these points in the Bečvář Atlas as presented in Table 1. Inaccuracy introduced by other factors persuaded us to use this easy and fast method rather than a more rigorous procedure [7].

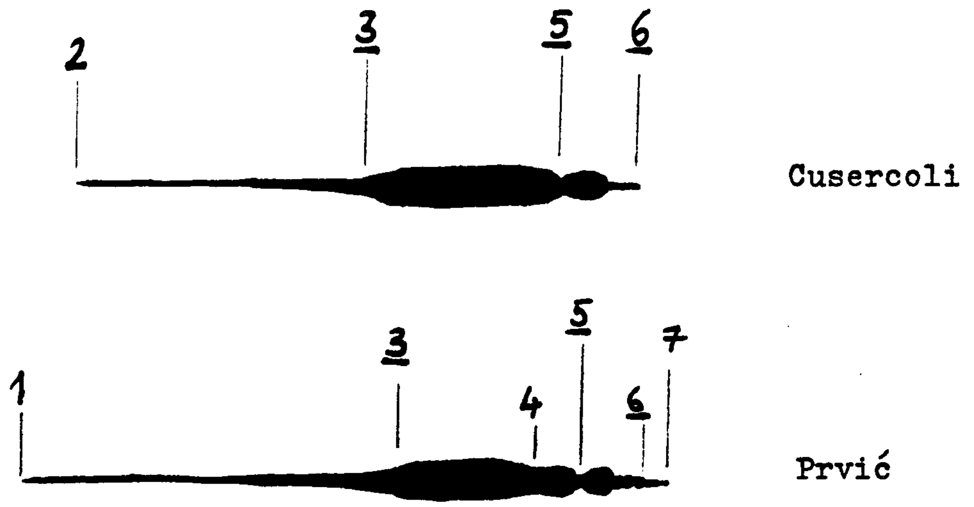

Figure 3 – Identification of some interesting points on the fireball: (1) beginning of track in Prvić; (2) id. in Cusercoli; (3) increase in brightness; (4) weak narrowing of track in Prvić; (5) major narrowing between flares; (6) end of big pillar in Prvić and end of track in Cusercoli; and (7) end of track in Prvić.

Table 1 – Positions of some important points on the fireball. The right ascensions and declinations are given with respect to the equinoctium 1994.6.

Site	Point	Description	α	δ	A	h
Prvić	1	beginning of track	318°.1	+53°.0	303°.6	61°.2
Prvić	3	increase in brightness	305°.4	+43°.1	288°.7	51°.1
Prvić	5	major narrowing	300°.7	+37°.6	283°.4	45°.6
Prvić	6	end big pillar	298°.7	+35°.4	281°.7	43°.2
Cusercoli	2	beginning of track	69°.3	+15°.6	90°.1	22°.8
Cusercoli	3	increase in brightness	70°.4	+11°.8	92°.3	19°.4
Cusercoli	5	major narrowing	71°.0	+ 9°.4	93°.7	17°.4
Cusercoli	6	end big pillar	71°.2	+ 8°.4	94°.3	16°.5

7. Computation of the atmospheric track

A major problem was a systematical error imputable in Cusercoli's observation. We found that the duration of the exposure (reported as 10 minutes) was actually only 8.5 minutes. In other words the timing of the exposure was not reliable. Nevertheless, using graphical methods, we noted that a good agreement with data from Prvić was achievable if the start of Cusercoli's exposure was around the time of fall, i.e., $1^h31^m32^s$ UT.

Figure 4 – Geographic map with the atmospheric track of the fireball and the observing sites (indicated with the symbol "⊕.")

Measurements in Table 1 were made with respect to this condition. We must point out that some other geometrical parameters, such as the intersection angle between views and very different distances to the fireball, were far from optimal [5]. In spite of these problems, we obtained the atmospheric track with a good reliability, as presented in Figure 4.

The fireball traveled over the islands of the Dalmatian Coast off Zadar and had a height from 117 km down to 73 km above the Adriatic Sea. The numeric values are as follows:

Beginning: $\lambda = 15.^\circ1$ E, $\varphi = 44.^\circ06$ N; $h = 117.5$ km;

End: $\lambda = 14.^\circ8$ E, $\varphi = +43.^\circ87$; $h = 73.5$ km;

Length of track: 54.4 km;

Time of fall: August 12-13, 1994, $1^h31^m32^s$ UT.

8. Discussion

Besides triangulation, some other investigations appear interesting. Backward extension of the paths plotted on gnomonic maps prove that the fireball was a Perseid (Figure 5). The observed radiant lies at $\alpha = 45°$, $\delta = +59.^\circ5$, only two degrees away from the literature value ($\alpha = 46°$, $\delta = +58°$, eq. 2000.0).

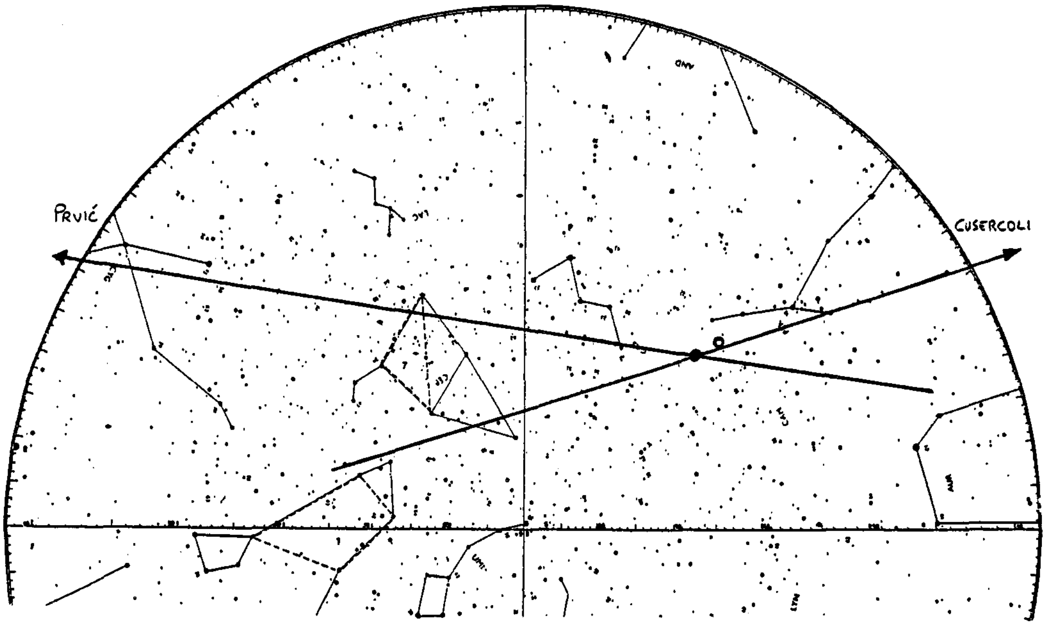

Figure 5 – Gnomonic polar map with intersection of backward extensions of photographic tracks and radiants.

With an atmospheric track of about 54 km long, using the known geocentric velocity of the Perseids (59 km/s), the fireball duration was about 1 second, in good agreement with the observations. The comparison between visual and photographic data appears encouraging. Visual observation from Pigra and Collepardo match very well with triangulation, within 1°–2°. This result shows that a fireball's visual observation can be of remarkable utility if correctly made with the required accuracy.

This fireball was widely observed from Italy only because it fell in in the Perseids' maximum night. Our country does not at this moment dispose of an array like the European Network in Central Europe. The only two Italian all-sky cameras are located in Venice and Pigra (Como), but they are operated manually, so do not cover the sky all nights.

With this situation, the probability that a major sporadic fireball falls without any registration is too big, as recently occurred on January 19, 1993, over the Emilia region [1]. With the hope that this situation can change fast, a near-future project could be a guideline on aims and methods of visual observation of fireballs.

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Two Head-on New Zealand Fireballs in October 1994

Graham W. Wolf

Two unusual head-on approaching flashes of light were observed from Steeple Rock near the mouth of Wellington harbor in October 1994, during Orionid meteor watches. Both lasted only briefly. These are described in detail, and an attempt is made to identify them. Other causes such as Optical Gamma Ray Emitters (OGREs) or upper atmospheric nuclear tests are easily ruled out, and it is subsequently established that the events were almost certainly head-on fireballs.

1. Introduction

These events were observed by chance, during the course of monitoring the 1994 Orionid meteor shower. The observing site was Steeple Rock near the entrance to Wellington Harbor, and is given by coordinates 174°50′18″ E and 41°09′42″ S. The site is 5 m above sea level, and has a clear light unpolluted view from the South through East to the North. The street lights of Eastern Wellington are shielded from the observer by a 15 m bank to the west of the site and located about 20 m away. On a good clear moonless night, the Zenith Limiting Magnitude (ZLM) can reach as good as 5.8. Wellington International Airport, located some 2 km to the South, has a flight "curfew" from 10^{h} p.m. to 7^{h} a.m. local time, so no aircraft fly nearby during darkness hours.

2. The events

The first "event" took place at $16^{\mathrm{h}}04^{\mathrm{m}}22^{\mathrm{s}}$ UT on October 12. At a position later determined to an accuracy of 1° in both axes to be $\alpha = 5^{\mathrm{h}}40^{\mathrm{m}}$, $\delta = -12°$ (eq. 1950.0), a brilliant flash was observed. This position is a little above and to the left of Rigel in Orion (for southern observers). The flash was not moving, but rapidly grew to about 3′ diameter. It flared quickly to magnitude −8, and faded away to nothing over a period of about 3 seconds, for a total of some 4 seconds. At its brightest, it was equivalent in brilliance to the crescent moon. It left a 5 second train. The ZLM at the time was +5.6.

The second "event" took place at $13^{\mathrm{h}}50^{\mathrm{m}}05^{\mathrm{s}}$ UT on October 15, just 3 days later, whilst again undertaking an Orionid observing session at Steeple Rock. This time, the object flared to magnitude −3, and faded away over a total period of one second. The position, again to an accuracy of 1° in both axes, was found to be $\alpha = 2^{\mathrm{h}}00^{\mathrm{m}}$, $\delta = +20°$ (eq. 1950.0). The position, for southern observers, is located a little above and to the left of the magnitude +2 star Hamal in the constellation of Aries.

Table 1 – Physical characteristics and weather characteristics.

Date	October 12, 1994	October 15, 1994
Time UT	$16^{\mathrm{h}}04^{\mathrm{m}}22^{\mathrm{s}}$	$13^{\mathrm{h}}50^{\mathrm{m}}05^{\mathrm{s}}$
Magnitude	−8	−3
Duration	4 seconds	1 second
Size	3′	1′
α	$5^{\mathrm{h}}40^{\mathrm{m}}$	$2^{\mathrm{h}}00^{\mathrm{m}}$
δ	−12°	+20°
Train	5 seconds	2 seconds
Ablates	nil	nil
Sounds	nil	nil
Temperature	4.°7 C	4.°2 C
Total sky cloud	20%	30%
Wind	2 kts SW	35 kts SW
Barometric	1003 hPa	1005 hPa
ZLM	+5.6	+4.5

3. Discussion

OGREs were ruled out, since a visual gamma-burster event has apparently never been witnessed on the ground, despite calls for observations by Dr. Bradley Schaefer of NASA-AMES through the journal *Sky and Telescope*. A high-altitude semi-orbital nuclear test, similar to that exploded 400 km over Johnson Island in the early 1960s was also ruled out, since no aurora was seen after even 20 minutes of careful visual scrutiny; a false aurora usually results from such nuclear activity. It should be mentioned that nuclear explosions have been internationally banned from outer space for some 30 years! Head-on meteors have been reported rarely in the literature, but they have indeed been reported. I can recall some years ago, in *Sky and Telescope*, a photo taken with an all-sky meteor camera taken near Ondřejov Observatory, that shows a head-on magnitude −13 fireball, so it *has* happened before.

After weighing up all the arguments, I am left with the less sensational and more reasonable assumption, that the two events witnessed, were in fact head-on fireballs.

Observational Results

The 1995 η-Aquarids from Brazil

Gilberto Klar Renner

An overview is given of Brazilian observations of the 1995 η-Aquarids.

The η-Aquarid meteor shower was observed in 1995 by four observers working at the same location near Porto Alegre, in Southern Brazil. They were the same who observed the shower last year [1]. Once more the η-Aquarids have had a good activity on those days.

On May 5 the shower was only observed for a few minutes because of the bad sky conditions. The ZHR values obtained are very uncertain.

The observers that participated in the η-Aquarid observations in 1995 were Darlan Morais, Gilberto Klar Renner, Luís Antônio Reck de Araujo and Luís Antônio da Silva Machado.

Tables 1 and 2 summarize our observations. Solar longitudes are referred to equinoctium 2000.0.

Table 1 – The η-Aquarids observed in Brazil in 1995. One asterisk means the effective time ($T_{\rm eff}$) varied from 0.2 to 0.47 hours, two asterisks mean it varied from 1.0 to 1.38 hours.

$\lambda_\odot$	Date	$T_{\rm eff}$	Obs	$\overline{Lm}$	η-Aqr	$\overline{m}_{\eta-\rm Aqr}$	ZHR	Spor	$\overline{m}_{\rm Spor}$
43°47	May 04	1h63	3	+6.0	147	+2.50	76 ± 10	64	+3.17
44°43	May 05	(*)	4	+5.7	45	+2.07	141 ± 43	13	+2.15
47°32	May 08	(**)	4	+5.8	181	+2.56	101 ± 16	79	+2.92

Table 2 – Magnitude distribution of the 1995 η-Aquarids and the sporadics, as seen from Brazil.

Shower	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot	$\overline{m}$
η-Aquarids	0	5	17	59	96	115	72	9	0	373	+2.48
Sporadics	0	3	2	15	37	32	55	12	0	156	+2.96

Reference

[1] Renner G.K., "The 1994 η-Aquarids in Southern Brazil", *WGN* 23:1, February 1995, p. 17.

SPA Meteor Section Results: July–August, 1995

Alastair McBeath

An overview of data sent to the *SPA Meteor Section* from July and August is presented. A massive fireball near the end of July, one of the most impressive and widely-seen meteors over the British Isles for many years, was one main highlight of the period, but a minor α-Capricornid "outburst" on July 29-30 was also seen, along with some enhancement of activity from the late stages of the 1995 Perseid outburst.

1. Introduction

July and August brought unusually hot, dry, clear weather to Britain for once, albeit many clear daylight skies became hopelessly hazy or cloudy by night. As expected, meteor and hours' totals were not as high as normal because of moonlight affecting the Perseid maxima in August. In such years, attention is switched to the lower activity of the Aquarid and Capricornid streams, though none of these are seen to best advantage from the UK. Table 1 condenses the observations reported to date.

In addition to these figures, Alan Heath reported $0\overset{h}{.}83$ radio work close to the predicted first Perseid maximum time. All but around 4.6 photographic hours were provided by the German *Arbeitskreis Meteore* (*AKM*) observers, although the only trail reported so far has come from Tom McEwan, who caught a fine Perseid just ending off the frame in $3\overset{h}{.}35$ in August. Peter Craven in Finland contributed the remaining camera time. Notable visual efforts were made by members of the *AKM*, Graham Wolf (New Zealand), Vasile Micu (Romania), Tim Cooper (South Africa), and Tony Markham, Ian Rigney, and Alastair McBeath (UK). Other observers who contributed results, and who have not yet been named, were: Members of Ayr Astronomical Society, Shelagh Godwin, Brian Kelly and Alexei Pace (Malta).

2. July

The majority of watches were carried out in the latter stages of the month, well after Full Moon, by which time activity from the Aquarids and Capricornids was already well established, and some early Perseids were being reported by the more northerly observers, although Tim Cooper in South Africa mentioned noting one long-pathed Perseid from his site; almost as rare as an η-Aquarid from Britain!

Preliminary results suggest the Southern δ-Aquarids may have peaked around July 28, but results for them are confusing due to the various radiants in close proximity to one another, and observers at sites in northern Europe find problems with their large radiant zenith distances for most of the night too. Sagittarid activity was also in reasonable evidence, certainly up to mid-month, according to results from New Zealand and South Africa.

July 28-29 was notable over Britain for the spectacular fireball which probably reached magnitude -20, and produced a massive detonation, both visual, electrophonic and acoustic, near the city of Sunderland in north-east England around 22^h53^m UT. Data were still being received on this object in early November, but the west-east track established earlier (cf. [1] or [2]) has now been confirmed by a spectrograph photo by Dr. Henry Soper on the Isle of Man. The first and second order spectra are still being measured, and any results established will be presented in WGN in due course. Dr. Soper's photography also helps rule out the possibility that two similar meteors on perpendicular paths appeared over northern England that night.

The α-Capricornids appear to have produced a rather more pronounced peak than normal the following night (July 29-30). Observations from Britain, Bulgaria (data presented by Valentin Velkov and Eva Bojurova at the 1995 *IMC* [3]), Germany, South Africa, and New Zealand confirm that the α-Capricornid maximum occurred on that night, with ZHRs of the order of 10, somewhat higher than the 3–5 we might normally expect. This slightly enhanced rate seems to have declined after 01^h UT, with best activity noted from around 23^h–00^h30^m UT.

In addition, several fireballs were reported to *FIDAC* on nights around then [4], including two bright α-Capricornids seen at $22^{h}52^{m}$ UT on July 29, one each by Jürgen Rendtel in Germany and Alastair McBeath in Britain, curious timing, almost exactly 24 hours in the wake of the Sunderland fireball, although this major fireball was probably not an α-Capricornid.

Table 1 – Visual and photographic hours' totals and meteor numbers recorded in each month, including a partial breakdown of meteor types and numbers of photographed meteor trails notified so far.

Month	Vis	SAG	SDA	NDA	CAP	PER	Met	Photo	Trails
July	$117^{h}.57$	47	148	44	105	84	963	$140^{h}.16$	0
August	$184^{h}.27$		120	30	27	1040	2312	$249^{h}.15$	1

3. August

Most of the meteor observing reported from August took place in the first ten or last nine days of the month, with only a very few people making the attempt to brave the bright moonlight and cover the Perseid peaks. Shower activity at such times was of the order we would normally expect, with low ZHRs from the minor Aquarid/Capricornid, κ-Cygnid, and, later in the month, α-Aurigid streams. The Perseids showed something of their usual slow ascending branch before their peaks around August 12, and near their primary maximum *AKM* observers in Germany and Vasile Micu in Romania caught what was probably the very tail end of the first peak near the start of their watches very early in the night of August 12-13. The full *IMO* report on the shower is naturally eagerly awaited, as always!

The late-month data saw the first meteor plots made in the Section's new regular plotting project covering the Aurigid and Taurid showers. A further project covering the Virginids in the early part of the year is also planned to begin in 1996. The concept is to build a database from several years which can then be analyzed together to help remove problems encountered due to clouds and moonlight in any one year.

4. Conclusion

Another odd near-coincidence of fireballs in late July to follow on from that reported earlier in the May–June *SPAMS* notes continues to exercise minds, and provided interest in a period when other activity could not be seen at its best. The probable enhancement of α-Capricornid rates on July 29-30, 1995, was also a welcome event. Once more, I wish to express my gratitude to all the observers and correspondents who have provided the news to make this article possible. Clear skies for your next observations!

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Complex Summer Meteor Activity Monitored

Godfrey Baldacchino

An overview is given of the attempts made by the Maltese *Astronomical Society Meteor Group* to monitor the Aquarid and Capricornid activity.

1. Introduction

One of the most challenging tasks facing amateur meteor watchers is to monitor the difficult regions of Aquarius and Capricorn during the months of July and August. The explanation for this is the existence of at least six active meteor streams, some with radiants lying uncomfortably close to each other. The low declination of most of these meteor radiants also means that the showers are not very well observed from northern latitudes, where the bulk of the world's active meteor observers are located.

2. Site

The *Astronomical Society Meteor Group* (Malta) set out to observe meteor activity in this difficult part of the sky as its main observational meteor project during MASP 1 (the first Meteor Activity Summer Project). This was held from August 21 to August 26, 1995, with a base at Centru Anton Buttigieg, part of the sprawling former British Military Barracks overlooking Ghajn Tuffieha Bay. The selected observation site was a concrete platform adjacent to a derelict observation post (what else?), situated a few meters away from the cliff edge at Ras il-Wahx.

3. Program

All observations were carried out on a group basis, with two teams on duty per project night, whenever the weather permitted. Watches were each approximately two hours long, starting at around 21^{h} to 1^{h} UT. Given the unstable weather conditions prevalent at the time, with at least two outbursts of rain and shifting wind directions and velocities, useful observations were only conducted during three of the five project nights: August 21-22, 22-23, and 25-26. Six group watches were thus held in all.

Observing conditions were quite satisfactory. A glow caused by light pollution to the south-east became less of a hindrance as the night wore on. Otherwise, the sky was clear and moonless, with ratings of stellar limiting magnitude among the best that could be achieved from a Maltese site. This started off at limiting magnitude 5.4, rising steadily to 6.2 towards the end of the observing stretch.

4. Observers

All MASPers (8 males and 4 females) contributed to the observational effort to the best of their varying abilities. Seasonal meteor observers were joined by newcomers to the hobby. The 12 participating observers are listed below. Observers are accompanied by their code and the total observing time in hours:

> Anna Baldacchino (**BALAN**, $3\overset{\mathrm{h}}{.}9$); Godfrey Baldacchino (**BALGO**, $3\overset{\mathrm{h}}{.}9$); James Baldacchino (**BALJA**, $3\overset{\mathrm{h}}{.}9$); Stephanie Chircop (**CHIST**, $5\overset{\mathrm{h}}{.}1$); Deborah Esposito (**ESPDE**, $4\overset{\mathrm{h}}{.}1$); Erika Esposito (**ESPER**, $4\overset{\mathrm{h}}{.}4$); Pierre Gatt (**GATPI**, $5\overset{\mathrm{h}}{.}1$); Martin Galea Degiovanni (**GALMA**, $5\overset{\mathrm{h}}{.}1$); Darren Mizzi (**MIZDA**, $4\overset{\mathrm{h}}{.}4$); Jacob Sammut (**SAMJA**, $3\overset{\mathrm{h}}{.}9$); Clayton Saliba (**SALCL**, $3\overset{\mathrm{h}}{.}6$); and Joseph Zammit (**ZAMJO**, $5\overset{\mathrm{h}}{.}1$).

5. Objectives

The purpose of the project was to improve knowledge of the activity and dynamics of five different annual meteor streams during the third week of August. Alleged to be active during the period in question are the following streams: α-Capricornids, Northern δ-Aquarids, Northern ι-Aquarids, Pisces Australids and Southern ι-Aquarids. Other meteors were expected from a sixth radiant, that of the κ-Cygnid stream, active at the time but whose radiant is somewhat distant from the region in question.

6. Results

In total, 51.1 hours of observation by the 12 observers secured 201 meteor events in all, of which 90 were recorded as shower and 111 as sporadic meteors. These were plotted on a map prepared by Vladimir Znojil from the Czech Republic, the same map used by the *International Meteor Organization* in its 1989 Aquarid project.

None of the observers had clear ideas as to the location of the allegedly active radiants. These were computed by interpolation from the *IMO*'s 1995 Meteor Shower Calendar and kept on a master map. The actual shower identity of each meteor trail was worked out after each watch, when observers plotted trails backwards in relation to given radiant positions.

7. Commentary

The α-Capricornids and κ-Cygnids stole the show with their display of more numerous, and also more relatively bright, meteor members. The κ-Cygnids were busy closer to their predicted maximum on August 19, but the Capricornids were still putting up a brave display at the very limit of their alleged activity phase, and well away from the predicted date of maximum activity (July 30). It may prove necessary to revise our knowledge of the α-Capricornids stream and consider extending its activity limits in the light of the evidence.

The opposite seems to be the case wit respect to the Northern ι-Aquarids, with their expected maximum on August 20. Hardly any meteors were seen belonging to this stream, even though observations were close to the expected time of peak activity and well within the shower's limits, which are expected to drag as far as September 20.

Only a trickle of possible Piscid Australis were seen. This shower meant to stop activity, according to working data, by August 17.

Both Northern δ-Aquarids and Southern ι-Aquarids meant to come to a halt by August 25, certainly put in a solid presence, in spite of a distant predicted peak date (August 12 for the Northern δ-Aquarids and August 4 for the Southern ι-Aquarids). Again it may prove wise to revise the limits of these streams, extending them further.

8. Conclusion

This project was an interesting exercise in the challenges of accurate meteor plotting. Of course, to err is human and the results reported above need to be confirmed by more accurate telescopic and binocular meteor watching. But definitely, more attention needs to be given to the Aquarid-Capricornid summer radiant complex. An indication of their marginal status in the meteor world is the realization that there are no polygons earmarked for stellar limiting magnitude determination in that part of the sky. The closest ones (still too far away to be of any use) are number 5 in Aquila and number 6 in Pegasus.

Dutch Perseids Observations of August 12-13, 1995

Marco Langbroek

Observational results are presented on the Perseids of August 12-13, 1995 by a team of the *Dutch Meteor Society*, the Netherlands. During the interval 20^h40^m–00^h05^m UT, activity was observed to be at a normal annual level. However, a minor but intriguing excess of bright meteors is noted in the data.

After four "near-comet type" (see [1]) outbursts of the Perseid stream on a row during the years 1991–1994, the possibility of a fifth outburst in 1995 could not be neglected. Though a near Full Moon hampered observations, several observers in the *Dutch Meteor Society* arranged for observational activities in the late evening of August 12. Though best chances for an outburst were for the period just before sunset (i.e., not visible for Dutch observers), the possibility of high activity in early twilight could not be ruled out.

Unfortunately, a dry and clear continental airflow which had prevailed for days changed in moisty western winds that day, resulting in hazy skies and cirrus clouds. Several stations had to face conditions which were too bad for serious observational activities.

One of the few exceptions was a team, including the author, which had settled in the western coastal dune district, on the glider airfield of Langeveld ($\lambda = 4°30'$ E, $\varphi = 52°18'$ N), near the town of Haarlem. In the coastal district, the sky cleared from cirrus and haze just before sunset. Unfortunately, this situation would not prevail for long.

After setting up the (photographic) equipment, with approaching and departing glider airplanes as a background, sunset was anticipated with excitement. Excitement changed into worry when we noticed fields of cirrus low at the western horizon, which seemed to come nearer. During early twilight (19^h30^m–20^h30^m UT), a large patch of thick cirrus occupied the larger part of the sky, including the zenith. It disappeared around the end of nautical twilight, though haze and small streaks of cirrus were present during the full observational interval of 20^h40^m–00^h05^m UT. Limiting magnitudes were near +5.2 typically. At midnight, we had to quit observations: a massive cirrus cover spread across the sky, soon to be followed by stratocumulus.

Table 1 – Perseid magnitude estimates at August 12-13, 1995, 20^h40^m–00^h05^m UT by a team of *Dutch Meteor Society* (The Netherlands) seem to indicate a minor but intriguing excess of bright meteors.

Observer	−3	−2	−1	0	+1	+2	+3	+4	+5
G. Docters van Leeuwen	2	1	0	0	1	3	11	13	1
M. Langbroek	0	4	0	2	1	3	10	9	1
P. van Tongeren	2	3	0	2	1	2	6	2	0
H. Klück	0	0	1	1	0	2	6	0	0

During early twilight, with a large part of the sky occupied by clouds, we got the impression of a quite good Perseid activity. A few bright Perseids of negative magnitudes were seen low at the horizon. The sky situation did not permit serious observations, however. When darkness advanced and the clouds disappeared largely (and the Moon became more and more a nuisance), meteor activity was found to be quite boring. Together, this sparked the impression that activity during early twilight might have been somewhat higher than usual, an impression independently reported by Belgian observers [2]. However, we are not able to support this impression with hard data.

Data from late twilight onward (20^h40^m–00^h05^m UT) are presented in Figure 1. Observers of whom data have been used are Guus Docters van Leeuwen, Hans Klück, Petrina van Tongeren, and the author. Though the uncertainties in the ZHR determinations are evidently larger than usual due to the low numbers of meteors observed (interfering moonlight, partial cloud cover, and low radiant altitude), the determined activity is compatible with the normal annual level for this solar longitude ([3], shown by a dashed line). Please do note that the correction factors involved before arriving at the depicted ZHR-values are large, and thus should be interpreted with care. Obviously, due to the observing conditions this is not one of the better sets of data the reducer would wish.

One of the other aspects to be mentioned is that I have assumed the observers to have a "standard" personal perception of $C_p = 1.0$ [3]. The observed numbers of sporadic meteors are too low to calculate a reliable personal perception. The results of Hans Klück came out significantly too low this way (suggesting a C_p significantly deviating from 1.0): thus, I have scaled them to the average of the other three observers at 23^h25^m UT. My own data have been reduced with $C_p = 1.2$, as determined from several recent observational campaigns. Calculations have been carried out according to the procedure outlined in [3].

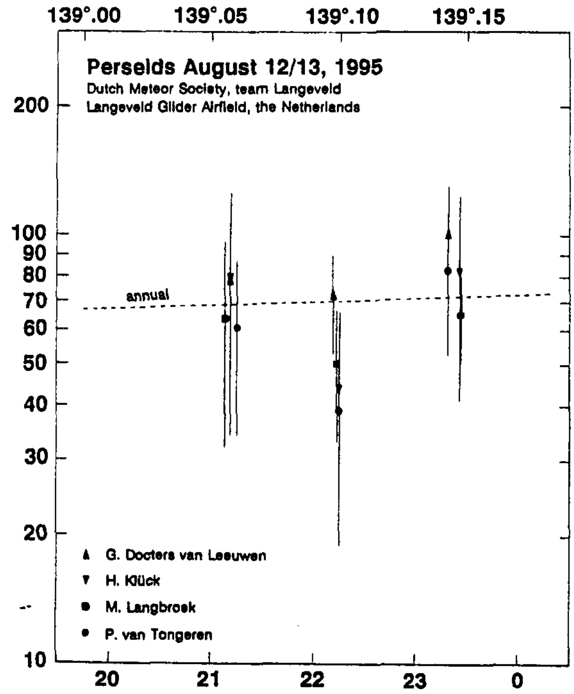

Figure 1 – ZHRs of 4 Dutch observers on August 12-13, 1995 (eq. 1950.0), suggesting normal Perseid activity.

Though the observations are compatible with normal annual rates, there might still be some indication that something unusual has been going on around twilight. In the magnitude distributions of the observers, there seems to be a tendency to an excess of bright meteors in the magnitude −1 to −3 range. Total numbers of observed meteors are low, however, and there is a theoretical possibility that interfering moonlight influenced magnitude estimates, though I do not believe the last option to be a satisfying explanation (a.o., because sporadic data do not show the same phenomena).

At best, this seeming excess of bright meteors might be seen as "circumstantial evidence" that might support a report on high rates (i.e., an outburst) around $18^{h}30^{m}$ UT by the Dutch radio-MS observer Peter Bus. However, a real, reliable confirmation should come from observers at more eastern longitudes. Three of the mentioned bright Perseids have been photographed multistation with two of our other stations. After reduction, the radiant position and orbital elements might indicate if these were indeed part of an outburst component.

Acknowledgments

We thank the *Zweefvliegclub Kennemerland* for hospitality on their airfield, and the *Noordhollandse Duinwaterleiding Maatschappij* for permission to enter their property at night. The photographic campaign should not have been possible without the power equipment sponsored by *Honda Power Equipment* and *Shell Netherlands b.v.*

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SPA Meteor Section Results: September–October, 1995

Alastair McBeath

A compilation of visual, photographic and radio results submitted to the *SPA Meteor Section* from September and October is given. Although September was not an especially good month for observers, October brought a quite well-viewed Orionid return, enabling some magnitude and train details to be derived for the shower, and another brilliant fireball occurred at $2^{h}28^{m}$ UT on October 31. A series of photographs of the morning zodiacal light taken during October were received from Romania.

1. Introduction

September continued the pleasant summer daytime weather for much of the UK, but as in July and August, this frequently meant the night skies were generally not helpful. Even the normally very active German *Arbeitskreis Meteore* (*AKM*) watchers were less so than usual, though several of their leading observers were heavily involved in organizing and running the excellent 1995 *IMC* near Brandenburg.

Table 1 – Visual and photographic hours' totals and meteor numbers recorded in each month, including a partial breakdown of meteor types and numbers of photographed meteor trails notified so far.

Month	Visual	DAU	STA	NTA	ORI	Met	Photo	Trails
September	$36^{h}.04$	53	9	22		434	$220^{h}.81$	0
October	$210^{h}.18$	6	258	85	878	3091	$318^{h}.62$	2

October brought more clearer nights, and with a splendidly Moon-free Orionid return, more incentive to observe too. Table 1 has the overall totals thus far reported. Additionally to these figures, radio observations were received from Robert White in West Sussex, England (267 hours of continuous operation from October 14–25 for 10 579 echoes) and Norman Fitch Surrey, England (96 hours of continuous monitoring between October 18–22). The photography was from *AKM* all-sky cameras of the European Fireball Patrol Network. The list of visual observers (in the UK except where noted) comprised the following persons:

AKM members (Germany, with one observer in each of Spain and Pakistan during October—summaries from Jürgen Rendtel), members of *Astroclub Canopus* (Bulgaria—summaries from Eva Bojurova), Charlotte Bland, Walter Bradford, Peter Craven (Finland), Shelagh Godwin, Valentin Grigore (Romania), Brian Kelly, Richard Livingstone, Alastair McBeath, Tom McEwan, Vasile Micu (Romania), Ian Rigney, members of *SARM* (Romania—details from Valentin Grigore), George Spalding, Graham Winstanley, and Graham Wolf (New Zealand—details from the NZ Fireball Network).

2. September

As noted above, September was poor generally, with most watches taking place in the final week of the month. This was rather unfortunate, as it meant the maximum of the α-Aurigids, expected around September 1, was not covered at all well. The δ-Aurigid peak was affected by Full Moon in 1995, but quite a number were spotted at other times, producing weak ZHRs. Only eleven trails were plotted during the opening part of the Section's meteor plotting project to cover the Aurigid and Taurid showers between late August and the end of October, however. Low early Taurid rates were recorded, mostly by *AKM* watchers, the northern branch apparently the more active at this stage. Watch lengths were normally kept short by conditions, and very few watches over three hours have been notified to us.

3. October

October brought more people out to observe, partly because of improved sky conditions overnight, but partly because meteor activity picked up with the Orionids. Observations were, unsurprisingly, concentrated on the clearer nights around the Orionid maxima, particularly on October 17–18 and 20–22, when shower ZHRs reached 15–20 and 20–30 respectively at best, confirmed by data from Europe, Pakistan, and New Zealand, but between October 27-28 and 30-31, up to three observers a night were out covering meteor activity generally. One report has come via Rainer Arlt [1] of two American observers, Bob Lunsford and George Zay, who recorded a brief burst from the Orionids around mid-day UT on October 22 from California, USA. The ZHR seems to have been around 50, although no other data has confirmed this so far.

Tables 2 and 3 contain details of the global meteor magnitude and train distributions derived from data provided by reliable, experienced observers under clear skies (limiting magnitude at least +5.5, cloud cover less than 20%) during October.

Radio data provided by Robert White and Norman Fitch indicated clear enhancements during the main phase of Orionid activity, although only Robert's data cover right over the expected maximum period. Norman reported his data in graphical form only, and also notes that there were severe problems with radio aurorae during mid October, particularly around October 18-19, which have given rise to some spuriously strong signals in the meteor scatter data. A graph showing Robert White's uncorrected echo counts is shown in Figure 1.

Table 2 – Global magnitude distributions, including mean limiting magnitude and corrected mean magnitudes for the Orionid, Taurid and sporadic meteors seen during October 1995 and reported to the *SPA Meteor Section* under better sky conditions.

Shower	-3^-	-2	-1	0	+1	+2	+3	+4	$+5^+$	Tot	Lm	$\overline{m}_{6.5}$
STA	1	0	1	2	0.5	5	4.5	5	7	26	6.20	2.72
NTA		1	0.5	3	9	7.5	5	4	3	33	6.24	2.37
ORI	4	11	26.5	35	64.5	45.5	35	27	35.5	284	6.01	2.21
SPO	2	3.5	18.5	36	76	72	94	79.5	248.5	630	5.92	4.06

Table 3 – Total numbers of trained meteors (N_{XXX}) and mean train durations in seconds (D_{XXX}) by magnitude class for the Orionids and sporadics. The overall trained meteor numbers (Tot) and percentages (%) are also given. As not all observers who contributed magnitude distribution data also reported train results in full, the total number of sampled meteors is considerably reduced, to 65 Orionids and 173 sporadics.

Shower	-3^-	-2	-1	0	+1	+2	+3	+4	$+5^+$	Tot	%
N_{ORI}	1	0	1	3	5	10	3	1	2	26	40
D_{ORI}	5		4	1.3	1.2	1.1	0.7	1	0.7		
N_{SPO}	0	1	2	5	5	3	1	1	0	18	10.4
D_{SPO}		12	2.2	1.5	1.5	0.6	0.5	0.5			

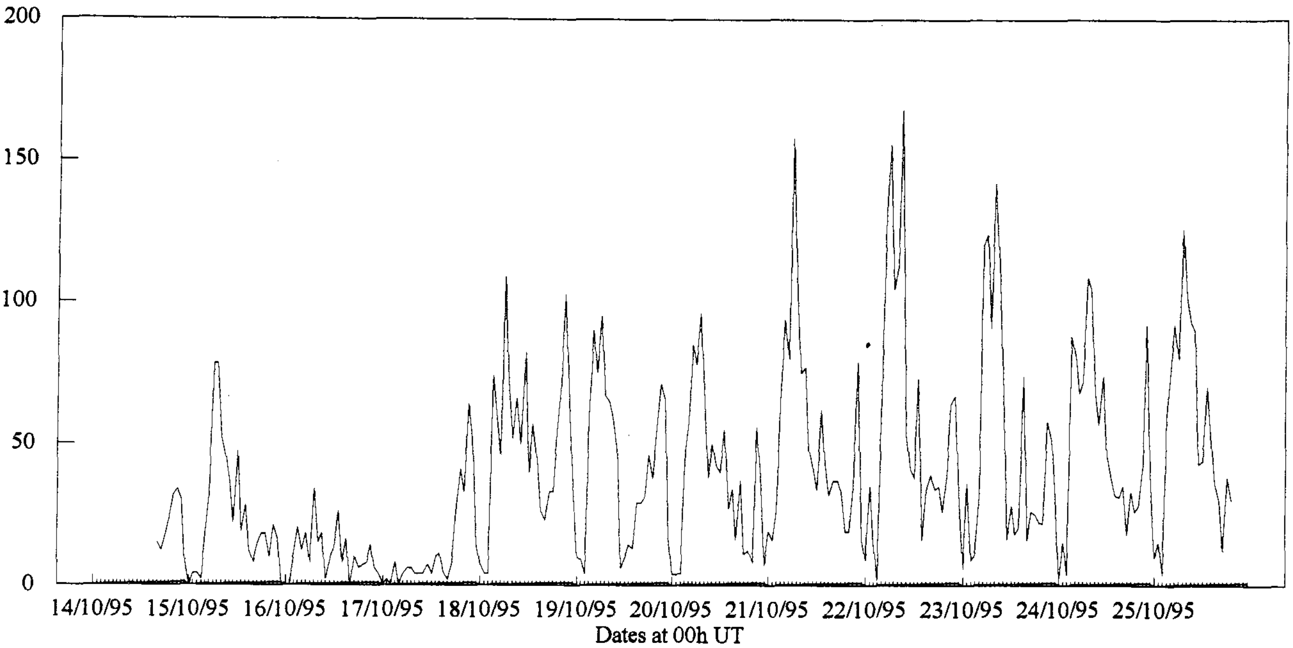

Figure 1 – Raw forward-scatter radio meteor counts produced by Robert White during the second half of 1995 October. Signals around October 18-19 were affected at times by interference due to radio aurorae.

The continuing Aurigid and Taurid plotting projects produced a further 64 recorded trails, but it has so far only been possible to very approximately define the Taurid radiants for one or two nights in late October from these results, as too few potential Aurigid stream members were detected.

Taurids were much in evidence, with ZHRs of the order of 3–8 from each respective stream branch, the Northern radiant seemingly again the more active, although in New Zealand, Graham Wolf reports sighting very few Northern Taurids at all, so this may simply be an observing hemisphere bias. With diffuse radiants so close together, it is often difficult to be precise in assigning shower association for the Taurids, even when plots are made.

Leading observers included Graham Wolf (New Zealand), Vasile Micu and Valentin Grigore in Romania, Jürgen Rendtel and Sirko Molau of the *AKM*, Shelagh Godwin, Richard Livingstone, and Alastair McBeath from the UK. Graham was routinely putting in up to seven hours a night, including two consecutive series of nights between October 14–18 and 21–25 inclusive, often under quite difficult conditions (limiting magnitude approximately +4.3 to +4.7). By contrast, Vasile and Valentin enjoyed limiting magnitudes around +6.3 to +7.5 at times, as well as plenty of meteors, but their total effective observing time was generally about 2.5–5 hours a night. Jürgen was fortunate in visiting the Calar Alto Observatory in Spain near the Orionid maxima, with at least short watches possible on all nights from October 15-16 to 20-21 inclusive. Limiting magnitudes were usually between +6.0 and +6.5. His best night was October 20-21, when in $9^{\text{h}}.24$, he spotted 243 meteors (102 Orionids) in a mean limiting magnitude +6.3 sky. Sirko was never as lucky with the sky, observing from Berlin, but he did spot the sole possible Draconid meteor to be reported to the Section in 1995, on October 10. In Britain, October 20-21 was a fine night too. Alastair managed a $7^{\text{h}}30^{\text{m}}$ watch then, under limiting magnitude +6.1 skies, noting over 150 meteors (40 Orionids), while it was also Richard's best night, and a four-hour watch was possible for him. Shelagh had to wait until October 30-31 for her longest watch, three hours, but this included a spectacular possible Taurid fireball at $2^{\text{h}}28^{\text{m}}$ UT, detailed below.

4. October 30-31 fireball

Although several Orionid fireballs were recorded by Section observers earlier in October, the brightest event was a possible Taurid which occurred at $2^{\text{h}}28^{\text{m}}$ UT on October 31, and was spotted by 6 witnesses at 5 sites in southern England. Most observers recorded the object as being blue or blue-white, although one described it as green, and one as green/blue. Most suggested some sort of flaring or sparks were shed by the meteor, and possibly some late-stage fragmentation as well. A persistent train lasting at least 15 seconds was noted by 5 of the 6 reporters. Approximate positions were obtained from 3 sites, 2 of which were only 10 km or so apart, and accurate triangulation of the flight path has not been possible. The implied track would have been either over the English Channel or Northern France, the object moving in a general SSW-NNE direction. The meteor was clearly very bright, well able to cast obvious shadows (two observers were inside an observatory at the time, and saw the flare light up the inside of the dome, while another witness said the ground was lit up bright enough to identify individual cattle in a field). The most experienced of the witnesses suggested the magnitude was probably around −15.

This seems to have been the first of a number of possible Taurid fireballs reported from sites in Europe between the end of October and mid-November, around nine of which seen reported in the literature or in data submitted to the *SPA Meteor Section*, reached at least magnitude −7. Two of these were reported from Germany [2] and the Netherlands [3] on November 5 at $20^{\text{h}}25^{\text{m}}33^{\text{s}}$ and $20^{\text{h}}35^{\text{m}}$ UT, respectively, and perhaps October–November 1995 was one of the possibly periodic good years for Taurid fireballs (cf. [4] or [5] for further notes on this topic).

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High Activity of the 1995 Orionids in Poland

Arkadiusz Olech and Przemysław Woźniak, Warsaw University Observatory

We report Polish visual observations of the Orionids in October 1995. The profiles of activity, magnitude, velocity, and color distributions are given. Our observations confirm high Orionid activity around October 22.5 UT with ZHR ≈ 50 previously reported by *IMO* observers.

1. Introduction

The Orionid meteor shower was discovered in 1839. It is one of the most active meteor streams in the sky and shows regular behavior. Its activity takes place from the beginning of October to the first week of November. Usually, a broad maximum with ZHR around 15–20 occurs on October 22 ($\lambda_\odot \approx 208.4$, eq. 2000.0), but there are few observations which seem to suggest the presence of a double maxiumum. The last such feature was detected in the 2-hour interval centered on October 18.1 UT, 1993, with ZHR about 35 [1].

2. Observations

There were some clear nights in Poland around October 22, 1995. These conditions allowed us to collect quite a few good observations of Orionids. Thus, from October 1 to 29, a group of 10 observers, the members of the *Comets and Meteors Workshop* (*CMW*), obtained 62^h21^m of observing time with 547 meteors from the Orionid shower detected. The complete list of observers is given below:

> Albert Krzyśków (22^h26^m), Maciej Reszelski (20^h), Arkadiusz Olech (5^h55^m), Krzysztof Socha (4^h), Michał Kopczak (3^h), Marek Jurek (2^h), Marek Samujłło (1^h30^m), Maciej Kwinta (1^h30^m), Krzysztof Wtorek (1^h), and Paweł Gembara (1^h).

Before ZHR calculations, we filtered the data by removing all observations with mean limiting magnitude smaller than 5.0, and with effective time of observation shorter than 30 minutes. Under these conditions, we obtained 60 correct hourly rate estimates. In our calculations, we also adopted a population index $r = 2.9$ and a zenith exponent $\gamma = 1.0$.

3. Results

The activity profile of the 1995 Orionids is displayed in Figure 1. This graph is based only on *CMW* observations. It is clearly visible that the highest point with ZHR = 40.7 ± 5.9 corresponds to October 23.0 UT ($\lambda_\odot = 209.2$, eq. 2000.0). Apparently, the maxiumum occurred later than predicted and had higher ZHRs.

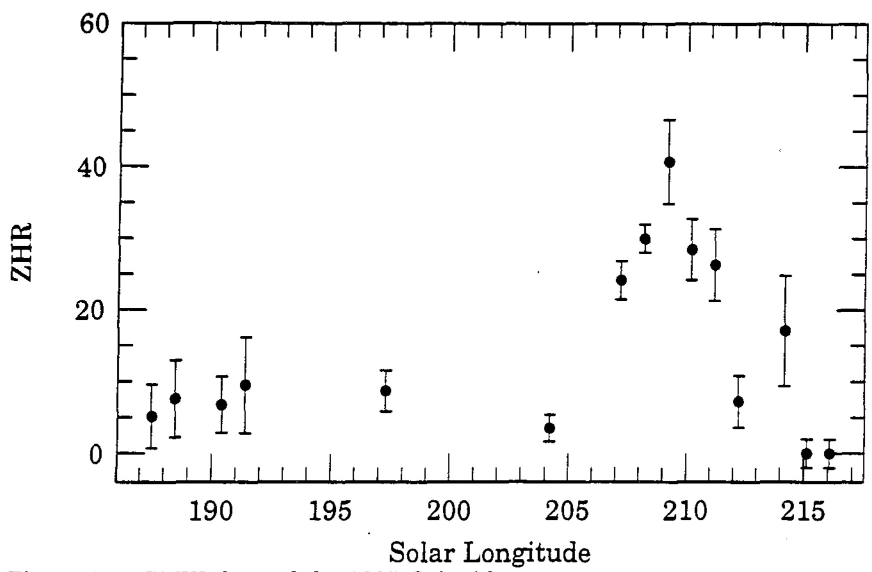

Figure 1 – *CMW* data of the 1995 Orionids.

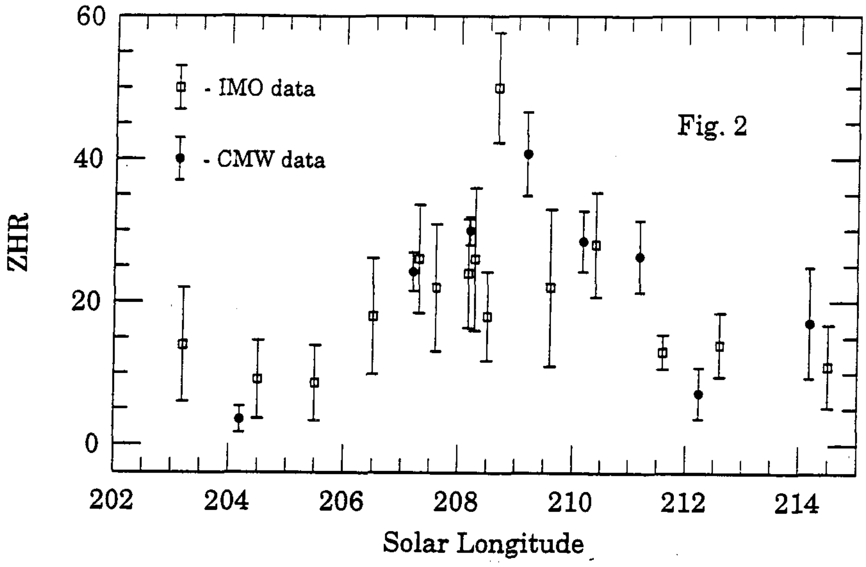

Figure 2 – Comparison between *CMW* and *IMO* data of the 1995 Orionids.

We compared our results with *IMO* observations presented in the *Orionid Circular 1995* [2] to confirm the conclusion. The effect of this operation is shown in Figure 2. Open squares correspond to the *IMO* observations and filled circles to the *CMW* measurements. The results of both teams are consistent and the effect described above is clearly visible. Our observations from the night October 22-23 also confirm high activity of Orionids around October 22.5 UT ($\lambda_{\odot} = 208.66$, eq. 2000.0) with ZHR $= 50 \pm 7.7$ reported by *IMO* observers.

The *CMW* observers also estimated the brightness, velocity, and color of each event. Thus, the apparent brightness was estimated for 547 Orionids. The magnitude distribution is given in Table 1. An average brightness of the meteors from the Orionid stream was 2.6. This value roughly agrees with results from previous years. The angular velocity in 0–5 scale was measured 546 times. The distribution of this quantity is as follows: 0, 1 time; 3, 32 times; 4, 197 times; and 5, 316 times. The mean velocity in this scale was 4.52, which corresponds to 64 km/s. The color was estimated for 497 meteors. Of these, 79.5% were white, 10.3% yellow, 4.3% red and, 2% blue. A trail was detected in 16% of the events.

Table 1 – Magnitude distribution of the Polish 1995 Orionid observations.

Magnitude	−2	−1	0	+1	+2	+3	+4	+5	+6
Meteors	1.5	9.5	31	82.5	123.5	147.5	104.5	41.5	5.5

4. Summary

We reported *CMW* observations of the Orionids in October 1995. Our results confirmed previously published observations of high activity of this stream around October 22.5 UT [2]. *CMW* observers detected 547 meteors from the Orionid stream. The brightness, velocity, and color were estimated for most of them. This enabled us to obtain some new low error points in the activity profile. Unfortunately, the next Orionid maximum will be difficult to observe because of the Full Moon occurring on October 26, 1996. It will be problematic to obtain a comparably good sample of data next year. Nevertheless, we find interest in further observations of Orionids and their broad maximum.

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