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This spectacular −10 δ-Aquarid fireball was photographed by Valentin Velkov, Astroclub "Canopus", Varna, Bulgaria, from Belite brezi on August 2-3, 1992. The photograph was exposed from 22^h59^m to 0^h01^m UT. The fireball appeared at 23^h07^m UT and was so bright that at its peak flare the surrounding stars could no longer be seen. A Praktica camera with 18/50 mm lens and an ORWO 27 DIN film were used.

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

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Contents

Useful Information

The February Issue *(WGN 22:1)*

The *February issue* will be mailed during the first week of February. Contributions are due on *February 14* at the latest. They should be sent to *Marc Gyssens*.

From the Editor-in-Chief

Marc Gyssens

This issue closes Volume 21 of WGN *which has again provided a record amount of information to meteor workers world-wide: never before has a volume of* WGN *contained that many pages. Beyond any doubt, Volume 21 is the most outstanding volume the* IMO *has ever produced, and this not only for quantitative reasons. What, in my opinion at least, is the most striking characteristic of Volume 21 is the wide variety of information offered: contributions by professional astronomers, global analyses of* IMO *data, information for observers, observational data, information on fireballs and meteorites, general articles, historical information, interviews, opinions from meteor workers on various subjects, and administrative information. Particularly noteworthy is the refereed section "Progress in Meteor Science" which has become an integral part of the journal and provides a guarantee for the quality of the most outstanding work submitted to* WGN*. In particular, global analyses are now being produced on a very regular basis and give observers the feedback they are entitled to. Most importantly,* WGN *has more than ever before become a lively forum for meteor workers world-wide.*

All of the above was only possible thanks to the efforts of many observers, active IMO *members, and several colleagues among the* IMO *Council Members and Directors. To all of them, I say, please keep up the good work and encourage interested people around you to join your ranks! On the more down-to-earth level of effectively putting the journal together, I have to thank the many members of the Public Observatory "Urania" for their efforts in typing articles, proofreading, physically assembling all the issues, and doing the mailing. Finally, my warm thanks also to our printer, André Gabriël, for making it possible to offer you* WGN *at such a low cost.*

As far as 1994 is concerned, I hope that the present efforts are not only maintained but also further increased: our work is indeed never finished! Moreover, there is a lot of work that has still to be commenced. Over and over again in these pages, I pointed out that, while visual work is handled fairly satisfactorily within the IMO*, we are still practically nowhere as far as photographic and radio work is concerned. Photographic and radio observers should not feel discouraged by this statement; instead, they should take initiatives to make sure that their work can be properly coordinated! While in an organization such as the* IMO *collaboration ensures that the whole is more than the sum of its constituents, the work nevertheless has to be done by individual persons. Therefore I invite each and every person who feels that he/she is being personally addressed by these words to either continue or start, however modest, contributing to our common Organization to make it ever more successful.*

Turning back to WGN *there is every reason to believe that Volume 22 will be at least as exciting as the volume we are about to close, so you certainly do not want to miss out on it. Nevertheless there are many subscribers who have not yet renewed, probably because they forgot, and that is very sad, because this is the last issue they are going to receive. Because it is our policy to run* WGN *on a tight budget, we cannot afford to continue sending issues to late renewers in the hope that they will eventually pay. To these people, I say, make life easier for both you and us and renew at once. The renewal information given in the last issue is reprinted below!*

1994 Membership and Subscription Renewal

Ina Rendtel and Marc Gyssens

At the *IMC* in Puimichel, the *IMO* Council decided to keep the annual **membership/subscription dues** at **25 DEM**. People outside Europe wishing **airmail delivery** pay **40 DEM**. In addition, the Council has decided to offer a **combined subscription** to the three periodical series of *WGN* (the *Bimonthly Journal*, the *Observational Report Series*, and *FIDAC News*) for just **60 DEM**. People outside Europe wishing **airmail delivery** pay **80 DEM** for this combined subscription. **Supporting Members** pay **15 DEM extra**.

Preferably, payments should be made in in German marks (DEM) to the **postal (giro) account** of Ina Rendtel, Gontardstraße 11, D-14471 Potsdam, Germany. The account number is 5472 34-107 and the post office code is 100 100 10 (Postgiroamt D-10916 Berlin). **Please note that post office code and postgiroamt must always be mentioned together with the postal account!** It is now also possible to pay Ina by **international postal money order**. If you do not mind violating some postal regulations and if you are prepared to take the risk, you could also consider sending the required amount to Ina **cash**, in bank notes. This is by far the easiest way to pay! To reduce the risk, make sure that the bank notes are not visible through the envelope!

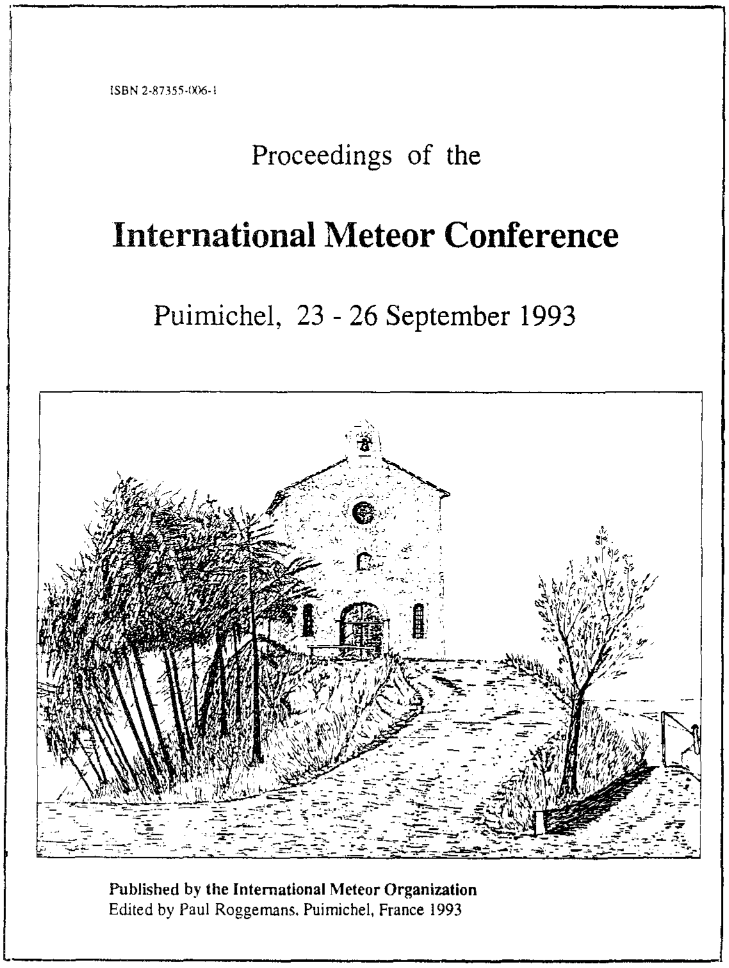
People who can only pay **from a bank account** should make an **international bank draft** payable in USD to Peter Brown (address on inside of back cover). It is also possible to pay by personal check drawn on a US bank in this way. In this case, the membership/subscription dues (this journal only) are 20 USD (without airmail delivery) or 30 USD (including overseas airmail delivery for destinations outside Europe). The combined subscription then costs 45 USD (without airmail) or 60 USD (with airmail). Supporting Members pay 10 USD extra. Please, **do not send checks to Ina Rendtel!**

For Belgian, British, or Japanese subscribers, we refer you to the information given in the October issue.

To conclude, a few more words regarding your payment. On the outside backcover of this issue we have printed the list of all available *IMO* publications. If you intend to buy some of them shortly, may we suggest that you combine the order with your renewal? In this way, you will save a lot on the bank costs involved in international payments. Also, indicate in the message accompanying your payment exactly what you order. If you pay for a combined subscription and/or supporting membership, or if you order publications as well, mention this explicitly. And finally, **do not postpone your renewal any longer**! Otherwise, this will be the last issue you receive! Furthermore, by renewing in time, you help IMO by allowing us to determine accurately how many copies we need to print of Volume 22 of *WGN* and thus keep costs low. As well, we do not need to send you back issues afterwards, which is a time-consuming business. Thank you for your understanding and your cooperation!

New: 1993 IMC Proceedings

edited by Paul Roggemans


ISBN 2-87355-006-1

Proceedings of the

International Meteor Conference

Puimichel, 23 - 26 September 1993

Published by the International Meteor Organization
Edited by Paul Roggemans. Puimichel, France 1993

The Proceedings of the 1993 *International Meteor Conference*, which took place in Puimichel, France, from September 23 to 26, 1993, are presently under preparation.

They will contain 30 different contributions, in total well over 100 pages of very interesting meteor literature:

- 1993 Perseids;
- Radio meteor work;
- Meteor photography;
- Fireball analyses;
- Telescopic results;
- Video observations;
- Meteoroids near Mars;
- The Taurid Meteoroid Complex;
- The Tunguska event;

and many other subjects...

If you participated in the 1993 *IMC* you will receive your copy of the proceedings as part of your registration fee, probably in March 1994.

Non-participants are encouraged to order their copy now, in conjunction with their subscription renewal.

The price for the *Proceedings of the 1993 International Meteor Conference* is 12 DEM or 9 USD post paid (surface mail delivery). Ordered copies will also be mailed in March 1994.

Letters to WGN

compiled by Marc Gyssens

Radio reflection duration and visual magnitude

The controversy surrounding this subject triggered by an initial letter from George Zay in last year's December issue (WGN 20:6, p. 210) *continues to bring reactions. Below, Jean-Marc Wislez and Knud Bach Kristensen give their respective opinions.*

In reaction to the current discussion in *WGN* about the relation between the radio echo duration and the visual magnitude of meteors, I would like to give an overview of parameters affecting the echo duration according to theory.

The classical basic formula for the diffusion-controlled duration T of overdense echoes (echoes from strongly ionized trails) is [1]

$$7 \times 10^{-17} \times \frac{q\lambda^2 \sec^2 \varphi}{D_a} \text{ seconds,}$$

where q is the line density of the trail (number of free electrons per meter), λ the used radio wavelength and D_a the ambipolar diffusion coefficient of the atmosphere at the height of reflection, i.e., a measure for the diffusion speed. The angle φ is the half forward scatter angle, i.e., the half of the angle defined by transmitter, reflection point and receiver. The factor 7×10^{-17} contains some physical constants.

This formula is very instructive to someone looking for a relation between echo duration and visual magnitude. It first shows that T is proportional to the line density q, of which the visual magnitude is a function (together with other parameters such as velocity, incoming angle, distance, etc.). Furthermore, T is also proportional to the square of the wavelength. This accounts for Mr. Zay's shorter reflections [2].

The two remaining parameters are somewhat more annoying. The angle φ is generally unknown as the geometry of the reflection cannot be derived. For this, the location of the transmitter and the position of the reflection point in the sky are needed.

The coefficient D_a depends mainly on the density of the atmosphere at the reflection point, which is a function of the height and a lot of other parameters such as solar activity, time of day, time of the year, etc. Sometimes, D_a can be derived from the radio meteor profile (evolution of signal amplitude with time) when the trail does not suffer from deformation by wind. However, this only happens with shorter reflections and is thus of no interest to one trying to derive magnitudes of presumed fireballs.

Unfortunately, these are not the only parameters affecting echo duration of overdense meteors. The duration of long overdense echoes is not only diffusion-controlled: long echoes tend to be limited in time due to attachment of electrons to neutral atmospheric molecules. This attachment reduces the line density q and consequently the echo duration. The attachment rate depends on the insolation of the meteor trail and is three times slower during day than during nighttime.

Also, the orientation of the trail with respect to the plane of transmitter, reflection point, and receiver has an effect: the power of the secant in the formula can range from 0.3 to 2 as a consequence of this orientation.

The antenna gain and the receiver sensitivity can also influence the measured duration somewhat. However, echoes from overdense meteors generally do not tend to fade away slowly into the background noise but stay at about the same order of amplitude (with strong fluctuations), before disappearing in some fractions of a second [3]. If one detects an overdense meteor echo, one will thus generally be able to observe it until it actual fades, and duration will most likely not be influenced much.

As polarization, which has often been put forward as an explanation for the failure of the discussed relation (See e.g., [4]), only influences echo amplitude, it should not influence the echo duration too much.

Any radio meteor observer surely finds this list of effects depressing enough. Still, I have one last, important, unpleasant remark: the derived visual magnitude, whatever its significance, is that of an arbitrary spot on the meteor trail, as reflection only takes place in a small part of the meteor trail, defined by geometry and thus independent of the trail ionization. It is thus not at all guaranteed that the brightest flare of a meteor trail is observed with radio equipment.

Although some of the presented effects can be taken into account when calculating a corresponding visual magnitude, I think it can be concluded that trying to establish a direct relation between echo duration of a meteor and its visual magnitude is highly hazardous and cannot yield a significant result. However, this does not at all mean that I think radio observations are useless and cannot yield valuable data! I am convinced amateur radio work can deliver useful meteor data, especially for fainter meteors, as long as much more care is taken to the observation method and the reduction of the data than is done at present. Finding these methods can only be done by a thorough analysis of the radio meteor phenomenon and is, I think, the big challenge for current amateur radio meteor workers.

[1] D.W.R. McKinley, "Meteor Science and Engineering", McGraw-Hill Book Company Inc..1961

[2] G.J. Zay, "Letters to WGN", *WGN* 21:5, October 1993, p. 224.

[3] J.-M. Wislez, "Interpretation of high resolution radio meteor profiles", to appear in *1993 IMC Proceedings*, P. Roggemans, ed., IMO, 1994.

[4] R. Venable, "Letters to WGN", *WGN* 21:1, February 1993, p. 3.

Jean-Marc Wislez, November 6, 1993

I would like to give my opinion about the connection between radio reflection duration and visual magnitude.

At present, I have observed for six years with automated radio equipment. This equipment receives on 144 MHz (2-meter amateur band). I have also observed visually and photographically. In 1993, I have been listening to three different frequencies at the same time. These frequencies were 144 MHz, 100 MHz (normal FM band), and 50 MHz (6-meter amateur band). I have done this to be able to compare different frequencies and different modulations.

My conclusion for the connection between radio duration and visual magnitude, is that there is none. In my investigation, there have been only coincidental connections.

My reasoning is as follows: Reflection from a meteor is at its best, when the meteor appears in our "receiving area," with an angle of 45°, halfway between transmitter and receiver. The phenomenon that makes meteors reflect radio waves, is ionization of the air. This ionization occurs when the meteor evaporates in the atmosphere, and thus the degree of ionization must depend on the size of the meteor. In turn, this strength gives rise to the strength of the reflection on our radio. The reflection sustains for a while, because it takes a while for the ionization to disappear. This phenomenon is called the train of the meteor. The echo duration will therefore largely depend on the appearance of such a train: a slow-moving, bright meteor will yield a much shorter echo duration than a fast-moving, weaker meteor leaving a long-lasting train.

I believe that there is a stronger connection between visual magnitude and the strength of the reflection (instead of the duration). When my wife and I compared the visual magnitude of meteors, and the strength of the reflection, we found some connections. There was also a connection between the strengths on the different frequencies, whereas we could not find any connection between the reflection durations on the different receivers. However, one thing seems clear: lower frequencies yield longer reflection durations. E.g., when we received a reflection on all frequencies (which is rather exceptional), the duration is longer on 100 MHz, and much longer on 50 MHz than on 144 MHz. But it can also be dangerous to conclude anything about duration on different frequencies, because on lower frequencies, meteors can produce something that looks like sporadic-E (maybe it is sporadic-E, I do not know for sure). This problem is less at higher frequencies, and therefore it might be better to receive meteor reflections on 432 MHz (70-cm amateur band).

Knud Bach Kristensen, November 6, 1993

Strange object over Danish oil rig

We received the following letter from Erik Hoeg of the Copenhagen University Observatory. Although obviously not directly related to meteors, we decided to publish the letter in view of the apparent interest of our readers in similar phenomena. (Cf. the discussion in WGN*s Letter Section which started in* WGN *17:4 and ended in* WGN *18:3. As we do not intend to re-open the discussion, we suggest interested readers to directly contact Erik Hoeg at the Copenhagen University Observatory, Oestervoldgade 3, DK-1350 Copenhagen, Denmark, e-mail* `erik@astro.ku.dk`.

An object near zenith was discovered and observed by the weatherman A on the Danish oil rig Tyra-East in the North Sea at position $\varphi = 55°43'.5$ N, $\lambda = 4°48'.2$ E. The observation was taken between 3^h50^m and 5^h15^m UT on October 20, 1993, and was reported to the present author from 7^h00^m UT the same morning and in several phone conversations since. Its integrated brightness was about magnitude -9. I would be grateful for your assistance. The object should have been seen from elsewhere since the night was quite clear and observers within a radius of 1000 km would have seen an object brighter than -6 at a zenith distance of less than 60°.

The object was watched by observer A for 85 minutes, interrupted then by clouds. He saw a diffuse circular orange disk of the Moon's diameter without structure, but he was much disturbed by background light from a big gas flame on the rig. He saw no change of brightness or appearance during that time.

The ship, Preventer, 500 m south of Tyra was called by radio and the object was observed by officer B for about 60 minutes. He could see much structure which did not change during the time. It looked like a drop pushing a bow wave in front of its but end. A drawing will be provided to me. Both observers used naked eye and good binoculars. By binoculars, A and B report to seeing a granular surface, a large number of small points inside the object.

The object stayed at nearly constant distance to Capella which was seen at 10° to WSW at 3^h50^m UT and at about 7° at 5^h15^m, the times of first and last sighting. This indicates a westward motion among the stars of 3° in 85 minutes, although this figure is uncertain and could be zero. The first position is $\alpha = 6^h10^m$, $\delta = +50^\circ\!.0$ (1950.0).

The constant appearance and the celestial motion indicated an astronomical object, perhaps a comet. But a report to B. Marsden on the same morning did not bring any further observation, and it was concluded that the object must be local. This hypothesis has however led to no acceptable explanation of the phenomenon.

The object was also observed by two persons, C and D, on the oil rig Gorm, 18 km south of Tyra who had overheard the radio conversation between A and B. They saw two orange drops close together, near zenith, both drops being about one square degree. From their drawings and from phone conversations the declination $\delta = +48^\circ\!.0$ and the same right ascension as above were derived. This corresponds to a parallax of $-2°$. Permitting very generously a total error of 5°, the maximum parallax is $-2° + 5° = 3°$, and the minimum altitude therefore 340 km above sea level.

The surface brightness was estimated by a simple visual photometer to one percent of the Moon. The photometry was obtained by observer A five days later on my proposal by watching the first quarter moon through the two acryl plates of an empty tape cassette. He estimated that the object was considerable brighter than the twice-reflected image of the Moon. Since this image has a surface brightness about 0.3% of the Moon, the object has had a surface brightness about one percent of the Moon. Since the integrated brightness of the Full Moon is −13 mag and the total area of the object was at least one square degree as seen by the other observers a total integrated brightness about −9 is inferred.

Explanations in terms of noctilucent clouds, chemical experimental clouds or space craft exhaust are not consistent with the long duration of constant appearance and the nearly constant position relative to the stars. Aurora seems to be excluded for the same reason and because their was no special event on October 20. P. Suesmann, Deutsche Telekom, reports: "The Sun was quiet with no flares or other events, the geomagnetic field was unsettled and from the view of HF propagation there was nothing extraordinary either."

Erik Hoeg, November 10, 1993

The 1994 International Meteor Conference

Belogradchik, Bulgaria, September 22–25

Paul Roggemans

The 13th *International Meteor Conference* will be organized in North-West Bulgaria in a beautiful environment selected by Bulgarian *IMO* members. It will be the first *IMC* in the Balkans, and we hope that it will be easy for people from East European countries to participate. We cordially invite you to register for this meeting!

The *IMC* will be organized at an observatory in Belogradchik, about 170 km from Sofia. The conference language is English. The *IMO* will be responsible for composing the lecture program, collect the papers for the Proceedings, and edit them. We invite you to present a lecture on your recent work, or to prepare a poster. In both cases, a paper (maximum 6 pages) must be delivered at the *IMC* for the Proceedings. Note that a lecture should be no longer than 30 minutes: 15 to 20 minutes is an ideal duration. Lectures must be presented in English. An overhead projector and/or slide projector will be available.

In Belogradchik, there is overnight accommodation for 60 persons, limiting the number of participants. Therefore, if you wish to participate, return the registration form without delay to the Secretary-General. The registration fee for the 1994 *IMC* is 170 DEM per person, covering conference participation, overnight accommodation and meals during the *IMC* as well as a copy of the Proceedings. (Drinks, etc. should be paid with cash at the *IMC*.)

Upon returning the registration form, at least 100 DEM must be pre-paid to the *IMO* Treasurer, in exactly the same way as you pay for *WGN*. Of course, you may pay the entire fee of 170 DEM altogether. Until June 30, 1994, you can cancel your registration, losing only some administration costs on your prepayment.

Invitations to participate in the *IMC* should be directed to the local organizing committee. Please note that the *IMO* cannot provide financial support: with a minimal membership fee, the Organization cannot afford to pay traveling or participation fees for anybody. However, people from countries with financial and economic restrictions can contact the local organizing committee in order to obtain special arrangements for participating in the *IMC*.

To enter Bulgaria, you will need, at the very least, a valid passport. For visa requirements, please check with a Bulgarian embassy in your home country and leave yourself ample time to complete the formalities. In general, a visa costs some 50 DEM. It is also a good idea to order your visa for some days more than is strictly required. We also advise that you take travel insurance.

Due to the war in the former Yugoslavia, many participants will have to travel by plane to Sofia. If there is sufficient interest, we may attempt to obtain flight tickets at a reduced rate for a group leaving from a central place in Western Europe. Please communicate your traveling preferences on the registration form.

Bulgaria is a beautiful country that is worthwhile visiting either before or after the *IMC*. For tourist information, hotels, and general advice, please contact the Bulgarian Tourist Office in your country. Also, the local organizing committee will gladly assist you with your traveling plans and give you general advice for visiting Bulgaria.

Local organizing committee: Mr. Valentin Velkov, Mrs. Eva Bojurova, and Mr. Zahari Donchev. They can be contacted at the following address: Astronomical Observatory "N. Copernicus," P.O. Box 120, BG-9000 Varna, Bulgaria, phone +359-52-222-890.

International Meteor Conference

Belogradchik, Bulgaria, September 22–25, 1994

Registration Form

Each individual participant should fill out a form and return it to Paul Roggemans, Pijnboomstraat 25, B-2800 Mechelen, Belgium, as soon as possible. The deadline is June 30, 1994. Your registration will be guaranteed only after Ina Rendtel has received the pre-payment of 100 DEM. If you strongly 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: ______________

- ○ wishes to register for the 1994 *IMC* from September 22 to 25;
- ○ intends to participate, cannot yet register, but wishes to stay on the mailing list.

I intend to travel by ________, together with ______________________________

____

Interested in coordinated traveling? ______________________________

____

For participants interested in car-pooling:

- ○ I have __ free places in my car from ______________;
- ○ I need __ places in a car from ______________;

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 170 DEM or a pre-payment of at least 100 DEM should be sent to the Treasurer, *Ina Rendtel*, in the same way as your membership/subscription fee. Remember that Ina cannot accept bank checks! People wishing to pay in other currencies (USD, GBP, or JPY) should contact the appropriate *IMO* officer for exchange rates. Participants paying only 100 DEM have to pay the remainder of 70 DEM upon arrival in Belogradchik.

Method and date of payment: ______________________ Amount: __________DEM

Date and signature: ____

Visual Observers' Notes: January–February 1994

Jeff Wood and Marc Gyssens

1. Introduction

Although early January begins with the major shower, the Quadrantids, this period is generally characterized as one with low rates, and so must therefore hold little interest to the meteor observer. This attitude, however, is based on a misconception. Even though rates may be low, there is still much to see as southern hemisphere observers and those in the northern hemisphere who have braved the winter weather have discovered.

Table 1, shown below, gives an overview of some of the showers to be seen in January and February 1994. Table 2 shows observing conditions during these months moon-wise.

Table 1 – Some of the meteor showers to be seen in January and February 1994.

Shower	Activity	Max	Radiant			Drift		V_∞	r	ZHR
			α	δ	Diam.	$\Delta\alpha$	$\Delta\delta$			
Puppid/Velids	Sep 28–Jan 26	several	120°	−45°	20°/5°			41	2.9	
Coma Berenicids	Dec 12–Jan 23	Dec 19	175°	+25°	5°	+0°.8	−0°.2	65	3.0	5
Quadrantids	Jan 01–Jan 05	Jan 03	230°	+49°	5°	+0°.8	−0°.2	41	2.1	110
δ-Cancrids	Jan 05–Jan 24	Jan 17	130°	+20°	10°/5°	+0°.9	−0°.1	28	3.0	5
α-Crucids	Jan 06–Jan 28	Jan 19	192°	−63°	10°/5°	+1°.1	−0°.2	50	2.9	5
α-Carinids	Jan 24–Feb 09	Jan 31	95°	−54°	5°			25	2.5	
Virginids	Feb 01–May 30	several	195°	−04°	15°/10°			30	3.0	5
θ-Centaurids	Jan 23–Mar 12	Feb 01	210°	−40°	6°	+1°.1	−0°.2	60	2.6	
α-Centaurids	Jan 28–Feb 21	Feb 07	210°	−59°	4°	+1°.2	−0°.3	56	2.0	25+
o-Centaurids	Jan 31–Feb 19	Feb 11	177°	−56°	6°	+1°.0	−0°.3	51	2.8	
δ-Leonids	Feb 05–Mar 19	Feb 15	159°	+19°	8°	+0°.9	−0°.3	23	3.0	3
γ-Normids	Feb 25–Mar 22	Mar 14	249°	−51°	5°	+1°.1	+0°.1	56	2.4	8

Table 2 – Moonlight and observing conditions in January–February 1994.

Date	k	Date	k
Friday December 31	0.95−	Friday February 04	0.43−
Friday January 07	0.28−	Friday February 11	0.00+
Friday January 14	0.05+	Friday February 18	0.43+
Friday January 21	0.61+	Friday February 25	0.98+
Friday January 28	1.00−	Friday March 04	0.58−

New Moon: January 11, February 10, March 12
First Quarter: January 19, February 18, March 20
Full Moon: December 28, January 27, February 26
Last Quarter: January 5, February 3, March 4

2. Coma Berenicids

This shower is active from December 12 through to January 23. Although the maximum occurs on December 19, rates are still moderate during January. The Coma Berenicids are best seen during the last few hours before sunrise from the northern hemisphere. They are fast meteors with a V_∞ = 65 km/s. Observers should have their field center situated no further than 30° from the radiant. All possible Coma Berenicid meteors should be plotted.

Table 3 – Radiant positions of the Coma Berenicids.

Date	α	δ	Date	α	δ
Jan 06	191°	+19°	Jan 16	199°	+16°
Jan 11	195°	+18°	Jan 21	203°	+15°

3. Quadrantids

Named after the now defunct constellation Quadrans Muralis, the Quadrantids are the first major shower to occur each year. They are active from January 1 to 5 with a maximum ZHR of around 110 on January 3. The Quadrantids are swift meteors ($V_\infty = 41$ km/s) which radiate from $\alpha = 230°$ and $\delta = +49°$. The radiant diameter is 5°. They are best observed from the northern hemisphere in the last few hours before sunrise. With a Full Moon on December 28, they do not experience good viewing in 1994.

4. δ-Cancrids

Very little is known about this stream which can be seen from either hemisphere during mid January. The δ-Cancrids therefore need urgent attention from meteor observers. The δ-Cancrids are best seen during the early to middle part of the night. Meteor workers should particularly monitor the first half of the activity period, as there will be little interference from the Moon at that time. As rates are low, observers should ensure they center their field of view no further away than 30° from the radiant and also plot all possible δ-Cancrids seen, as this ecliptical shower has a complex radiant structure. Therefore, the radiant diameters to be taken into account for shower association of meteors of different radiant distances differ a bit from those of sharply defined radiants. The relevant part of the table concerned is reproduced below as Table 5.

Table 4 – Radiant drift of the δ-Cancrids. The x, y coordinates (in mm) refer to chart 8 of the *Atlas Brno 2000.0*.

Date	α	δ	x	y	Date	α	δ	x	y
Jan 05	116°	+22°	288	236	Jan 20	130°	+19°	237	216
Jan 10	121°	+21°	269	228	Jan 25	134°	+18°	223	210
Jan 15	125°	+20°	252	222					

Table 5 – Optimal radiant area to be assumed for shower association of ecliptical radiant complexes. The major axes are given (α/δ).

Radiant distance	15°	30°	50°	70°
δ-Cancrids	20°/15°	25°/20°	27°/22°	30°/25°
α-Crucids	20°/15°	25°/20°	27°/22°	30°/25°
Virginids	30°/20°	32°/25°	35°/26°	40°/30°

5. α-Crucids

The α-Crucids are active from January 6 through to 28. With a radiant occurring near the Southern Cross, this southern hemisphere stream has a complex activity period with several submaxima occurring on or around January 12, 15, 19, and 24. The January 19 peak seems to be the greatest when the ZHR can reach upward of 5. α-Crucid meteors are fastish and often colored. Since they have relatively low rates, all possible α-Crucids should be plotted. Observers should center their fields around $\alpha = 160°$ and $\delta = -55°$ so that both the tail of the Puppid/Velids and the α-Crucids may be monitored simultaneously. Moon-wise, meteor workers should concentrate on the first half of the activity period in 1994. Please use Table 5 above for determining shower membership from the plots.

Table 6 – Radiant positions of the α-Crucids.

Date	α	δ	Date	α	δ
Jan 06	178°	−60°	Jan 19	192°	−63°
Jan 11	183°	−61°	Jan 24	198°	−64°
Jan 16	189°	−62°	Jan 28	202°	−65°

6. Virginids

As there are a large number of low activity radiants close together, it is very difficult to delineate which branches of the Virginids are active at which time and also to classify each individual meteor seen into its appropriate stream. Consequently, observations over the years have shown a whole myriad of Virginid showers, some real, some fictitious. Also, reported rates have varied from nil to over 10 meteors per hour! With this in mind then, the *IMO* has for the time being to incorporate all of the Virginids seen into the one "shower". The "Virginids" are active from February 1 to May 30. They have a V_∞ of 30 km/s and are reknowned as fireball producers, though their population index r of 3.0 indicates there are many fainter members as well.

The *IMO* would appreciate your efforts to monitor this shower in 1994. Intending observers should locate their center of field of view no more than 40° away from the radiant and should plot all meteors seen. Since the Virginids have a velocity typical of the sporadic background and also come from a large radiant area, careful attention to path length and angular velocity should be given before classifying a meteor as Virginid. As for the δ-Cancrids, please use Table 5 for determining the radiant area.

Table 7 – Radiant drift of the Virginids. The x, y coordinates (in mm) refer to charts 8 and 5 respectively of the the *Atlas Brno 2000.0*.

Date	α	δ	x_8	y_8	x_5	y_5	Date	α	δ	x_8	y_8	x_5	y_5
Feb 03	159°	+15°	149	199			Apr 04	200°	−06°			169	144
Feb 13	167°	+09°	125	181			Apr 14	204°	−08°			157	138
Feb 23	174°	+05°	103	169	256	179	Apr 24	208°	−09°			146	135
Mar 05	182°	+01°	74	157	226	164	May 04	211°	−11°			137	129
Mar 15	189°	−02°	45	146	202	155	May 14	214°	−12°			128	126
Mar 25	195°	−04°	15	138	183	150	May 24	217°	−13°			120	123

7. θ-Centaurids

This shower has a complex radiant structure and is active from January 23 to March 12. With the complex radiant structure also comes a complex activity period with several submaxima. The main ones seem to occur on or around February 1, 21 and 26 with a peak ZHR of between 5 and 10 meteors per hour. θ-Centaurid meteors are fast and often leave a train. They are also noted for producing fireballs of a lemon yellow or greenish hue. They are best seen in the morning hours from the southern hemisphere. Observers should center their field of view around $\alpha = 200°$ and $\delta = -50°$ to aid in separating the θ-Centaurids from the other two Centaurid showers that occur at a similar time in mid-February. In late February and mid-March, the observer's field should be centered around $\alpha = 200°$ and $\delta = -20°$ so that the θ-Centaurids and the Virginids can both be monitored. All possible θ-Centaurids should be plotted.

Table 8 – Radiant positions of the θ-Centaurids.

Date	α	δ	Date	α	δ
Jan 23	185°	−37°	Feb 20	209°	−40°
Jan 31	192°	−38°	Feb 28	213°	−41°
Feb 10	202°	−39°	Mar 12	222°	−43°

8. α-Centaurids

The α-Centaurids produce a good display of meteors each year for southern hemisphere observers. They are active from January 28 through to February 21 with a sharp maximum on February 7. For most of their period of activity ZHRs range between 1 and 3 meteors per hour, but at maximum, rates generally rise to between 5 and 10 meteors per hour. Every 4 to 6 years, the maximum activity seems to be greatly enhanced and on two notable occasions in 1974 and 1980, rates exceeded 25 per hour. Always this enhancement has been short-lived lasting no more than 2–3 hours.

The α-Centaurids are fast meteors which are noted for their brightly colored fireballs. Many α-Centaurids also leave a train. If ZHRs are less than 10, then all possible α-Centaurids must be plotted. If ZHRs exceed 10, then they may be recorded in the manner of the major showers. To avoid confusion with the other Centaurid showers, observers should watch for the α-Centaurids with a field center at $\alpha = 200°$ and $\delta = -50°$.

Table 9 – Radiant positions of the α-Centaurids.

Date	α	δ	Date	α	δ
Jan 28	197°	−56°	Feb 13	215°	−60°
Feb 03	203°	−58°	Feb 18	221°	−62°
Feb 08	209°	−59°	Feb 23	227°	−63°

9. o-Centaurids

The o-Centaurids are a minor shower that occurs during a similar time as the other two February Centaurid showers. The o-Centaurids are active from January 31 through to February 19 with a maximum ZHR of about 5 meteors per hour occurring on February 11. The o-Centaurids are visible only from the southern hemisphere and can be seen in dark skies during the late evening hours. The Moon in 1994 is about New around maximum. The o-Centaurids are fast meteors. Observers should plot all possible o-Centaurids seen. To aid in identification, the center of their field of view should be located at $\alpha = 200°$ and $\delta = -50°$.

Table 10 – Radiant positions of the o-Centaurids.

Date	α	δ	Date	α	δ
Jan 31	165°	−52°	Feb 12	177°	−56°
Feb 06	171°	−54°	Feb 18	183°	−58°

10. δ-Leonids

The δ-Leonids are thought to be related possibly to the minor planet 1987 SY and so a top priority of the *IMO* is to investigate the activity of this shower to see if this is indeed the case. Despite some interference from the Moon during late February, much of their activity period can be observed in dark skies. The δ-Leonid meteors are of average brightness, slow in speed ($V_\infty = 23$ km/s) with very few leaving a train. Since there are numerous sporadic meteors as well as the Virginid meteor shower occurring in the vicinity of the δ-Leonid radiant area, great care needs to be taken in identifying them. Observers should center their field of view around $\alpha = 180°$ and $\delta = +20°$ or $\alpha = 160°$ and $\delta = 0°$. As the δ-Leonids are few in number, all should be plotted. Meteors coming from the radiant area should only be classified as δ-Leonids if their path lengths and their angular velocities are appropriate.

Table 11 – Radiant drift of the δ-Leonids. The x, y coordinates (in mm) refer to chart 8 of the the *Atlas Brno 2000.0.*

Date	α	δ	x	y	omit Date	α	δ	x	y
Feb 05	141°	+25°	202	234	Feb 28	161°	+18°	144	210
Feb 10	145°	+24°	189	228	Mar 05	165°	+17°	131	205
Feb 15	150°	+22°	176	223	Mar 10	169°	+15°	119	201
Feb 20	154°	+21°	164	218	Mar 15	173°	+13°	105	196
Feb 25	158°	+19°	151	213	Mar 20	177°	+12°	92	192

11. Call for radio observations

In the past few years, Dirk Artoos has noticed enhanced radio activity on January 22-23 several times. This can hardly be a coincidence. The highest peak occurred during early morning hours ($\lambda_\odot = 301.^\circ7$, eq. 2000.0). Therefore we request that radio observers be alert between January 19 and 25.

Call for Observations

Luis R. Bellot

As you probably know, the Taurid complex is a very interesting topic for professional meteor astronomers. Therefore, it seems important to analyze it from the observational point of view (radiant positions and drifts). This study will be performed with the aid of the RADIANT program developed by Rainer Arlt. However, as was demonstrated earlier (see, e.g., the Aquarid Complex analysis), a large amount of data is required to get reliable and statistically significant results. Therefore, we ask observers having monitored the Taurids to send in as soon as possible their plots together with the relevant data (date, observing place, time of appearance of each meteor, velocity, etc.) to the following address:

Luis R. Bellot, Instituto de Astrofísica de Canarias, C/ Vía Láctea s/n, E-38200 La Laguna, Spain.

Gnomonic *Atlas Brno* as well as "FEMA" charts are welcome. Please be sure that the scale is not too small and that the numbers of the individual meteors are legible on the maps. The observer does *not* have to measure the coordinates of each meteor as was required during the Aquarid analysis, since the maps will be digitized and reduced on a computer.

Telescopic Observers' Notes: January–February 1994

Malcolm J. Currie

Several telescopic observers have welcomed the new charts. I have nearly completed production of set A, suitable for apertures 40–50 mm (10° field to magnitude +10), and set B for 60–70 mm (10° to +11) is well advanced. Set C is aimed at the popular 80-mm binoculars ($5.^\circ5$ to +11). Each set currently comprises 164 charts for northern observers. I could produce a southern extension if required. Each set includes charts for monitoring known major and minor showers, and a distributed pattern for searching for new or unknown radiants. Some observers have already expressed an interest in purchasing complete sets. In order to gauge how many copies to make I would appreciate knowing if others want a set. The cost is likely to be around 20 DEM per set.

In January and February most telescopic observers prefer to snuggle up in front of the fire rather than venture into the frosty nights. I plead guilty, M'lud. After all, with the Quadrantids unfavorable due to a Last-Quarter Moon, you would be forgiven for saying that there are no decent showers. However, at telescopic magnitudes, several showers are active during the period. Some of these do contribute rates equivalent to the sporadic background; that is respectable for telescopic meteors. Because of the bad weather and seasonal observing, our knowledge of these showers is sketchy at best. Even an hour's observation on each clear dark night accumulates over several years into a clearer picture. From longer sessions you may even discover a previously unknown shower.

The best known is the *δ-Cancrid* minor shower of January. This low-inclination shower exhibits the characteristic extended period of weak activity, lasting most of the month, though peak rates are expected to occur mid-month when the Moon does not interfere. Careful visual plotting has revealed that its radiant is large and elongated, and comprises several sub-centers. Thus, the main aim of telescopic observations is to obtain high-quality positional data that will let us investigate the radiant structure further, allowing us to, for instance, compare the results with visual findings and to look for persistence of components from year to year. Since the shower appears not to have many very faint meteors, small binoculars are recommended. Long-duration watches are possible to improve the statistics, since the radiant is above the horizon for virtually the whole night. Observing under winter conditions is especially demanding so take frequent breaks.

Moving east, the most-active of the January ecliptic showers in recent years has been the *α-Leonids*. According to Kronk [1], it is a long-duration telescopic shower certainly persisting through the latter part of January and probably through the whole of the month. However, 1990 data show strong activity as early as January 10 ($\lambda_\odot = 291°$). It is unknown if this was due to the same shower, though the position of the radiant ($\alpha = 140°$, $\delta = +17°$) is consistent with a single shower. In 1994, there are dark skies around this date, so we can aim to determine when the maximum is; but we also need observations for the following week to monitor activity and the radiant motion to assess whether there is but one shower. Other shower parameters are poorly known too. You should be able to follow this shower simultaneously with the δ-Cancrids. At least three field centers are recommended for these complexes. The recommended chart numbers are 75, 79, 82, 104, and 144. They form an arc from the Sickle of Leo through Leo Minor, Lynx to Canis Minor, but none are along the ecliptic, as it would be difficult to separate the two showers. The low declination makes this shower accessible to those in the balmy summer nights of the southern hemisphere. Charts 144–146 and 104 would be more appropriate for those lucky southern observers.

There is some complex activity in the Leo Minor and Coma region during January that may be related to radiants in Lynx during the latter part of December [2]. The meteors are faint and fast. So the showers are best studied by video or telescopic means. A series of telescopic watches by several observers over a number of years should resolve the components and determine whether or not there is a single shower. Gary Kronk [3] has requested data for a possible shower rich in telescopic meteors at $\alpha = 233°$, $\delta = +37°$ during January 16–18. Moonlight only partially interferes in 1994. I encourage observers to look out for meteors from this position. The radiant location suggests pre-dawn watches. The sporadic rate will be much higher too.

The *α-Aurigids* are slow meteors in early February with a mean radiant at $\alpha = 74°$, $\delta = +42°$. Although best known for its bright fireballs, this shower does have measurable telescopic activity too. The meteors are visible during the first half of the month, with peak activity around February 9. Evening watches are favored while the radiant is high and before the Moon interferes. Charts 75 and 121 form one of many suitable pairs to observe this shower. The *δ-Leonids* are also slow moving, and active during February to mid-March peaking around mid-month. The visual rate is low, but this shower probably contributes at telescopic magnitudes. Kronk [1] suggests that there may be a telescopic southern component, though observation of its suggested maximum on February 3 will suffer from moonlight. However, telescopic activity may last from mid-January until February 24. During February, the occasional early Virginid can be seen from radiants in Leo. A couple of suitable charts are 82 and 123.

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[1] G.W. Kronk, "Meteor Showers: a Descriptive Catalog", Enslow, Hillside, NJ, 1988, p. 21 and p. 29.

[2] M.J. Currie, *WGN* 17:5, October 1989, pp. 186–187.

[3] G.W. Kronk, *WGN* 14:6, December 1986, p. 191.

Ongoing Meteor Work

Illustrating a Meteoroid Stream

David W. Hughes, The University of Sheffield

Popular schematic representations of meteoroid streams are often incorrect, first with respect to the positioning of the meteoroids around the "mean" orbit, and second with respect to the cross-sectional area around the orbit.

One has to be very careful when drawing a schematic picture of a meteoroid stream in the solar system. Joe Rao [1] quoted from the 1971 edition of the *Encyclopedia Brittanica*:

> *In the case of the Perseid shower... the dispersion (of particles) around the orbit is so complete that no evidence of long-term periodicity can be found.*

He also illustrated this proposition by reproducing Figure 1. He is not alone in producing figures like this (see [2–5]). Unfortunately they are all incorrect. Figure 1 is both dynamically and genetically impossible [6].

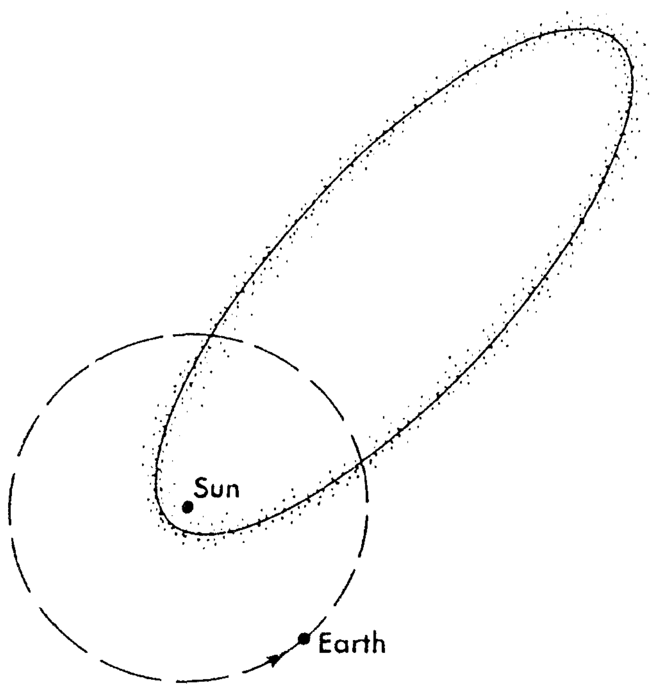

Figure 1 – The representation of the distribution of meteoroids in a meteoroid stream given in [1]. Similar figures are shown in [2–5]. This distribution is supposed to result in a reasonably constant shower flux every year. This supposition is completely incorrect. The figure is wrong in as much as it shows a uniform distribution of meteoroids around the orbit, and a stream of constant cross-sectional area. Neither of these illustrated aspects actually exist in reality.

The first mistake lies in the positioning of the meteoroids around the "mean" orbit. The author of Figure 1 seems to be under the impression that the meteoroids always move at constant speed around their orbits. They do not. The speed varies considerably as a function of the distance between the meteoroid and the Sun. Being pedantic the speed, V, is given by

$$V^2 = GM_\odot \left(\frac{2}{r} - \frac{1}{a}\right)$$

where G is Newton's constant of gravity, $M_\odot$ is the mass of the Sun, r is the meteoroid-Sun distance and a is the semi-major axis of the meteoroid orbit. The meteoroids obey Kepler's second law of planetary motion in as much as the line joining the meteoroid to the Sun sweeps out equal areas in equal times. This law has been applied to the 76 dots shown in Figure 2. These are placed around a single orbit such that the area dot-Sun-adjacent dot is constant (see [7,8]). The orbit shown in Figure 2 is that of Comet Halley. The spacing between the dots represents a distance a specific meteoroid on that orbit would move in a year. At perihelion (0.59 AU) the meteoroids are moving at 54.55 km/s, whereas at aphelion (35.3 AU) the velocity has dropped to 0.91 km/s, under 2% of the perihelion value.

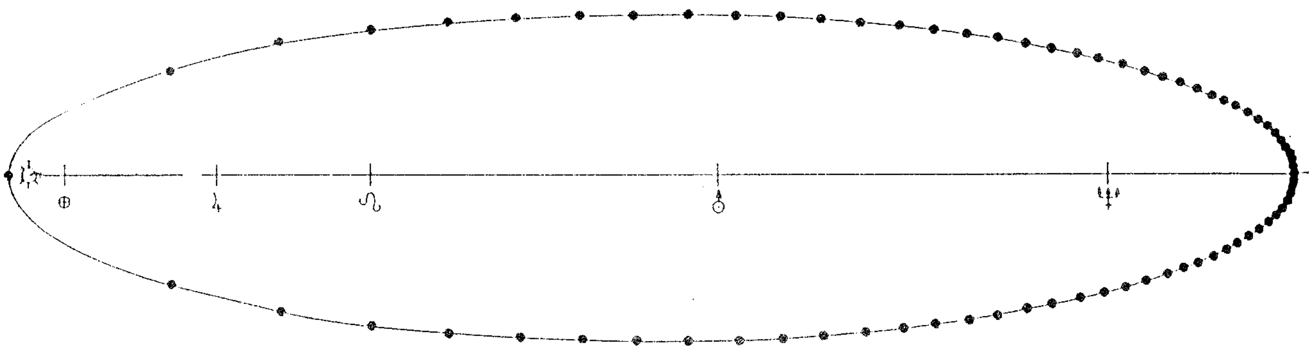

Figure 2 – Seventy-six meteoroids are placed around a single orbit (that of Comet Halley) in such a way that the area (particle-Sun-adjacent particle) is constant. The spatial distribution of meteoroids will also remain constant as a function of time. The glyphs on the x-axis represent the mean radii of the orbits of Earth, Jupiter, Saturn, Uranus and Neptune drawn to the same scale as the comet orbit.

What is even more important about the orbital spacing shown in Figure 2 is the fact that it leads to a constant flux of meteoroids past *any* specific spot on the orbit. If the meteoroid orbit intersects the orbit of, say, planet Earth, the number of meteoroids that pass the Earth's orbit per unit time would be constant and the maximum zenithal hour rate of the observed meteor shower would remain the same from year to year. This would not happen for the distribution of meteoroids shown in Figure 1. The Figure 1 distribution would also change quickly as a function of time. The Figure 2 distribution would remain the same.

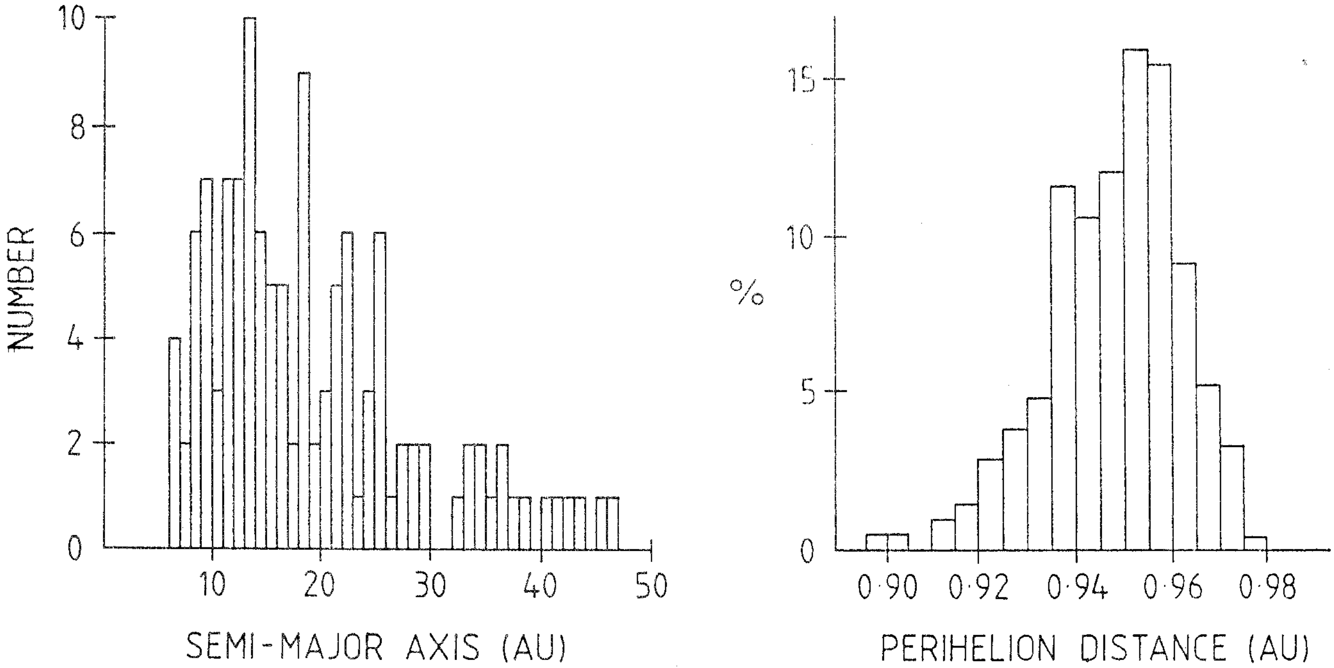

Figure 3 – The histograms show the distribution of orbital semi-major axes and perihelion distances of photographic Perseid meteoroids (mass around 0.7 g, magnitude around −5) found in the *IAU Photographic Meteor Data Catalogue* [9]. About 64% of the orbits shown in the semi-major axis histogram lie in the range 11 AU $< a <$ 27 AU. The 64% range for the perihelion distribution is 0.922 AU $< q <$ 0.976 AU. The latter is only 0.3% the former.

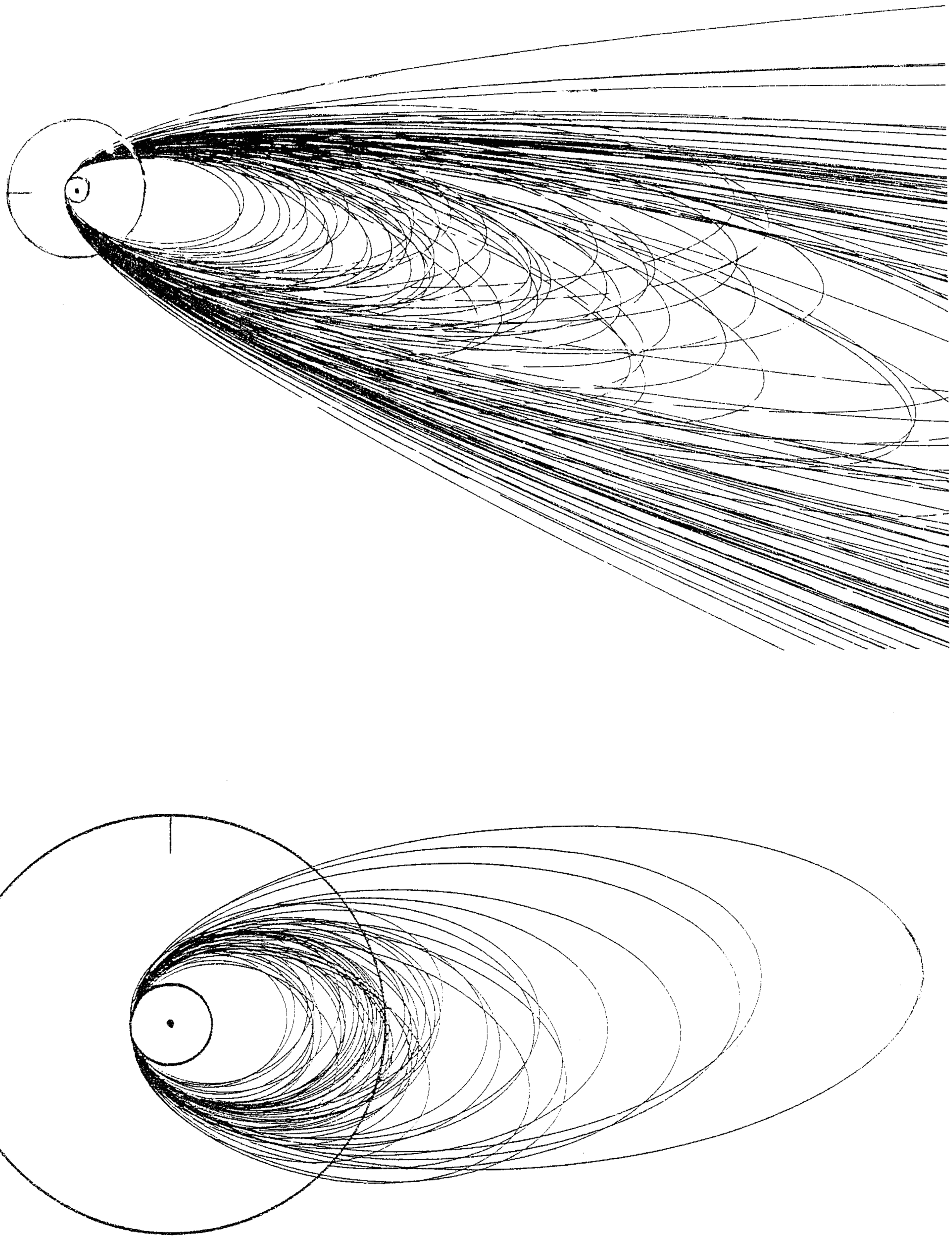

Figure 4 – This figure shows the orbital distribution of two "typical" meteoroid streams, the Perseids *(top)* and the Quadrantids *(bottom)*. Both streams are drawn in their mean orbital planes. The dots represent the Sun and the two circles are of radii 1 AU and 5.2 AU respectively, distances equivalent to the semi-major axes of the orbits of Earth and Jupiter. The markers indicate the direction of the First Point of Aries. The Perseid data has been obtained from the *IAU Photographic Meteor Catalogue* [9]. The Quadrantid data was obtained by the *Radio Meteor Project*'s six station radar network at Havana, Illinois [10].

Figure 2 shows that if a shower's activity is constant from year to year then most of the stream meteoroids responsible for that shower are close to the the aphelia of their orbits at any specific time.

The second mistake in Figure 1 is the indication that the stream has a constant cross-sectional area. This is not borne out by observations. It would require the orbits of meteoroids in a specific stream to have a similar standard deviation for the distribution of perihelion distances as they have for the distribution of semi-major axes. Figure 3 shows these two quantities for a collection of photographic Perseid meteoroids. The spread of aphelion distances is about 300 times greater than the spread of perihelion distances. So the illustration of a typical stream should have a cross-section that is a few hundred times wider at aphelion than it is at perihelion. This sort of distribution is shown in Figure 4 for two typical meteoroid streams, the Perseids and the Quadrantids.

In Figure 1, the individual meteoroids are represented by dots. Let us now try and do this for a "proper" meteoroid stream. The number of meteoroids per 0.25 AU × 0.25 AU area of the mean orbital plane of the Quadrantids is shown in Figure 5 (see [8]). A contour plot of Figure 5 is shown in Figure 6. Here the number of dots per unit area is proportional to the number of meteoroids present. The rather patchy nature of the illustration is due to the fact that the model was based on only 57 Quadrantid orbits. Meteoroids were placed around these orbits using the scheme illustrated in Figure 2. The model also suffers due to the fact that a large grid area (0.25 AU × 0.25 AU) had to be used. Figure 6 does, however, show clearly the way in which the mean stream density decreases as one moves away from perihelion. The variation in the cross-sectional width of the stream can also be clearly seen.

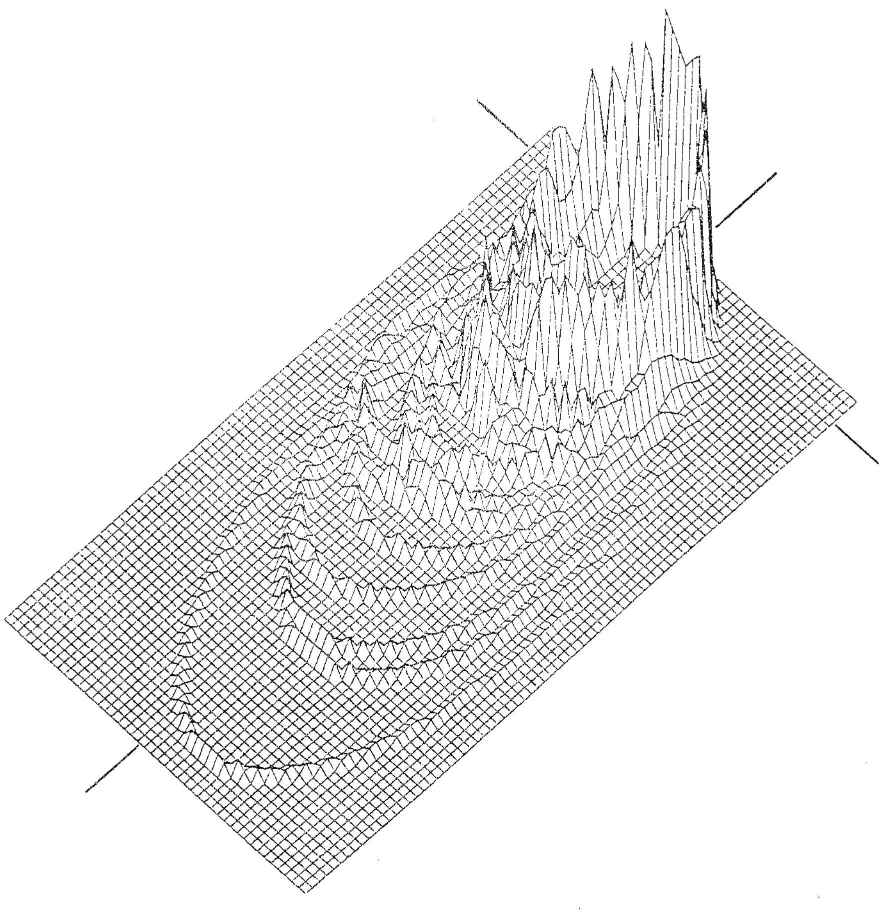

Figure 5 – The number of Quadrantid meteoroids above and below a specific area (0.25 AU × 0.25 AU) of the mean orbital plane is represented by the height of the "mountain." The two axes pass through the Sun.

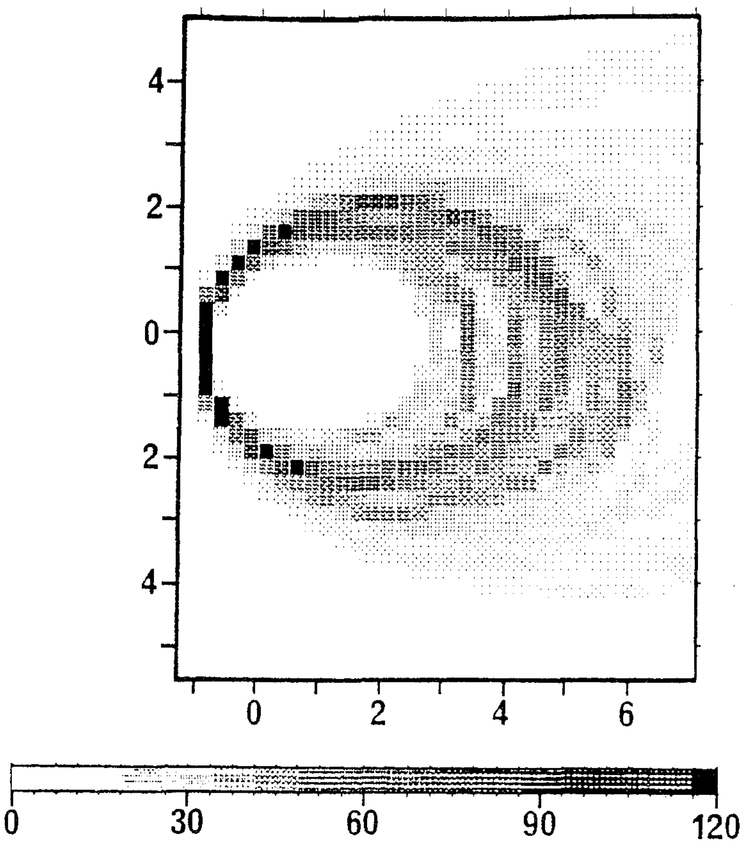

Figure 6 – A "contour" plot of Figure 5 in which the number of meteoroids per 0.25 AU × 0.25 AU area of the mean orbital plane is represented by differing numbers of dots. The shading scale is linear but the units are arbitrary. The units on the ordinate and abscissa are in AU, the Sun being at the origin (0,0).

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The Makings of Meteor Astronomy: Part V

Martin Beech, University of Western Ontario

The first true comparisons between the observations and the "rising vapors" hypothesis of meteor origins were made in the early eighteenth century. One of the key figures in the new meteoric dialogue was Edmond Halley.

1. New beginnings

The development of science is characterized by its paradigm shifts. And, the history of science shows us that the process of changing a philosophical paradigm is often a long and drawn-out affair. This is understandable in the sense that a new paradigm can only be accepted once it is clear that the old paradigm is obsolete, and can no longer offer a good description of the observations. The events that eventually lead to the overthrow of Aristotle's meteoric hypothesis took place during the eighteenth century. The rising vapors hypothesis for the origin of "fiery" meteors was outlined by Aristotle in his *Meteorologica*, published circa 357 B.C. [1], and interestingly it was one of the last of his doctrines to succumb to the observations, his Universal Model having all ready been abandoned by the close of the seventeenth century.

The initial challenges to Aristotelian doctrine came about through the works and observations of such luminaries as Nicolas Copernicus (1473–1543), Tycho Brahe (1546–1601), and Galileo Galilei (1564–1642). Their important contributions essentially show that the perfect, Earth-centered Universe of Aristotle was not so perfect, and not so Earth-centered. Copernicus, for example, was able to show that the positions of the planets could be calculated just as easily (although not much more accurately) if one assumed that they rotated in circular orbits about the Sun rather than the Earth. Brahe was also able to show from parallactic measurements that the Great Comet of 1577 moved in an orbit outside that of the Moon. This measurement placed the comet within the realm of Aristotle's "perfect" and "unchangeable" heavens—a place where no comet was allowed to be. Aristotle's geocentric doctrine was further challenged by Galileo's discovery of Jupiter's moons and his observation of the phases of Venus.

While Aristotle's Universal Model was shaken to its very core by the observations of Brahe and Galileo, his meteoric hypothesis seemed, at least initially, to suffer less badly. Johannes Kepler (1571–1630), for example, believed that meteors were purely atmospheric phenomena, and as such did not even fall into the realm of astronomy [2]. Isaac Newton (1642–1727) also believed that meteors were atmospheric phenomena, and wrote in his *Optics*, published in 1704, that,

> *sulfureous steams, at all times when the Earth is dry, ascending in the air, ferment there with nitrous acids, and sometimes taking fire cause lightning and thunder and fiery meteors.*

Newton has clearly adopted an Aristotelian model in his explanation of the "fiery" meteoric phenomena. Newton's explanation, however, re-dresses Aristotle's meteoric hypothesis in terms of seventeenth century chemistry. The active ingredient is a "sulfureous steam" because sulfur was believed at that time to be the agent responsible for combustion, and "nitrous acids" were invoked because they were believed to be chemically active elements [3].

In spite of the fact that Aristotle's Universal Model had in general been discarded by the end of the seventeenth century, his meteoric hypothesis was still the accepted paradigm at that time. Questions of the meteoric hypothesis were being asked, however, and as early as 1676 John Wallis wrote to the then newly established Royal Society about a "considerable meteor" seen on September 20, 1676 [4]. Wallis explained,

> *that which makes it to me the more surprising, is this; that I find the same [meteor] to have been seen in most parts of England.*

What seems to have concerned Wallis was how a "fiery" meteor could travel as far as the observations suggested. Rather than being a meteor Wallis suggested that perhaps a small comet has skimmed the Earth's surface. The important point that Wallis was attempting to address was, how could a phenomenon so widely visible be explained in terms of rising vapors.

The question of how rising vapors might produce widely observed meteors was again mooted by Ralph Thoresby in 1710. Writing to the Royal Society, Thoresby communicated his observations of a very bright fireball seen on May 18th of that year [5]. Describing the fireball as a *hot, and dry sulfureous exhalation, the natural effect of so great a drought.* Thoresby was happy to ignore its appearance until he discovered that it had been seen in neighboring towns. Incredulous of how such a lowly meteor could be seen in so many different places Thoresby was eager to know if the Royal Society had received any other accounts of the meteor. No published reply was given to Thoresby's letter, but the question of how bright meteors might form was eventually picked up by Edmond Halley (1656–1743) in 1714.

2. Halley's first look at fiery meteors

The first in-depth analysis of the meteoric phenomena was that presented by Edmond Halley in 1714 [6]. In all, Halley published three papers on "fiery" meteors, and in the process initiated the chain of events that ultimately saw the overthrow of Aristotle's meteoric hypothesis. While Halley "flip-flopped" in his view of how meteors might form, he began the important process of questioning how the observations might be explained in terms of the rising-vapors paradigm. He also reasoned that if the theoretical paradigm is not consistent with the observations, then it is not necessarily correct to assume that the observations are wrong.

Key to Halley's 1714 analysis [6] was his improved knowledge of the structure of the Earth's atmosphere, and the observation that very bright meteors (what we would call fireballs) were often seen from many different locations. Reasoning just as Wallis and Thoresby had reasoned earlier, Halley noted that the collected observations implied that bright meteors occurred at heights between 40 to 50 miles (65 to 80 km) above the Earth's surface. This deduction was critical to Halley's analysis because, from experiments he had conducted in the mid 1680s, he knew that the Earth's atmosphere did not extend much beyond a height of 40 to 45 miles (i.e., about 70 km) [7].

Knowing that the Earth's atmosphere did not extend much beyond a height of order 45 miles, Halley reasoned,

> *It may deserve the Honourable Society's Thoughts how so great a Quantity of Vapour should be raised to the very Top of the Atmosphere.*

Not only this, however, Halley also questioned how some of the "fiery" meteors could apparently appear at heights beyond the top of the Earth's atmosphere. The direction of Halley's reasoning is clear; if meteors are really produced by rising vapors then their observed heights should be less than that attributed to the upper reaches of the Earth's atmosphere. Upon considering the data that he had collected, Halley argued that the "fiery" meteors must be,

> *some collection of matter form'd in the aether, as it were by some fortuitous concourse of atoms, and that the Earth met with as it past along in its orb. Then but newly formed, and before it had conceived any great impetus of descent towards the Sun* [6].

Halley's suggestion that "fiery" meteors might be produced by something other than the collection of combustionable vapors was revolutionary. Not for several thousand years had anyone seriously suggested that meteors might not be ignited vapors [1]. Recognizing that his interpretation of events might not be a popular one, Halley challenged his readership with the words,

> *I would be glad to have the opinion of the Learned there on, and what Objection can be reasonably made against the above said hypothesis, which I humbly submit to their Censure.*

It is interesting to ask why Halley's extraterrestrial hypothesis of meteor origins did not meet with immediate approval. Certainly no one openly challenged Halley on his interpretation of the observations. As we shall see next time one of the main reasons that Halley's extraterrestrial hypothesis did not meet with wide-spread acceptance was the fact that in 1719 he reversed his ideas on meteor origins, falling back at that time on an Aristotelian-like rising-vapors hypothesis. Even if Halley had not changed his mind, it is not at all clear that his extraterrestrial hypothesis would have gained much popularity at the time that he proposed it. For example, the extraterrestrial hypothesis challenged Isaac Newton's then popular idea that the heavens were empty of all solid matter saving the stars, planets and comets. Not only this, however, Halley was essentially describing an Epicurean model for meteor origins [1]. The atomistic philosophy of Epicurus, with its emphasis on the "materialistic" and the "probabilistic" side of nature had been greatly criticized during the latter half of the 17th and early 18th centuries by the Church, and the (mainly European) supporters of the Cartesian doctrine of continuous matter [8]. While in Britain Halley's Epicurian views might have been received with some sympathy, his comments concerning the "fortuitous concourse of atoms" would not have been received kindly elsewhere in Europe.

3. Next time

Although the Aristotelian based paradigm of meteor origins survived its first real comparison with the observations, some doubts had been cast towards its true applicability. In the decades that followed Halley's initial analysis, it became increasingly clear that the observations of bright meteors could not be fully explained upon the basis of ignited vapors. The best part of a century was still required, however, to drive-home the idea that meteors had an extraterrestrial origin. As we shall see next time, the theories on meteor origins had first to become more confused before a new meteoric paradigm was to emerge.

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A September Radiant in the Aries-Triangulum Region?

Gary W. Kronk

Independent observations of unexpected meteor activity were made by *IMO* members Gary W. Kronk (Troy, Illinois) and George W. Gliba (Greenbelt, Maryland) on the night of September 11-12, 1993.

The author was assisted by Kurt Sleeter (Swansea, Illinois) and commenced observing deep-sky objects in the region between Pegasus and Cassiopeia at 4^h00^m UT on September 12. With only occasional naked-eye observing up to 5^h15^m UT, these observers saw 15 meteors, of which 11 definitely came from the Aries-Triangulum region. Beginning at 5^h15^m UT, Sleeter and Kronk began looking exclusively for meteors. During the course of the next hour, they were severely hampered by clouds for half the time, but still observed 5 meteors, of which 1 was a Piscid and 3 were from the Aries-Triangulum region.

Gliba began observing meteors at 5^h18^m UT. He was located near Mathias, West Virginia, at a private observing site for members of the Westminster Astronomical Society in Maryland. He had just finished some extensive deep-sky observing and decided to put in some time looking for meteors. During the next two hours, under very clear skies, he observed 35 meteors. These included 6 Piscids, 1 γ-Aquarid, and 11 from the Aries region.

Fortunately, all three observers estimated radiants. Kronk visually estimated the radiant as $\alpha = 35°$, $\delta = +30°$. Sleeter plotted five of his observed meteors on a star chart and obtained a radiant of $\alpha = 30°$, $\delta = +30°$. Gliba, finally, estimated his radiant was near γ Arietis, which indicated a radiant near $\alpha = 28°$, $\delta = +19°$. Gliba added that the radiant seemed diffuse. Taking the three available radiants and adding a high weight to the declinations of Sleeter and Kronk, and to the right ascensions of Sleeter and Gliba, the resulting average radiant was $\alpha = 30°$, $\delta = +29°$. The average solar longitude of these observations would be $\lambda_\odot = 169.^\circ5$. Overall, the three observers noted the radiant in the Aries-Triangulum region produced generally faint meteors. Kronk and Sleeter noted all of the meteors were between magnitudes +3 and +4.5, except for a yellow, magnitude +1 meteor early in the session. Gliba noted the meteors were generally between magnitudes +3 and +5, with two exceptions: one at magnitude −2 and the other at +1. Gliba, Sleeter, and Kronk all reported the meteors were moving at slow to medium speeds. Sleeter and Kronk noted the meteors were much slower than Perseids, and comparable to the speeds seen for the Aquarids and Capricornids.

The author posted brief details of this activity on several computer bulletin boards. These details did not include times or radiants, only that enhanced activity was noted on the night of September 11-12. Although several potential confirmations were received, especially from the United States, there were no additional radiant determinations. A very promising observation was obtained between 0^h00^m and 2^h00^m UT on September 12, when Maurice De Meyere (Deurle, Belgium) was operating a forward scatter radio meteor detector and registered enhanced activity that was 17% to 83% higher than during the same hours on all other dates during the period of September 1 to 15.

A search was conducted through the visual observations of meteor radiants which have been published during the last 140 or so years. Major sources included the *Astronomische Nachrichten*, *Memoirs of the Royal Astronomical Society*, *Monthly Notices of the RAS*, and the *American Journal of Science*. From these it can be concluded that there is no trace of this radiant in the records of any meteor observer up into the early years of this century, including Alphonso King, Alexander S. Herschel, Eduard Heis, Robert P. Greg, and William F. Denning. Seven probable radiants were found in Cuno Hoffmeister's book *Meteorströme* (1948). These radiants were detected between 1915 and 1937, and indicate activity occurring between solar longitudes of $\lambda_\odot = 164.^\circ0$ and $\lambda_\odot = 169.^\circ0$. There are also 13 probable radiants in the records of the *American Meteor Society (AMS)* during the period of 1934 to 1967. These radiants imply that activity can occur between solar longitudes of $\lambda_\odot = 163.^\circ0$ and $\lambda_\odot = 171.^\circ6$, and over half of the radiants occur between solar longitudes of $\lambda_\odot = 167°$ and $\lambda_\odot = 171°$. Three prominent *AMS* alumni account for 9 of the radiants, and they are Franklin W. Smith, Charles E. Worley, and Jeremy H. Knowles. When all of the visual radiants are looked at as a whole, it is revealed that independent observations by two observers occurred in 1934, 1940, and 1951. The 1934 radiant was observed on September 10 by Smith in the United States and Hoffmeister in Germany.

A search was then made through the various photographic and radio-echo surveys conducted during the 1950s, 1960s, and 1970s. No trace appeared in the photographic records, which might lend support to the general faintness of the radiant's meteors as observed in 1993; however, two streams appeared in the radio-echo data. Zdenek Sekanina's 1969 survey revealed streams which he called the α-Triangulids and the α-Arietids. The α-Triangulids were based on 13 radio-echo meteors which indicated an average radiant of $\alpha = 30.^\circ4$, $\delta = +29.^\circ5$. The α-Arietids were based on six radio-echo meteor orbits which came from an average radiant of $\alpha = 32.^\circ6$, $\delta = +21.^\circ8$. The resulting orbits were as shown in Table 1.

Table 1 – Orbits of the and α-Triangulids and α-Arietids.

Stream	ω	Ω	i	q	e	P
α-Triangulids	$345.^\circ9$	$165.^\circ7$	$38.^\circ7$	0.087 AU	0.870	0.55 yrs
α-Arietids	$324.^\circ6$	$165.^\circ8$	$117.^\circ4$	0.143 AU	0.929	2.81 yrs

The nearly 40 000 radio-meteor orbits determined by Sekanina during his two radio-echo surveys of the 1960s were then checked for additional members. These surveys covered the first half of September during 1962, 1963, 1964, and 1969. While the solar longitude of the radiant's appearance in 1993 was $\lambda_\odot = 169.^\circ5$, Sekanina's surveys never operated while the radiant was above the horizon beyond a solar longitude of $\lambda_\odot = 168.^\circ1$, or more than a day earlier than the potentially observed maximum in 1993.

The result of the initial search was the detection of 47 meteors. Among those were perhaps five potential streams. Both the α-Triangulids and α-Arietids were detected among this group, as well as three potential minor radiants which produced 4 meteors or less. The α-Arietids appeared exclusively in 1969, so the above orbit could not be improved upon. The α-Triangulids produced meteors in 1962, 1963, and 1969, thus representing the strongest radiant in this group. This increased the overall number of radio meteors from this radiant; however, it was then noted that a strong core of 9 meteors was apparent. The orbit of this core was as shown in Table 2.

Table 2 – Radio determination of the orbit of the α-Triangulids.

Stream	ω	Ω	i	q	e	P
α-Triangulids	$344.^\circ1$	$165.^\circ8$	$36.^\circ1$	0.097 AU	0.857	0.560 yrs

The average radiant for solar longitude $\lambda_\odot = 165.^\circ8$ was $\alpha = 27.^\circ5$, $\delta = +28.^\circ8$.

Despite the evidence presented above, much still needs to be learned about this radiant. The only solid facts that seem to be indisputable from the above discussion is that the radiant probably produces annual activity and its perihelion distance is well within the orbit of Mercury. The next opportunity for observation would be September 12.5, 1994 (UT), when the radiant would be situated over the Pacific Ocean.

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Orionid Meteor Activity on October 18, 1993

Jürgen Rendtel and Hans Betlem

Unusually high Orionid activity was reported around 02^h UT on October 18, 1993. This event has been well-documented by visual and photographic data from Europe. Rates were higher than in previous years for the period $\lambda_\odot = 204.^\circ7$–$204.^\circ9$ (eq. 2000.0). There are no data which would suggest high ZHRs from periods just before or after this interval. Photographic records during this period show an impressive ratio between the rates around 2^h UT to the surrounding periods of about 2:1. The photographic data prove that the activity was caused by the Orionids, and not by a coincidental, simultaneous increase of rates of both the Orionids and ε-Geminids.

1. Introduction

The Orionids are normally expected to display average ZHRs of the order of about 20 around their relatively broad maximum in the interval $\lambda_\odot = 207°$–$210°$. It is also known that the entire rate profile of the Orionids is not smooth, and occasionally rates may be significantly higher or lower than average. Around October 17-18 ($\lambda_\odot = 204°$–$205°$), the typical ZHR is of the order of 10 [1]. In 1993, however, experienced visual observers in the Netherlands and Germany independently reported remarkably high ZHRs. During the period 1^h–3^h UT on October 18, the ZHR exceeded 30. Visual reports from other regions also suggest enhanced activity and a larger number of bright meteors roughly over the period $\lambda_\odot = 203°$–$206°$ [2-5]. We are grateful to Neil Bone who made many data of observers of the *BAA Meteor Section* available for this paper. Unfortunately, observers in Japan did not have favorable weather conditions at the specified period [6], and at press time we still do not have their visual data. Furthermore, there is only one series of Orionid data from North America from the period under study (obtained by Bob Lunsford and provided by Peter Brown).

2. Radio and photographic data

Radio echo counts of K. Shibata Sapporo, Japan (data kindly provided by J.-I. Watanabe) do not show an enhancement of radio count rates. We have to bear in mind, however, that the period of interest, 1^h–3^h UT, coincides with 10^h–12^h JST with the radiant very low in the sky or even below horizon. In the forward scatter counts of M. De Meyere [7] there is about the same number of (all) reflections on October 18 compared to the next morning. However, there is an enhanced number in the hour 4^h–5^h UT on October 18 (about 1.3 the number during the same hour on October 19).

Another very reliable record of the enhanced activity on October 18, especially of bright photographic meteors, was obtained by a camera battery operated by Hans Betlem in the Netherlands. The cameras photographed 27 Orionid meteors during 110 "camera hours" on the night of October 17-18, while there were 9 Orionids photographed the following night during 96 "camera hours". The ratio of these records is 2.6:1. The fireball-patrol camera in Potsdam, with an $f/3.5$, $f = 30$ mm fish-eye lens, photographed four Orionids between $23^h23^m07^s$ and $4^h27^m00^s$ UT on the night of October 17-18, and zero during the next night.

3. Visual data

The radiant of the ε-Geminids is relatively close to that of the Orionids. This shower is active at the same time of the year. Furthermore, the geocentric velocities are comparable (66 km/s for the Orionids and 71 km/s for the ε-Geminids). Therefore, visual observers might line up meteors to the wrong radiant if the field of view is badly chosen. This is certainly not the case here, since the observers used fields which allowed them to distinguish Orionids from ε-Geminids. The visual and, in particular, the photographic data prove that the observed high ZHR is due to the Orionids only, and not the combined effect of a coincidental, simultaneous increase in the rates of both showers.

We are grateful to the observers who sent in their visual data immediately and made this analysis possible. These 21 observers noted 912 Orionid meteors during 106.74 hours effective observing time. Apart from these data, we received several qualitative reports of casual observers, but they only stated a striking level of activity. Here we list the observer's name, *IMO* code, number of Orionids seen, and the effective observing time included in the analysis (i.e., with the Orionid radiant being at least 20° above the horizon):

Pierre Bader (BADPI, 23, $2^{\mathrm{h}}00$), Neil Bone (BONNE, 4, $1^{\mathrm{h}}00$), Steve Evans (EVAST, 19, $5^{\mathrm{h}}41$), Chris Hall (HALCH, 17, $3^{\mathrm{h}}25$), Mark Harris (HARMA, 2, $1^{\mathrm{h}}00$), André Knöfel (KNOAN, 65, $3^{\mathrm{h}}38$), Ralf Koschack (KOSRA, 46, $1^{\mathrm{h}}68$), Ralf Kuschnik (KUSRA, 22, $1^{\mathrm{h}}77$), James Lancashire (LANJA, 35, $8^{\mathrm{h}}45$), Richard Livingstone (LIVRI, 10, $5^{\mathrm{h}}00$), Robert Lunsford (LUNRO, 81, $5^{\mathrm{h}}00$), Tony Markham (MARTO, 78, $11^{\mathrm{h}}25$), Raymond Minty (MINRA, 3, $0^{\mathrm{h}}91$), Koen Miskotte (MISKO, 159, $11^{\mathrm{h}}36$), Terry Moseley (MOSTE, 4, $1^{\mathrm{h}}00$), Graham Pointer (POIGR, 6, $1^{\mathrm{h}}00$), Jürgen Rendtel (RENJU, 97, $10^{\mathrm{h}}30$), Jonathan Shanklin (SHAJO, 86, $9^{\mathrm{h}}58$), George Spalding (SPAGE, 29, $3^{\mathrm{h}}08$), Ulrich Sperberg (SPEUL, 22, $2^{\mathrm{h}}07$), David Strachan (STRDA, 94, $17^{\mathrm{h}}25$), Melvin Taylor (TAYME, 12, $2^{\mathrm{h}}00$).

The enhanced activity on the morning hours of October 18 was noted by four observers only. Jonathan Shanklin, also observing this morning, but started at $2^{\mathrm{h}}40^{\mathrm{m}}$ UT, a little while after the remarkable ZHRs were recorded. His data are confirming that the Orionid ZHR returned to its "average level" of about 20. The four observers were as follows:

André Knöfel (KNOAN, 65, $3^{\mathrm{h}}38$), Koen Miskotte (MISKO, 81, $3^{\mathrm{h}}77$), Jürgen Rendtel (RENJU, 57, $3^{\mathrm{h}}78$), Jonathan Shanklin (SHAJO, 21, $2^{\mathrm{h}}00$).

4. Population index during period of increased activity

Since the population index, r, is a fundamental quantity for further analysis and since there were reports stating "large proportion of bright meteors", we first analyzed the magnitude data of the period under consideration and compared it to previous years [1]. In the analysis of the 1990 Orionids, the population index was found to be $r = 2.3$–2.9 with an average of $r \approx 2.4$ for the entire period. In the specified night of October 17-18, 1993, however, the magnitude data yielded a value of $r = 1.75$–2.0. This generally seems to confirm the statement that there were a higher proportion of bright meteors during the outburst. However, the figures are based on few observations compared to the 1990 analysis.

5. ZHR around period of increased activity

All available individual ZHRs were computed for which the radiant elevation was greater than 20° and the total correction factor was less than 5. This correction factor is given by

$$C_{\mathrm{lm}} \times F \times C_z,$$

with C_{lm} the correction factor for limiting magnitude, F the correction factor for field obstruction, and C_z the zenith correction factor.

There was no perception correction applied, because there are only very few intervals included in this analysis (cf. the small list given in Section 3). Furthermore, the perception expressed in average limiting-magnitude offsets $\Delta\mathrm{lm}$ does not play any role in the present case because the limiting magnitudes of the observations were close to the reference value of $\mathrm{lm} = 6.5$ during the period of the highest rates.

In Figures 1, 2 and 3 we present different ZHR profiles.

Figure 1 shows a smoothed activity curve with a sliding mean over 3° in solar longitude over the entire period of October 14 to 25. This very smooth profile can be regarded as a reference profile with no particular features. Such a profile can be obtained if there are very few data points only.

Figure 2 was obtained by applying a much shorter interval length ($\Delta\lambda_\odot = 0.^\circ04$, or about 1 hour) for the night of October 17-18. It shows the significance of high ZHRs compared to the reference profile. In the late evening of October 17 (23^{h}–24^{h} UT) the ZHR was already at a level of 25. Between 1^{h} and 3^{h} UT on October 18, i.e., around $\lambda_\odot = 204.^\circ80$, it exceeded 30, and returned to a value of 22 after $3^{\mathrm{h}}30^{\mathrm{m}}$ UT ($\lambda_\odot = 204.^\circ86$). For comparison, we added averages from the 1990 analysis.

Figure 3 is a detail of Figure 2.

The averaged values are listed in Table 1. The given error bars again correspond to the 68% confidence interval of the average. From the available data we may conclude that, at least during the period between $\lambda_\odot = 204\overset{\circ}{.}6$ to $\lambda_\odot = 205\overset{\circ}{.}0$, the ZHR was well above average. The lack of data from Japan and North America does not allow us to estimate the time of the beginning and the end of the period of higher ZHRs. The European data of the previous and the following night give ZHRs at the expected level.

Table 1 – Data calculated from the 1993 Orionids around October 18: solar longitude, population index r, mass index s, number of included intervals, number of Orionids, ZHR, and number densities (per 10^9 km^3) for Orionids *(i)* of magnitude at least 6.5 ($\rho_{6.5}$), and *(ii)* of mass at least 20 mg (corresponding to magnitude at least 0.0, $\rho_{0.0}$). Note that we did not produce a complete analysis for the entire period. Thus all values except for the specified interval should be regarded as rough and preliminary.

$\lambda_\odot$ (2000.0)	r	s	Interv.	Ori	$\overline{\text{lm}}$	ZHR	$\rho_{6.5}$	$\rho_{0.0}$
201.81	2.50 ± 0.55	1.90	5	8	5.74	4.5 ± 2.4	9.5 ± 10.6	0.4
202.41	2.50 ± 0.55	1.90	10	39	5.96	7.9 ± 1.8	16.2 ± 15.0	0.7
203.44	2.35 ± 0.35	1.85	11	68	6.06	12.0 ± 1.4	19.9 ± 13.2	1.0
203.80	2.20 ± 0.15	1.78	6	37	6.03	14.7 ± 1.4	18.3 ± 6.2	1.2
204.74	1.75 ± 0.15	1.55	3	32	6.37	26.5 ± 0.6	9.9 ± 4.8	1.5
204.75	1.75 ± 0.15	1.55	3	45	6.42	29.2 ± 2.7	11.3 ± 5.8	1.6
204.78	1.80 ± 0.15	1.60	3	55	6.42	31.6 ± 4.6	15.2 ± 7.2	2.0
204.79	1.85 ± 0.10	1.62	3	57	6.40	30.9 ± 4.3	17.9 ± 6.8	2.1
204.82	1.95 ± 0.05	1.68	3	65	6.41	31.1 ± 0.9	24.4 ± 4.3	2.3
204.83	2.00 ± 0.05	1.70	2	44	6.45	30.8 ± 1.5	26.0 ± 4.1	2.3
204.86	2.00 ± 0.50	1.70	3	47	6.21	20.8 ± 2.4	18.0 ± 22.5	1.6
204.87	2.00 ± 0.50	1.70	4	79	6.32	22.4 ± 2.0	19.4 ± 23.6	1.7
204.89	2.00 ± 0.50	1.70	2	43	6.36	24.3 ± 1.4	21.0 ± 24.9	1.8
205.89	2.10 ± 0.20	1.75	20	322	6.56	17.1 ± 0.7	18.1 ± 7.9	1.4
206.14	2.15 ± 0.20	1.75	23	341	6.50	17.0 ± 0.7	19.6 ± 9.1	1.4
208.70	2.80 ± 0.55	2.00	12	67	5.87	14.8 ± 2.5	45.4 ± 34.6	1.3
209.55	2.80 ± 0.55	2.00	13	102	5.80	20.3 ± 3.8	62.2 ± 48.5	1.7
211.31	2.80 ± 0.53	2.02	6	63	5.77	23.0 ± 6.0	70.5 ± 56.8	2.0
212.31	2.80 ± 0.53	2.02	2	9	6.17	8.5 ± 1.2	26.1 ± 18.3	0.7

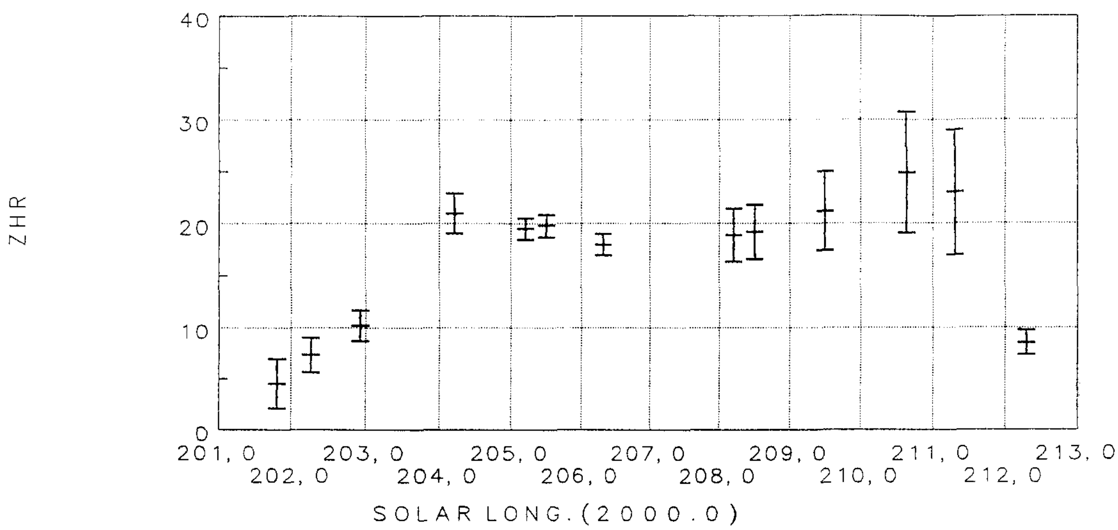

Figure 1 – Complete, smoothed ZHR-profile of the 1993 Orionids as described in the text. A sampling interval of $3\overset{\circ}{.}0$ shifted by $1\overset{\circ}{.}5$ erases all characteristic features, but shows the general shape of the profile.

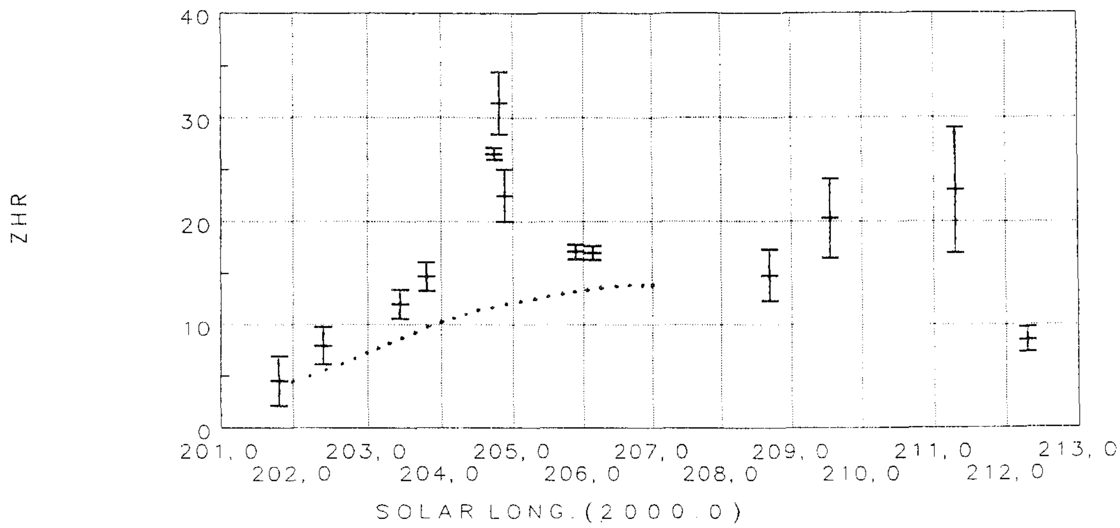

Figure 2 – ZHR-profile of the 1993 Orionids with a sampling period of only 1 hour on the night of October 17-18 ($\lambda_{\odot} = 204^{\circ}.50$–$205^{\circ}.00$). Here the "peak" and the remarkable activity level become obvious. For $\lambda_{\odot} < 204^{\circ}.50$, we used $2^{\circ}.0$-intervals shifted by $1^{\circ}.0$; for $\lambda_{\odot} > 205^{\circ}.0$, we used $3^{\circ}.0$-intervals shifted by $1^{\circ}.5$ as in Figure 1. For comparison, we indicated the 1990 Orionid ZHR (dotted line).

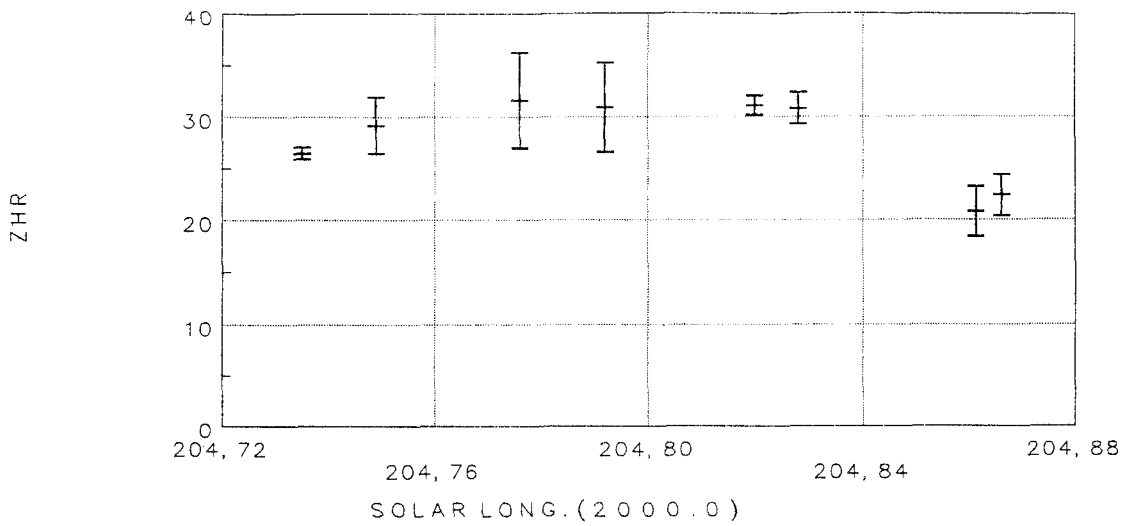

Figure 3 – Part of the Orionid ZHR profile of the outstanding period for the night October 17-18 ($\lambda_{\odot} = 204^{\circ}.68$–$204^{\circ}.84$). The first value of the night at $\lambda_{\odot} = 204^{\circ}.73$ is already higher than the annual average. The last displayed ZHR at $\lambda_{\odot} = 204^{\circ}.88$ indicates that the activity returned to the "average level" a bit later.

6. Comparison with previous returns

It has been suggested that the Orionids have a variable activity profile and maximum strength from year to year. The most complete analysis of the *IMO* was done on the 1990 data (see [1] and also references therein). Radar observations indicate that the Orionids do not have a recurrent curve of hourly rates. The position of the maximum activity varies from year to year in solar longitude as well as the maximum rate of meteor echoes [8]. For example, the highest numbers of long-duration echoes between 8^{h} and 13^{h} UT in Ottawa radar observations were reported for October 17 in 1957 and 1966, while in the years between 1959 and 1967 the maximum rates were registered on October 21 or 22 [9]. The papers [8] and [9] explicitly refer to long-duration echoes while the radio counts mentioned in Section 2 refer to the total number of the counts. Probably it is worth-while to further deal with the forward-scatter data as well.

7. Conclusions

Our analysis mainly concerns the Orionid activity during the night October 17-18, 1993. For this night, we find a population index for the Orionids of $r = 1.8$ which is lower than any value of r found in the study of the 1990 Orionids [1], and which is much lower than the standard value given in several shower lists. This finding is supported by a large number of Orionid meteors recorded photographically in the same period. This indicates that the Earth passed through a region of the stream containing a higher fraction of large particles. Although the calculated number densities should be treated with great care, the data in the last column of Table 1 clearly show that the "peak" is mainly a peak of larger meteoroids. Their number density, $\rho_{0.0}$, is larger than the corresponding value at the maximum around 21 October.

Considering the errors, we may state that the observed peak is significant. It lasts for about $\Delta\lambda_\odot = 0\overset{\circ}{.}12$, or 3 hours. The photographic results support the relative ratio of 2.5:1 in the rates for the period $\lambda_\odot = 204\overset{\circ}{.}73$–$204\overset{\circ}{.}85$ compared to neighboring intervals.

Obviously, the Orionids do not show a stable activity curve from return to return. In some years (1957 and 1966, according to radar results [9]) the maximum rates were found on October 17, similar to the 1993 visual and photographic observations analyzed in this paper. Only a global analysis of Orionid data can provide information about the activity profile and the other parameters of the 1993 Orionids.

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A Meteor Color Survey

George Zay

An analysis is presented of visual colors for all meteors recorded by myself during 1992 through May 1993. In this survey, yellow and white meteors were treated more conservatively as being part of the same category. The color distribution does not follow the trend shown in previous color scheme arrangements [1,2].

1. Introduction

An analysis of meteor colors has been performed on several showers [2] and sporadics [1]. The working data had input from several individuals, which most likely had independent methodologies in their color determinations, whether they be conscious or unconscious. I would like to present a color distribution scheme based upon one individual's methodology.

Three groupings were selected based upon numbers of meteors available. They are *(i)* an all-meteors combination from 1992 through May 1993, *(ii)* the Lyrids of 1992 and 1993, and *(iii)* the Geminids of 1992. There is very low contrast between white and yellow and as part of my methodology, I only designate a meteor as being yellow if it displayed the color approaching that of gold; if it is not color-saturated enough to have a 10 carat gold look, I would classify it as being white. Thus, I have few true yellows in my tally.

In an attempt to keep from diluting my data from marginal observations, I eliminated all meteors dimmer than magnitude +2. I felt magnitude +2 meteors were bright enough to reliably represent the low end for color determinations.

When I computed color percentages, I compared the colors to each other for each magnitude, rather than percentages for each color for the shower as a whole [1,2].

I do not have enough meteors in either major shower represented to feel thoroughly comfortable in interpreting the results. However, enough may be present to give some possible insight, such as the fact that I noticed what I feel is an interesting trend developing with the results for the Lyrids, the Geminids and the all-meteors combination. The Geminids and the all-meteors combination resembled each other somewhat, but the Lyrids appear to have a color scheme that belongs entirely to themselves.

2. The all-meteors combination (1992 through May 1993)

With a total of 1248 meteors from 76 different nights of random observing sessions throughout the stated period, which included observing periods both before and after midnight, magnitudes ranged from +2 through −15. Looking at the magnitude/color distribution in Tables 1 and 2, you will see the most prevalent colors in descending order to be white, green, blue, yellow, and orange.

Table 1 – All-meteors combination magnitude/color distribution.

Magn.	Red	Orange	Yellow	Green	Blue	White	Total
−15					1		1
− 9				1			1
− 7				1			1
− 6					2	1	3
− 5						1	1
− 4			1		1	1	3
− 3			1	2	2	9	14
− 2			2	6	3	21	32
− 1			1	15	3	21	32
0			2	15	4	244	265
+ 1		1	3	18	4	279	305
+ 2		1	1	35	1	493	531
Tot	0	2	11	93	23	1119	1248

Table 2 – All-meteors combination magnitude/color percentage distribution.

Magn.	Red	Orange	Yellow	Green	Blue	White
− 3	0%	0 %	10 %	15 %	15 %	65 %
− 2	0%	%	6 %	19 %	9 %	66 %
− 1	0%	%	1.0%	16.5%	5.5%	77.0%
0	0%	%	0.8%	5.7%	1.6%	92.0%
+ 1	0%	0.3%	1.0%	5.9%	1.3%	91.5%
+ 2	0%	0.2%	0.6%	6.6%	0.2%	92.8%

Notice the sudden jump in percentages from magnitude −1 and brighter meteors for the green and blue meteors. This indicates to me that something significant may be happening at this point—a threshold of some sort. It could be that at magnitude −1 or brighter, blue and green meteors become more readily detectable for my eyes, or this may represent a threshold where sufficient energy is present to make oxygen atoms radiate the color green. Although there are less blue meteors, they may show this same threshold from their interaction with nitrogen atoms. The brighter a meteor gets, the trend indicates an increase chance of it being green or blue. Seemingly, from magnitude −1 meteors and brighter, their color is probably derived from atmospheric reactions. I would like to speculate that some meteors of magnitude 0 and less that display blue or green color may be caused by actual chemical compositions of the meteor itself. Usually the coloration is most pronounced as a halo of sorts, around a more brilliant nucleus. I do recall one +1 meteor that was as green throughout as dark green grass. I have no doubt that this particular meteor was displaying color because of something else rather than atmospheric reactions or eyeball trickery.

3. Lyrids of 1992 and 1993

With a total of 54 Lyrids within the acceptable magnitude range, Table 3 lists the magnitude/color distribution. White seems to be the dominant color with a real noticeable lack in green and blue at just about all magnitudes. The real significant thing for the Lyrids was a genuine lack of color for non-fireball meteors.

Table 3 – Magnitude/color distribution for the 1992 Lyrids.

Magn.	Red	Orange	Yellow	Green	Blue	White	Total
−6					1		1
−2						4	4
−1						4	4
0						9	9
+1			1	1		13	15
+2						21	21
Tot	0	0	1	1	1	51	54

4. Geminids of 1992

With a total of 90 acceptable Geminids, Tables 4 and 5 list their magnitude/color distribution. As noted with the all-meteors combination survey, there is again indication of a threshold between the 0 and −1 magnitude range, albeit in weak form. I feel that if larger numbers were used, the results would more resemble that of the all-meteors results.

5. Comparison with other surveys

¿From the results obtained by other surveys [1,2], I can only compare to the Geminids observed in 1990 by the *JAS Meteor Section* and inferences by others in regards to other sporadic surveys. I find it most interesting that in the *JAS* survey that out of 716 Geminids, only 2 green-colored meteors were observed, whereas in my own personal survey for 90 Geminids, I recorded 12 green meteors. This is definitely a disproportionate number. I personally have only myself to answer to, as to how reliable I feel my observations were. Whereas the other surveys have an apparent multiple number of observers. Usually in surveys where the data of multiple observers are used, the introduction of questionable data can be averaged out. I am personally suspect of a non-homogeneous method of gathering for color by the observers that contributed to the *JAS* survey. No doubt, analyzers of other color surveys will probably be suspect of my methodology or eyesight in general.

Table 4 – Magnitude/color distribution for the 1992 Geminids.

Magn.	Red	Orange	Yellow	Green	Blue	White	Total
−7				1			1
−6					1		1
−4				1			1
−3					2		2
−2			1	2		2	5
−1			1	3	1	3	8
0			2	1	1	22	26
+1				3	1	15	19
+2				1	1	21	23
Tot	0	0	4	12	7	48	90

Table 5 – Magnitude/color percentage distribution for the 1992 Geminids.

Magn.	Red	Orange	Yellow	Green	Blue	White
−1	0%	0%	10%	20%	10%	20%
0	0%	0%	8%%	4%	4%	85%
+1	0%	0%	0%%	13%	4%	83%
+2	0%	0%	0%%	4%	4%	91%

6. Eyeball trickery

As pointed out by McBeath [2], most color results can be related to effects from the observer's eyes. I agree that there is a certain number of mis-interpretations for every observer, some more than others. For myself, I have noticed some nights with a slight green cast to the dark sky. To some readers, an immediate "A-Haa! That's why you see more green meteors than others" may arise. I would agree if I included +3 and +4 meteors, but I eliminated these and I am confident in my judgment when I do designate a color. I am always conscious about illusions and marginal color interpretations. As part of my methodology, if it is questionable, I will designate it as white in color. As for blue-colored meteors, I feel I have less mistakes with these: most meteors that I identify as being blue are generally quite bright.

7. Conclusion

One thing is certain: reliable interpretation of meteor colors is generally still up in the air. There are probably as many interpretations as there are observers. Some showers, such as the Lyrids, might have potential for presenting a color signature that is unique to its membership. It can be used in conjunction with radiant determinations and velocity to weed out a few non-shower members, but not by themselves. Considering any sporadic rates and chance radiant alignments with just the right velocity, little gain will probably be had for this kind of usage. Apparently, few if any showers will show enough uniqueness to be able to reliably use color as a useful tool without the aid of some automated equipment that detects electromagnetic frequencies. Colored meteors might have to remain in the realm of spectator enjoyment much like rainbow watching or firework extravaganzas.

References

[1] A. McBeath, "Sporadic Meteor Colors", *WGN* 18:4, August 1990, pp. 114–118.

[2] A. McBeath, "Shower Meteor Colors", *WGN* 19:5, October 1991, pp. 198–205.

Interview Series

Dr. Zdeněk Ceplecha

Jürgen Rendtel

The purpose of this series of interviews with distinguished professional meteor astronomers is to provide another perspective on the work undertaken by professional meteor workers and in doing so create more personal contact between professional and amateur meteor astronomers. This interview was conducted by Jürgen Rendtel in July 1992, at Smolenice, Slovakia.

Question: How did you come to study meteors?

Answer: I liked meteors when I was a young boy of about 13. I started to observe meteors as amateurs do: through visual observations. And at the same time (1942) there was the Petřín Observatory in Prague, where I lived, on the top of a hill. So I went there for night observations. At the same time there was a small group dealing with photography. They also photographed meteors, and the older man, Mr. Černý, who was in charge of this group, presented these at a meeting. I said, "gosh, those are nice photographs, but what can one do with them?" I like nice photographs, but on the other hand I also like to solve problems, to evaluate something. At that time I was also very much interested in mathematics. That helped me. Two years later—when I was in the Septima and Octava in the Gymnasium (final years of high-school)—I won the first place in the Math Olympics for the entire country of Czechoslovakia, and this helped me to think about computational methods. At that time, you know, there were no computers, even a normal desk machine with a rotating panel was something... That is how I got involved and started my professional interest in meteors.

Q: Did you learn about astronomy at school, or did you read the astronomical literature?

A: A part of it was at school. There was a small group at my school. One older student who was interested in astronomy—by the way, he later became an architect—attracted my attention to astronomy in some out-of-class activity. Then I read a lot of popular astronomical books, of course, Czech-written. But already when I was in the 7th or 8th grade class I started to read German and English books.

Q: ... and then you found the already mentioned group at the Petřín observatory. Did you immediately start with meteors, or did you make more general astronomical observations in the beginning?

A: I was specialized from the very beginning in two fields: solar and meteor observations. Once I was in charge of solar observations for the entire amateur group. But I quit this after 3 years and continued with only meteors.

Q: I suspect you went to a university after school?

A: Yes, at that time it included 2 years of mathematics and physics, a combination of both, and after 2 years we got another 2 years of specialization, and I specialized in astronomy and astrophysics. Astronomy then led me to the Ondřejov observatory. During the last year of my studies I already had a job at the observatory. I was put in charge of the 1951 first double station photographic meteor program. That was my beginning and because I was the only one working on the subject, I started to compute one of these double station meteors. This was really done manually: I used a normal desk calculating machine, tables of trigonometrical functions, and it took me about 100 hours. This was in 1951, and it was published in the *Bulletin of the Astronomical Institutes of Czechoslovakia*. I made 15 calculations in half a year. Currently I have a 486 PC in my office, and exactly the same calculations are finished now within a small part of a second. On the other hand, I can make much more sophisticated computations nowadays. This just demonstrates the progress of mankind.

Q: What was the topic of your PhD?

A: Meteor photography. After this I started into a post-doctoral study. I compared an older concept of single-body theory and a new concept presented by Prof. Hoppe from Jena, Germany. Actually, also the old single-body theory was the pre-war work of Prof. Hoppe. I compared both concepts in my post-doctoral thesis to receive the title "candidate of sciences." I found the new concept was wrong; this result was based on my photographic observations.

Q: When was the European Network started?

A: We started the double station program in 1951 at the Ondřejov observatory gradually. At first there were 2 stations with 5 cameras each, 42 km apart. Then we enlarged the program, and made more sophisticated cameras. We used Tessar optics of Zeiss production with 180 mm focal length, and all cameras were identical. The focal ratio was $f/4.5$. Agfa ISS plates, which were very good, were used. We continued with this program for 8 years. We exposed for a total time of something like 2500 hours during the course of these years. Cameras were opened each clear night when there was no moon shining. Then the Příbram fireball came. This was of course a nice event. You can imagine that this was a real once-in-a lifetime event.

At the moment I first held the meteorites in my hand, I was quite happy as I knew I became the first to have photographed the fireball with the double station and scientific program, with the time marks delivering very precise velocity data and a precise orbit and so on, and I then held in my hands the body which landed on the Earth's surface and for which mankind had the first firm idea where it had come from in the cosmos. At that time I knew that it was a really historic event.

On the other hand I get great pleasure from working to get more and more information. Meteor astronomers from Czechoslovakia came together and discussed the program. How was it possible to repeat Příbram? Not only from the point of view to get meteorites—of course, this was something already accomplished— but also from the point of view of obtaining precise records of very bright meteors. Not the usual -4 or -5 events, but -7 and brighter which tend to be rare if you use the "classical" techniques. We wanted more stations with just *one* camera, because we could not handle the amount of equipment and pictures otherwise. We decided to use the all sky-cameras, the old type with a tripod and a convex mirror. That was in 1963. In 1967 or 68, at an occasion of a meteorite conference in Moscow I met Prof. Zähringer of Heidelberg, Germany. He became very interested in the program. He was able to start the network in Germany within 1 or 2 years. And it was practically as it is now, except we changed the old all sky-cameras with something which is 10 times more precise, which are the fish eye lenses used in the Czech part of the network, now. You *(Jürgen Rendtel, ed.)* are actually heavily involved in the program, and you know more about it.

Q: Have you been building the mirrors and cameras in the observatory's workshop?

A: The glass mirrors were bought in Bratislava. These were regular mirrors for projectors, and we used the other side of them. Later they started to produce these mirrors in a more sophisticated way, and the side we used became less good. Thus we were limited with mirrors. At the same time we got the first fish eyes.

Q: How long did the surface coating survive for the mirrors?

A: We renewed the coating on average once in a year at the beginning of the program, in 1963. But with growing industry, pollutants became worse. I remember a case where we gave a mirror to a station in northern Bohemia, and we visited there 2 months later; there was no remaining aluminum at all on the surface. It was just glass, because it was very close to a region with coal power plants blowing sulphur dioxide into the air. Later we decided to use fish eye lenses and we brought them outside the building only for the exposures, never leaving them outside permanently like the all sky mirrors.

Q: Let me return to the meteorite fall (Příbram). I know about several searches for other suspected meteorites. How long did it take to discover the Příbram meteorites?

A: The first piece was discovered by a farmer, around April 20, 1959. *(Note: Precise circumstances and dates can be found in the original paper on Příbram: Bull. Astron. Inst. Czechosl. 12, 1961, p. 21.)* The fall occurred on April 7. At that time there were no big collective farms, and most of the farmland was divided into small fields, and the farmers really knew their fields perfectly well. The first meteorite was found in fields between forested areas. The farmer was pretty sure that somebody threw that stone into his field. First he threw it to the edge of his field. Some days later he brought it home and we learned about this in the village shop. That is how we got the first fragment. The computations of the trajectory lasted about one week. This was not the way it is today—in terms of the time taken to make such computations. We then knew where the territory was located that additional material might be found: the projection of the main line and also projection of lines of several fragments visible on our photographs. And we also knew that we should go along these lines to find more material, something like 15 or 20 km and, say, 2–3 km on both sides of the main line; and we also asked in the villages.

Q: This was the first piece. How many other pieces were found?

A: There are 3 more. Moreover, one was found and lost.

Q: ...found and lost?

A: ...by another farmer. This farmer found two pieces. We have the first one (Velká). The second one found by the same farmer before taking in his crop, was lost. At the time of the second piece, he knew only that there was some announcement at the village board, and by the local radio, and he also saw the example, the first meteorite, which I showed to everyone who might come into contact with other fragments. And then he immediately recognized that he found a meteorite. But he never has been able to recover the previous piece he left somewhere at the edge of his field some weeks before... And we also systematically searched the region ourselves, mostly in forests. In forests it is a hard task, but farmers do not go to the forests in spring.

Q: There was no piece found by systematic search?

A: In the case of Příbram, no. Only by systematically going to the region and asking everybody, advertizing and so on. The last one was only 105 grams, a very small one, close to the edge of a forest. A young boy of 13 found it.

Q: That is an interesting coincidence. It is similar to the case of the Hohenlangenbeck (Eastern Germany) meteorite fall—it was 43 grams only—also found by a school boy of about the same age.

A: Maybe, children have better eyes, perhaps? And they are interested in strange things around them, etc. That may be a reason. Once every 2 or 3 years on average we have a systematic search. Last time was in 1991, which was continued this year *(1992, ed.)* on places which were not accessible in 1991. At the beginning of this spring we went to such places close to country roads for 3 more days. The photograph showed the trajectory down to 16 km! But until now only Příbram has been photographed and recovered by us. We came only to four Příbram meteorites during all these years, of course if you do not count the daylight fall in Police in northern Bohemia and another one in eastern Bohemia. But in these cases we have no photographic or other precise records.

Q: Many readers know that you have made a lot of studies of fireballs in general and their interaction with the Earth's atmosphere, trajectories, parameters, etc. Which astronomers did you mainly cooperate with?

A: I am very much indebted to many of my professional contacts, in particular to Dick McCrosky. Dr. Richard McCrosky from the Smithsonian was practically deriving the same idea (to start a fireball network) from the Příbram fall; at the same time we were expanding our efforts as a result of this success.

He started to operate the so-called Prarie Network in the United States and I came in close contact with him. I recognize him as an exceptionally good fellow. He is older than I and is retired. He gave his material freely to me. I spent a lot of time with him in the past, working on similar programs. I have free access to the data; at the moment, for example, I have not only Příbram original photographs in my office, I also have the Lost City original records there. These two unique snaps came together, somehow.

I had, of course, more contacts with other colleagues, for example with Ian Halliday who was the chief of the Canadian network. We exchanged material and observations, views, etc.

At the observatory I have a very good group. At the moment there are 2 young men, very enthusiastic, smart and creative. One is Pavel Spurný, and the other is Jiří Borovička, who mostly deals with meteor spectra, now. This is another business I was in. I was not only working with fireballs, in fact, I dealt with about 5 different topics in meteor astronomy, also comets. But fireballs are perhaps my main work, and meteor spectra the second choice. We have a lot of nice spectra records with resolutions like 50 Å per mm.

Q: We just saw in a lecture the fantastic spectrum with hundreds of lines in it...

A: At that time I did the analysis by hand. There were no such nice identification procedures like nowadays. Twenty years ago, I spent 3 years with a spectrum, identifying lines. It showed more than 1000 lines in the visible region. And not only identification, but also absolute intensities of lines and computation of abundancies and temperatures. This was the way I did 5 spectra in my life. About 20 more of the same high quality are waiting for analysis.

Q: Can we speak about an "Ondřejov school" of meteor astronomy?

A: If these 2 young men, I mentioned, go on—yes. There is another one, who is 15 years younger than myself: Vladimír Padevět. He is interested in making proposals for theories in the cosmogonic sense, and interrelationships—something which is higher and broader scope than meteors. On the other hand, during the last several years he proposed a program whereby we use a TV camera for observations especially of meteor spectra in order to check if there are differences in composition towards fainter meteors of cometary and non-cometary origin.

Q: Have you also been working with amateurs, amateur groups?

A: Yes, especially at the beginning. About the first 10 years of my professional career I was more bound to amateur groups. I even published visual observations of the group I was in charge of in the *Publications of the Astronomical Institutes of the Czechoslovak Academy of Sciences*, together with Prof. Guth. Actually, Prof. Guth was my predecessor at the observatory and he was at least 50 percent responsible for my interest in meteors. I heard him when I was young giving some lecture for amateurs. If you want to call it "Ondřejov school," you might better call it Prof. Guth school. Of course, later, when my interest in visual observations decreased, and I became completely engaged in photographic programs, I had less time for contacts with amateurs. But for the case of reports of fireballs, etc., I am in contact with them permanently. I am not only in contact with amateurs in the Czech Republic and Slovakia, but also in other countries, e.g., in the Netherlands, Belgium, Germany,... I think the amateur observations, especially of meteor showers, are still of great use now. You cannot do it in another way, because the professionals are too few. You know, a professional astronomer is a stellar astronomer, or a relativistic astronomer in the sense of black-hole physics. Even the solar astronomers and such sorts think of us as geophysicists. The geophysicist looks at us—people being interested in meteors in the atmosphere—like somebody outside the field.

Q: Even if you speak with atmosphere specialists, the meteor phenomenon occurs in a region nobody knows a lot about. Up to 30 km we have balloons, above 150 km the satellites.

A: Exactly. There was a program of the middle atmosphere. It was the first attempt to improve our knowledge, say, from 30–40 km up to 100 or 120 km. It was the first trial on an international scale to attempt such a feat. This project existed for several years.

It is almost unbelievable that meteoroids are little known from the point of view of the atmosphere, and are very little known from other branches of science as well. This means that many scientists feel: I know nothing about it, and I would not be interested in it. This is a completely wrong standpoint. Even for meteorites, this is the case: before the Antarctic meteorites were discovered, there was almost no interest in them. People brought stones from the Moon. A gram costs a large amount of money to be brought from the Moon and yet there is an easy source of cosmic matter which can be found on the Earth's surface. It costs you nothing—O.K., the search—but really nothing. But there is not much attention paid to it. It appears that the value of something is "inversely proportional" to the amount of attention it receives.

Q: Another topic is public work, publication of scientific results in popular journals, giving lectures, etc.

A: In popular journals I intend to publish some more broad, general views. Sometimes I also described my research and the kind of work, but this is an exception. Usually I popularize general things, for example in a Czech journal for general sciences, where also things about other sciences are published.

Q: Have you been involved in space projects?

A: No. I never was much interested in space projects, except for their results, of course. We had been able to perform it only with the Russians. And, generally speaking, I am really not in favor of very expensive experiments.

Q: What was the most interesting event or phenomenon you have seen in your life?

A: The most impressive in my life were actually the Giacobinids, or Draconids, in 1946. I saw them— even with the moonshine, etc., there was one short period when I saw 7 meteors at the same time. It made a really big impression on me. Another unique impression was when I saw the Příbram meteorite. It was the second biggest event at the time, but if I think now, it may be the most outstanding event. I saw the meteorite—I knew it was the meteorite immediately—and I knew that I got all the records. I also knew the exact orbit—that is 4 AU at its aphelion—and here was the body in my hands. Nobody before could say what is the exact orbit of any meteorite. By the way, I tried to find a trajectory from the many visual observations. If we would not have had the photographic trajectory, and we would have collected the best visual observations for sophisticated computations, we would come to a location about 15 km north from where it really was.

Q: You mean, it is worth to encourage visual observers to obtain good fireball path data?

A: Casual observers usually try to pull the trail down. They usually do not point as high as the event was, but 20°–30° lower. If it is close to the horizon, elevations are right. Close to zenith, elevations are also O.K., but if it appears in medium heights, there are systematic errors.

Q: Did you actually see the Příbram fireball?

A: I saw the light, actually. I was watching TV, and at the moment I saw the illuminated wall, I decided immediately that this was not from a car, as I lived along a minor road only, and the motion of the light and shadow was very strange for a car. I just switched off the signal and adjusted the brightness of the screen to that of the light I saw on the wall and measured how many lux came from outside. Later I got this also from the fireball records. The fireball caused 150 lux, a value which was close to what I found from the screen measurement with a usual exposimeter.

Q: Was there also sound to be heard?

A: Yes. And also anomalous and electrophonic sounds. The luminous trajectory of Příbram went down to 13 km. Except normal sonic booms, there were also rumbling sounds, and different zones of audibility including silent zones, probably because of reflections at the stratosphere.

Fireballs and Meteorites

Fireball

Czech Republic, August 7, 1993, $21^{h}08^{m}15^{s} \pm 15^{s}$ UT

Pavel Spurný, Ondřejov Observatory

On the evening of August 7, 1993, a slow-moving fireball of −10 maximum absolute magnitude was photographed by four Czech stations.

A slow-moving fireball of −10 maximum absolute magnitude was photographed by four Czech stations of the European Network. The fireball traveled 49.548-km during its luminous trajectory in 3.361 seconds and terminated its light at a height of 29.347 km. The following results are based on all available records measured by J. Keclíková.

Table 1 – Trajectory data.

	Beginning	Maximum lightl	Terminal
Velocity (km/s)	17.58 ± 0.02	16.24 l	6.2 ± 0.5
Height (km)	77.063 ± 0.006	46.33 l	29.347 ± 0.011
Latitude (° N)	49.4178 ± 0.0002	49.481 l	49.5163 ± 0.0004
Longitude (° E)	15.7939 ± 0.0003	15.860 l	15.8964 ± 0.0006
Abs. magnitude	− 0.2 ± 0.8	−10.3 ± 0.7l	+ 0.5 ± 0.8
Photom. mass (kg)	11.6 ±	6.2 l	less than 0.01
Z R (°)	15.57 ± 0.06	l	15.69 ± 0.06

Fireball type: I

Ablation coefficient: 0.0150 ± 0.0018 s^2/km^2

Table 2 – Radiant data.

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	278.54 ± 0.08	276.17 ± 0.09	
δ (°)	+ 35.95 ± 0.07	+ 34.04 ± 0.07	
λ (°)			235.93 ± 0.03
β (°)			+ 18.55 ± 0.04
Initial velocity (km/s)	17.59 ± 0.02	13.67 ± 0.03	36.16 ± 0.02

Table 3 – Orbital data.

Orbit (2000.0)	
a	2.005 ± 0.007 AU
e	0.5166 ± 0.0016
q	0.9693 ± 0.0003 AU
Q	3.041 ± 0.014 AU
ω	209°.46 ± 0°.09
Ω	135°.4415 ± 0°.0002
i	18°.85 ± 0°.04

Preliminary Report on Bright Fireball

USA, New England, August 6, 1993, 1^h16^m UT

Daniel W.E. Green, Smithsonian Astrophysical Observatory

A magnitude −18 fireball was seen over New England during the (local) evening of August 5. Calculations indicate that the orbit was cometary but not related to the Perseids, and that associated meteorites are unlikely.

I began receiving reports on Friday, August 6, of a bright fireball that had been seen over New Hampshire the previous evening. Early reports spoke of a fireball moving from the northeast toward the northwest or west, leading to some excitement in hopeful anticipation that this might have been an early Perseid fireball. And the early reports mentioned it being much brighter than the Full Moon, so there was reason to think that a meteorite may have resulted from the fireball. Thus, thinking how wonderful it would be to find a piece of P/Swift-Tuttle, I began looking into the reports more deeply.

The first reports came out of Conway, New Hampshire (NH), in east-central NH near the Maine (ME) border. There, an employee with the Conway daily newspaper, who saw the fireball with her fiancee, began eagerly collecting reports from her area, which increased following an announcement of the event in her paper a few days after the event. On August 12, an Associated Press report out of Concord, NH, based initially on the Conway reports, was sent out and subsequently published in papers throughout New Hampshire, Vermont (VT), and the Boston, Massachusetts area. The Associated-Press story resulted in my receiving many more reports than I would have obtained otherwise. Three weeks after the event, stories were still circulating in daily newspapers in Maine and Vermont, and more reports arrive daily even in early September, as this is being written.

My direct reports come from the three northern New England states of ME, NH, and VT, as well as from northern Connecticut and New York and from the Canadian province of Quebec. Damien LeMay of Rimouski, Quebec, an amateur astronomer associated with the Royal Astronomical Society of Canada and also with the Meteorite and Impacts Advisory Committee (MIAC) to the Canadian Space Agency, is pursuing reports from Quebec, although the so-called Estrie region in Quebec, where a meteorite fall was most likely to have occurred, appears to have been mostly cloudy on the evening of August 5. A field trip by LeMay, Bernie Volz, and myself during the first weekend in September yielded only three observers in Quebec, only one for which actual directional readings could be measured. The anticipated fall area is heavily forested and contains lakes and swamps, and the likelihood is small for any possible meteorite recovery from this event.

This preliminary report summarizes my findings thus far (September 6, 1993). We have received well over one hundred reports that give some sort of credible information that assures that the observer saw this particular event. Unfortunately, very few people saw the beginning of the fireball, so there is still much uncertainty as to where the entry point was over the earth, and thus exactly how steep the meteor's path was through the atmosphere. Only about 1 out of every 20 or 25 observers seem to have seen the beginning: the bright light drew the average observer's attention skyward so that they saw the middle and/or beginning of the fireball's path. Unfortunately, no photographs of the event are known, and it is unlikely that any useful such images will surface. And to complicate matters, it appears that one or two lesser fireballs may have been seen in New England and Quebec on the same night, moving in different directions!

My best assessment is as follows: the fireball entered the atmosphere over west-central Maine at about 9^h16^m p.m. Eastern Daylight Time (1^h16^m UT on August 6, 1993). It took around 6 seconds to traverse the sky in a direction from east-southeast to west-northwest, and the object reached apparent visual magnitude -18 ± 3 at maximum. The fireball itself was generally seen as white or bluish-white, with a color change toward orange or red being noted by many observers about halfway through the event, when a big explosion yielded a large piece leaving the main fireball at a large angle. Many also noted yellow and orange "sparks" flying off in different directions. The short-lived train (maximum duration about 10 seconds) was described as remarkable by some observers, one reporting it as wide and split.

The fireball appears to have terminated over southern Quebec, north of the border with New Hampshire. A preliminary calculation has the entry angle at about 29° (measured from the ground up), with the visible fireball terminating about 21 km above the ground. Preliminary calculations also suggest a radiant in Cygnus, with the precursor orbit being highly-inclined and likely being cometary. This fact, together with the high average velocity of about 22 km/s for the visible fireball, leaves little hope for surviving meteorites. NORAD has confirmed to me that no known artificial object was re-entering the atmosphere at that location at that time.

Damien LeMay and I continue to collect reports of this event. A final report will be forthcoming. Anyone with information regarding this fireball should contact the author at *M.S. 18, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge, MA 02138, USA.*

Plotting Errors in FIDAC Data and Consequences for Shower Association

L.R. Bellot, A. Román, and A. Rute

A preliminary analysis of fireball plotting errors is carried out. We use simultaneous events to derive the error sources. Experienced and unexperienced observers show big differences among them. As a result, about 60% of the fireballs are supposed to present some kind of tilt, even reaching 30°. Other common errors are wrong path lengths and parallel shifts. We conclude that fireball shower association is not possible nowadays, and that the program RADIANT will play a vital role in the near future. However, more research is needed to use it with reliable results.

1. Introduction

The *Fireball Data Center (FIDAC)* constitutes an extremely important source of information regarding fireball appearances. Nowadays, *FIDAC* stores quite a large amount of visual records which can be used for different purposes.

Normally, the observer provides several parameters of the fireball, such as magnitude, velocity, color, train, fragmentation, and apparent path. These data allow the study of fireballs from different points of view.

One of the most interesting topics is the association of fireballs in streams. If such a work was performed, we would have a deeper insight into the asteroidal origin of large particles. Terentjeva [1] proposed a list of fireball-producing radiants after the reduction of photographic observations. These radiants should become apparent in visual data, and *FIDAC* might be able to demonstrate it if they actually exist.

Before searching in *FIDAC* data, however, it would be wise to find out the limit imposed by plotting errors. Fireballs are unexpected phenomena. Because of this, they are mostly seen by unexperienced people who first become impressed and then have to remember the data, sometimes even a few days after the event. These people often do not know the sky, and consequently the plotting accuracy will be low in general. On the other hand, fireballs are also registered during regular meteor observations and night flights of commercial planes. In these cases, we can expect better plotting accuracy, since these people are more familiar with the sky.

The main point is that the analysis of visual fireball data has to deal with a rather inhomogeneous sample coming from very different sources. Any serious attempt to extract useful information from fireball records should first study the quality of the basic data. This is particularly true for shower association.

In this article, we define the most important plotting errors for fireballs and the consequences for shower association. To this end we use the *FIDAC* records for the period 1988–1991.

2. Determination of plotting errors

Unfortunately, the number of fireballs available is very low which imposes further limitations on carrying out any study. At the beginning of 1992, *FIDAC* stored over 550 visual fireballs with path information. Some of them were seen simultaneously from different places. In order to analyze the accuracy of fireball plots we have to use these multi-station events, since individual paths cannot give relevant information.

Only 28 cases of simultaneity were suitable for our purposes. These fireballs were caught by 72 different observers. Normally, there are 2 stations for each fireball, but sometimes this number increases up to 3 or 4.

The vast majority of the fireballs were seen by casual eyewitnesses. However, some were also recorded by regular observers. This allows the comparison of inexperienced and experienced people. In such cases, we assume the regular observer's plot to be the best one. When no experienced person saw the fireball, it is only possible to search for inconsistencies between the plots.

3. Results

To begin with, only 7 fireballs (25%) have consistent data. This does not necessarily imply, however, that they are plotted correctly. For the remaining 21 fireballs, we can distinguish five kinds of errors: tilts [2], parallel shifts, incorrect path lengths, incorrect velocity determinations, and, finally, positional misplacements. This last error occurs when the observer gets confused with the constellations and plots the meteor in a wrong area of the sky.

Figure 1 shows an example of the tilt error. The fireball was recorded on May 26, 1990, from very nearby geographical locations. The apparent paths intersect each other, thus making shower association impossible. Unfortunately, the above mentioned error is very usual: *at least 16 fireballs (60%) show traces of it.* Moreover, the amount of the tilt sometimes is extremely high, reaching even 30°.

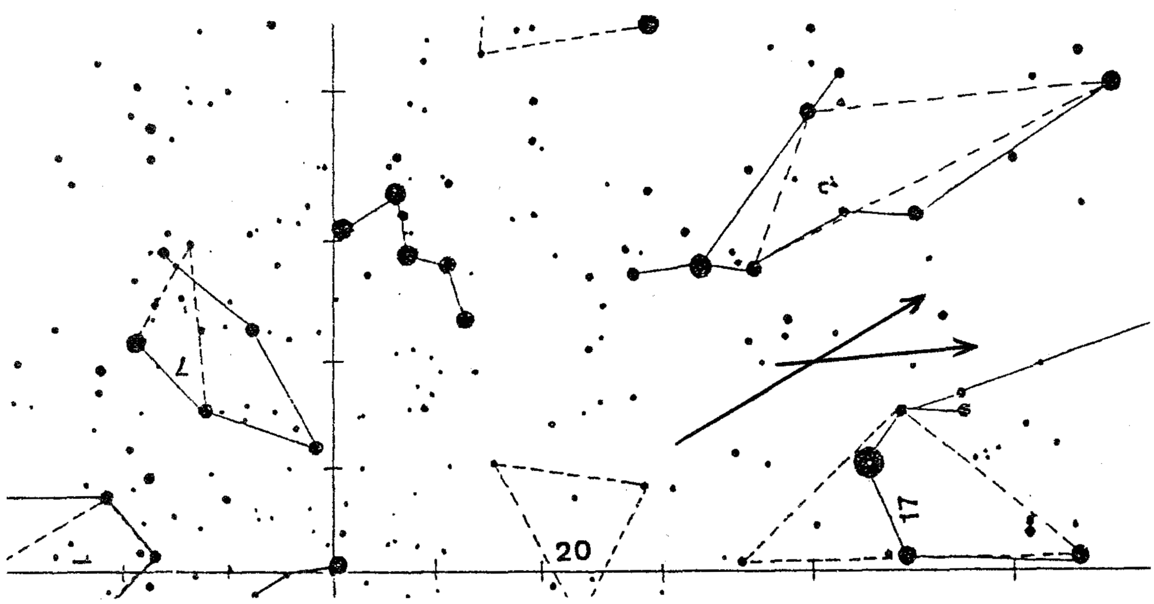


Figure 1 – Example of the tilt error in a fireball seen from the same region on May 26, 1990. The apparent paths intersect each other, making further analysis impossible.

We can say little about the parallel shift due to the lack of data. More-than-two-stations fireball events suggest it is present in almost every plot, but on the other hand it does not affect the radiant determination so much as the tilt error does.

Path length is a controversial matter: inexperienced people tend to assign enormous paths to fireballs. Very often we hear of a fireball which traveled more than 180° while other eyewitnesses record lengths for the same fireball no more than 30°. The velocity determination is also a difficult task. The same fireball may be recorded as slow to fast depending on the observer. In general, it seems that inexperienced people tend to assign faster velocities, even when the fireball was slow. A tentative percentage of erroneous velocities would range between 30% and 40%.

Finally, the most curious kind of error is confusion between constellations. There is at least one case in the sample. It was observed on January 11, 1988, from Potsdam and Altenburg, Germany. The observer in Potsdam (an experienced person, by the way) plotted it in Ursa Minor, while the observer in Altenburg (probably an inexperienced person) placed it near Cetus. The path length is similar in both cases, but due to the long distance between them, this does not admit a geometrical solution. It rather seems that one observer got confused with the sky. Indeed, a closer analysis reveals that Ursa Minor and Cetus *do look alike* if we consider only certain stars. The conclusion is evident. This kind of error is by far the most dangerous error, since it creates spurious intersections which can be taken as actual radiants.

How can we deal with these problems? Of course, one has to be very careful when analyzing fireball data because the quality of the plots is much lower. Consequently, shower association should be carried out in a different way than that of visual regular observations. It would be a waste of time to apply the same procedures as for normal meteors. In the following section we will give some hints on how to change the method to analyze fireball plots.

4. Fireball data reduction

As stated before, we must expect large errors when working with fireball plots. What is even worse, we also must expect a high percentage of erroneous path determinations. However, we can improve this situation to some extent.

When a fireball is recorded by experienced observers, we should give more weight to their plots. They may also permit rejection of some outliers. For example, if the meteor observer assigned a path length to the fireball and other eyewitnesses located near him mention much different path lengths, these latter estimates ought to be ignored. In this way, a first selection is made.

When no experienced people saw the fireball, little can be done. It is relatively easy to reject evidently erroneous paths (i.e., those which travel too large distances), but in general we will not be able to distinguish tilted or parallel-shifted fireballs. In such cases, two possibilities still remain: not to use the data or processing them with computer programs like RADIANT [3]. The second option is preferable, but it cannot be applied without first modifying the program.

Naive backward tracing is not suitable because there are too few meteors, and thus probability distributions are needed. As explained in [3], the probability for each sky "pixel" to be the radiant of a meteor depends on the plotting and velocity errors $\sigma(\Delta)$ and $\sigma(\omega)$. In the case of fireballs, these errors are much bigger than that of normal meteors, so the standard values currently stored in RADIANT are useless for fireball analyses. As a consequence, more research on fireball inaccuracies should be carried out before applying the program RADIANT.

One thing is clear however: RADIANT will become a necessary tool for fireball research. It is the only available tool to deal with inaccurate plots. Fireball radiant association is just impossible to perform by hand when the suspected radiant lies close to other active regular showers (remember that most fireball streams are ecliptical). But RADIANT also needs some further developments to obtain reliable results, which will be a hard job. We require a large amount of simultaneous events to draw statistically significant conclusions. Perhaps during the next years we will be able to collect such quantities of data, and then we will be ready to analyze the complete set of records.

5. Conclusions

We have shown that plotting accuracy is much lower for fireballs than for normal meteors. The most common sources of error are tilts, wrong path lengths, and parallel shifts. The presence of these errors does not mean fireball data are useless: although the quality of the plots is lower, the magnitude estimates and the reporting of specific features are extremely important for other studies. We must realize, however, that fireball radiant association is very difficult. We cannot apply the same reductional procedures as for annual showers. Instead, new methods have to be developed in future years. Particularly, we should investigate in more detail the error distributions to modify the program RADIANT to make it the most powerful tool for analyzing fireball data. Thereto,we need a lot of simultaneous fireballs.

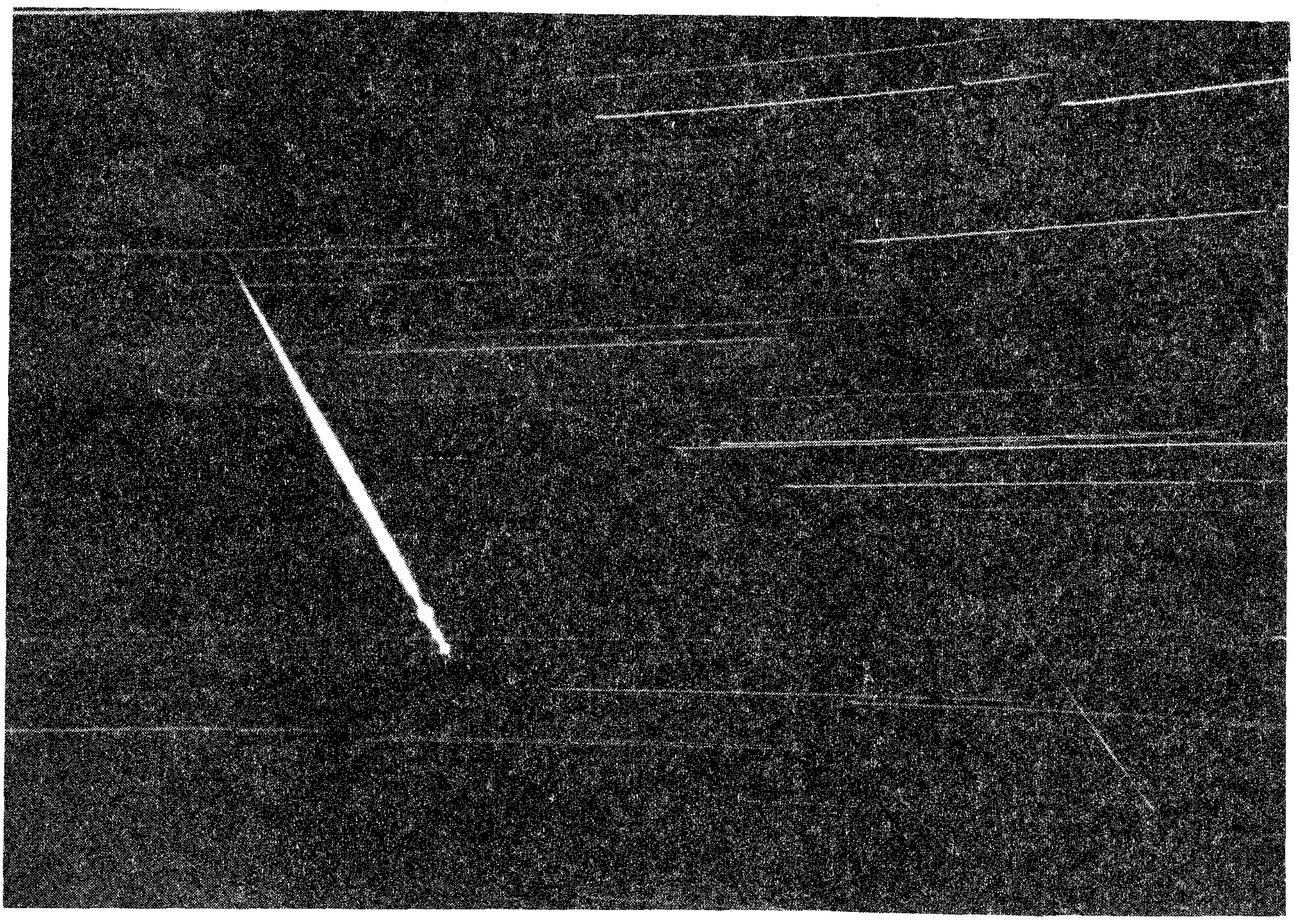
We would like to thank André Knöfel for sending us the data and for many useful discussions.

References

[1] Terentjeva A.K., "Fireball Radiants", *WGN* 17:6, December 1989, pp. 242–245.

[2] Koschack R., "Analysis of Visual Plotting Accuracy and Sporadic Pollution and Consequences for Shower Association", *WGN* 19:6, December 1991, pp. 225–241.

[3] Rainer A., "The Software Radiant", *WGN* 20:2, April 1992, pp. 62–69.



Two Perseid meteors captured by Daniela Rapavá on August 12, 1993, from liabkly, Slovakia ($\lambda = 19°27'38''$ E, $\varphi = 48°45'08''$ N). The photograph was exposed from 0^h15^m to 1^h11^m UT on Foma F 27 400 ASA film with a 20 mm $f/2.8$ lens. The film was developed during 9 min. in Fomal Developer at 21° C. The brighter fireball ($0^h15^m15^s$ UT) was of magnitude −6 and had a train lasting for 30 s.

Observational Results

About the Perseid Outbursts in 1991 and 1992

Andrey Grishchenyuk

Observations from Siberia and Crimea are used to derive population indices for the 1991 and 1992 Perseid outbursts. A lower-than-normal value is found. The results are used to derive the corresponding ZHR values.

In [1], an attempt was made to correct the rates obtained in the observations of the Perseids during August 11-12, 1992, using a smaller value for the population index r. Experience with processing Perseid observations shows that the population index can strongly vary from one year to another, over the range $r = 1.9$ to $r = 3.3$. Having good observations of the Perseids during the outburst in 1991 (Krasnoyarsk, lm = 6.3) and after the outburst (Crimea, Malorechenskoe, lm = 6.3) and observations of the bursts in 1992 (Crimea, Pochtovoe, lm = 5.5–5.7), we made an attempt to check the conclusions of [1] and compared maximum rates and results of Perseid showers.

The population index was calculated from observations by groups and by individual observers, for August 12-13, 1991, in Krasnoyarsk, during the outburst, and in Crimea, after the outburst, and also for August 11-12, 1992, in Pochtovoe, during and after the outburst. The results are shown in Tables 1 and 2. The individual observers are Anna Levina (LEVAN), Alexander Smetanko (SMEAE), and Andrey Grishchenyuk (GRIAI). The method used for the determination of r was as follows: $\log N(m)$ was drawn as a function of m; the straight part of this graph was then chosen to compute r.

Table 1 – Population index value during and after the Perseid outburst in 1991.

Krasnoyarsk				Crimea, Malorechenskoe		
Time (UT)	Group	LEVAN	SMEAE	Time (UT)	Group	GRIAI
16^h00^m	2.14	1.88	1.86	21^h00^m	3.1	2.4

Table 2 – Population index value during and after the Perseid outburst in 1992.

Period (UT)	Group	GRIAI
19^h20^m–20^h30^m	1.98	1.75
20^h30^m–23^h00^m	2.65	2.51
19^h20^m–23^h00^m	2.24	1.90

From this study we can make the following conclusions:

1. During the outburst, the value of the population index is significantly smaller than during the rest of the shower. Bright meteors prevail, and a deficit of weak meteors is observed.
2. In accordance with expectations, observations by a group gave higher population index values because the perception for weak meteors is correspondingly higher. The group values, however, seem to be closer to the real ones.

With the r-values obtained, ZHRs were calculated for the Perseids on August 12-13, 1991, and August 11-12, 1992 (Tables 3 and 4). These values are in agreement with the results of [1].

Table 3 – Perseid ZHRs during the outburst of 1991.

Time (UT)	Per		lm		T_{eff}		ZHR	
	LEVAN	SMEAE	LEVAN	SMEAE	LEVAN	SMEAE	LEVAN	SMEAE
$16^{\mathrm{h}}00^{\mathrm{m}}$	239	237	6.3	6.3	1.68	1.83	322	293

Table 4 – Perseid ZHRs during and after the outburst of 1992.

Time (UT)	Per	lm	T_{eff}	ZHR
$19^{\mathrm{h}}55^{\mathrm{m}}$	93	5.5	1.05	388
$21^{\mathrm{h}}45^{\mathrm{m}}$	72	5.6	1.08	120

Reference

[1] V. Znojil, "The 1992 Perseids in Czechoslovakia and the problem of overcorrection", *WGN* 20:6, December 1992, pp. 244–247.

Editor's comment:

I want to point out that the results obtained above regarding the value of the population index are in contradiction with the results of the global study [2], in which no *significant decrease of the population index during the outbursts were found. If the results of the global analysis [2] are correct (the upcoming global analysis of the 1993 Perseids might resolve this question), then the results of the present article may be due to either a tendency to ignore faint meteors when bright meteors are abundant (in absolute rather than relative terms) or to a rougher method used in taking into account differences in individual perceptions.*

[2] R. Koschack, R. Arlt, J. Rendtel, "Global Analysis of the 1991 and 1992 Perseids", *WGN* 21:4, August 1993, pp. 152–167.

The 1993 Lyrids in Bulgaria

Valentin Velkov

Observations of the Lyrids and some other meteor showers are presented. They were carried out from April 19 to 29, 1993, by members of *Astroclub Canopus* in Varna, Bulgaria.

1. Introduction

During the period of April 19 to 29, 1993, members of the *Astroclub Canopus* in Varna observed the Lyrid Meteor Shower in the village of Avren ($\lambda = 27°40'14''$ E, $\varphi = 43°07'12''.5$ N). Visual, telescopic and photographic observations were carried out. Participants were as follows:

> Anton Antonov, Diliana Porojanova, Dinko Mironov, Lilia Porojanova, Plamen Stafanov, Stanimir Mechev, and Valentin Velkov.

During a total observing time of 65.7 hours, 726 meteor were registered, among them 211 Lyrids, 134 meteors belonging to other observed showers, and 381 sporadic meteors.

2. Lyrids

The averaged ZHR values for the Lyrids are given in Table 1.

Table 1 – Averaged 1993 Lyrid ZHR values.

Date	Period (UT)	ZHR	Nr. Obs.
April 21-22	19^h15^m–01^h45^m	14 ± 2	3
April 22-23	19^h15^m–01^h45^m	14 ± 3	3
April 24-25	20^h30^m–01^h50^m	3 ± 1	4
April 25-26	22^h00^m–02^h00^m	2 ± 1	3
April 26-27	21^h30^m–02^h00^m	4 ± 2	1
April 27-28	21^h25^m–02^h00^m	2 ± 1	2
April 28-29	00^h00^m–02^h00^m	4 ± 2	2

Due to the unfavorable sky conditions, reliable ZHRs cannot be calculated for the nights before April 21. During the nights of April 21-22 and 22-23, the mean Lyrid rates were above the sporadic level. Towards dawn on April 22, a steep increase of the Lyrid activity occurred, the mean ZHR reaching a value of 30! Similar high rates were recorded during the first observing session on the night of 22-23, followed by a rapid decrease of the shower activity. Maybe the maximum happened during daytime on April 22. *(According to the* 1993 IMO Meteor Calendar, *the maximum was expected for April 22 at* 2^h *UT, ed.)* Taking into account that the maximum is usually a sharp peak of very short duration, we cannot say whether the increased activity we observed was connected with the maximum itself, or was caused by some less significant fluctuations. It is interesting to note that during the nights of April 19-20 and 20-21, bright Lyrids of up to -3 appeared, while during the time of highest activity the brightest Lyrids recorded were at best -1, and on the next nights no Lyrids brighter than $+2$ were seen.

Radiant positions for the different observing nights were determined based on the plotted meteors. We suspect that on the nights of highest activity a subradiant appeared at $\alpha \approx 277°$ and $\delta \approx +36°$.

3. Other showers

The first *η-Aquarids* were seen as early as April 21-22. In the last observing night (April 28-29) each observer recorded 6 to 8 η-Aquarids. This corresponds to a ZHR of about 25! Single *Virginids* were being seen during the whole period. Highest activity was observed on April 21-22 with a ZHR of 3.5. During our expedition, the radiant of the *α-Scorpids* was still in Libra. Highest rate was recorded by the end of the expedition (a ZHR of 4). The activity of the *α-Bootid* Meteor Shower was lower than that of the sporadic background. The highest ZHR of 5 ± 2 was obtained for the night of April 27-28. Although the lack of enough statistical data does not allow us to make any certain conclusions, we have the impression that there are either two subradiants at a distance of about 8° from each other, or two separate radiants—one located near α Bootis and the other between ζ and π Bootis. The *Coronids* are a meteor shower not mentioned in the *IMO* list. They are present in the catalogue of photographic radiants published in [3]. There, the following data for the shower can be found: $V_\infty = 40.4$ km/s, $P = 462$ years, $i = 56°$. Few visual Coronids and one telescopic Coronid were seen by our group.

On April 24-25, an interesting sporadic meteor of -1 was observed—a slowly moving point-like core with an almost "transparent" trail. By the end of its path, the meteor split into two fragments. One of the fragments lagged behind the other until both disappeared.

4. Telescopic and photographic observations

Telescopic observations were carried out by Stanimir Mechev only on April 21-22, using 8×80 binoculars. During 2.84 hours, 32 meteors were seen, among which 5 Lyrids, 1 α-Bootid, 1 Coronid and 24 sporadic meteors. One of the photographed meteors is probably a Lyrid according to the data in the *IMO* list.

References

[1] Roggemans P., ed., "Handbook Visual Meteor Observations", Mechelen, 1987.
[2] McKinley D.W.R., "Meteor Science and Engineering", Toronto, 1961 (Russian translation).
[3] Abalkin V.K., ed., "Astronomical Calendar—Invariable Part", Moscow, 1981 (in Russian).

The 1993 Perseids in Sliven, Bulgaria

Ivanka Getsova

An overview is given of Bulgarian observations of the 1993 Perseids.

From August 9 to 15, 1993, Ivanka Getsova, Galina Dimitrova, Atanas Nikolov, Krasimir Manov, and Peter Dalakov observed the Perseids and some other showers that were active at the time. We settled in a mountain camp, situated 40 km north of the town, at 950 m above sea-level.

After a "modest" start on August 9-10, when the bad weather only allowed us 1 hour of observations, a confirmation of the first principle of Manov followed: "The more time you spend preparing an observation, the more probable it is going to fail." At that time (August 10 to 11) the mass media were shouting that we expected either a rain of meteors or even of meteorites! At last, we observed only thick clouds and a rain of natural water. From August 12 to 15, the nights were bright and full of meteors, and the activity of the Perseids was falling slowly. The limiting magnitude stayed above +6. We were impressed by the fact that some of the meteors were coming from the region near Algol. On August 15-16, I identified 3 meteors near Algol radiating from a region with coordinates $\alpha = 2^h41^m$, $\delta = +44°$ and a diameter of 2°.

The 1993 Perseids and κ-Cygnids in Crimea

Andrey Grishchenyuk

A summary is given of the 1993 Perseid and the κ-Cygnid showers in Crimea.

As with other members of the *IMO*, we were prepared to observe the 1993 Perseids, waiting for the meteor storm. Beside Crimean observers (more than 50 persons at five different locations), there were gathered photographers form Kiev and visual observers from Kirov (Russia). But the weather destroyed the show. On August 11, our peninsula was covered with heavy clouds, and at all observation points, there was heavy rain and a thunderstorm instead of a meteor storm. Some small gaps between the clouds permitted observations of shower activity for 2–3 hours, in the interval 20^h–23^h UT. Very cautious calculations yield a ZHR of about 90 to 140 for different observers.

Observers in Simferopol were luckier. Already during dawn, in gaps with a diameter of about 60° between clouds, about 15 flares of meteors were noted in the interval between 2^h30^m and 2^h35^m UT. Keeping in mind the light sky background with stars already disappearing, the brightness of the meteors can be estimated as −4 and brighter. However, this is a result from only one observer.

After the Perseid maximum, the activity of the κ-Cygnid Meteor Shower attracted our attention. We estimated the activity of this shower on the night of maximum activity (August 13–14) as ZHR = 13.8 and determined the radiant position as $\alpha = 19^h21^m$, $\delta = +52°$,and $D = 4°$.

The 1993 Perseids from the Mediterranean Sea

Joe Rao

An overview is given of the author's observations of the 1993 Perseids from a ship on the Mediterranean Sea. Radio observations are also discussed. Finally, the prospects for the 1994 return are evaluated.

1. Introduction

The 1993 Perseid meteors were observed off the southwest coast of Italy from the deck of the Sun Line cruise ship Stella Maris, a yacht-like 3500 ton vessel. After having suggested the possibility of building a theme cruise around the Perseids to the cruise line last February, Sun Line decided to dedicate the Stella Maris August 7–14 itinerary to viewing the shower. I was one of three lecturers on board, the others being Mr. Sam Storch of the Hubble Planetarium in Brooklyn, New York, and Dr. Warren Young of Youngstown State College in Ohio.

There were 162 paying passengers on board, 84 of which were there specifically for the Perseids. On the night of August 11–12, the Stella Maris was located just off the southwest coast of Italy, roughly between Massena and Capri. The hope was that we would encounter the strongest meteor activity around the time that the Earth was crossing the descending node of P/Swift-Tuttle—August 12 at 1^h15^m UT. Since Italy was two hours ahead of Greenwich, the predicted peak for us would come at 3^h15^m a.m. local time. This would place the constellation of Perseus high up in the northeast sky, giving us an excellent chance of observing something spectacular—if it indeed occurred!

The cruise began on August 7 from Venice under very hazy, humid conditions. We had some apprehensions about the sky conditions at night, since the thick haze caused our limiting magnitude to be only near +4. However, on the night of August 9, as we headed south and west from Corfu, Greece, our ship encountered broken cloud cover as well as frequent lightning, accompanied by a few sprinkles of light rain. The next day, as we reached the isle of Malta, we were impressed by a sudden turn in the wind into the northwest, with some very strong gusts to over 30 knots. Unfortunately, this made for a very rough sea condition and the majority of those on board became quite ill as the Stella Maris was tossed about. There was a positive side to all of this however: the winds pushed out all of the haze and caused a considerable improvement in sky transparency. On the night of August 10-11, with the rolling seas slowly subsiding, the limiting magnitude was +5.5 (before moonrise), with the Milky Way arcing spectacularly across the sky from Cassiopeia/Perseus in the northeast to Scorpius/Sagittarius in the southwest. It was hoped that we would have these sky conditions on the predicted peak night.

Sun Line cooperated by turning virtually all the lights that might interfere with stargazers off. Even the *emergency lights* were shut down! Those lights that might have leaked out from within the interior of the ship were "masked" either with blankets of red filters. On the night of August 11-12, the favorable sky conditions of the previous night were duplicated and we settled in for what we were hoping would be a memorable night.

2. Meteor counts

In hopes of a possible meteor storm, my meteor counts were broken down into five-minute intervals. Using a tape recorder, counts were started at 22^h20^m UT and continued through 2^h54^m UT, with three five-minute break periods commencing at 23^h20^m, 0^h20^m, and 0^h55^m UT.

We did not see a meteor storm although by the latter part of the night, the shower's strength was certainly above average. As noted by both the actual tabular figures and a smoothed graph of the shower's strength, it appears that the meteor rates took a noticeable upturn beginning around 0^h35^m UT and reached the first of two peaks at 1^h20^m UT (this was only five minutes after the predicted nodal crossing). The rate then seemed to drop slightly only to resurge to a higher and more consistent second peak at 2^h05^m UT. At the first peak, the rate per five-minute interval was smoothed to about 7. This corresponds to an hourly rate of about 84. Actually, between 1^h20^m and 1^h25^m UT, 10 Perseids in a five-minute interval were logged... corresponding to an hourly rate of 120. From 2^h05^m to 2^h49^m UT, the rate per five-minute interval was close to 8, corresponding to an hourly rate of 96. Once again, between 2^h15^m and 2^h20^m UT, 10 Perseids in five minutes were recorded, again corresponding to an hourly rate of 120. It seemed that the increase in Perseid activity after 0^h35^m UT was four-fold, as the hourly rate during the interval from 22^h20^m to 0^h35^m UT seemed to average closer to 24.

It is interesting to note that the upsurge in activity came while the sky conditions deteriorated. Prior to the rising of the waning crescent Moon at 22^h35^m UT, the limiting magnitude was estimated to be +5.5. By 0^h35^m UT, we had lost a full magnitude—now down to +4.5; by 2^h35^m UT the limiting magnitude had fallen even further to +3.5! Yet instead of correspondingly falling, the meteor count rose significantly! The highest actual one-hour rate came between 1^h40^m and 2^h40^m UT, when 82 Perseids were noted. From all of this data, one could say that prior to 0^h35^m UT, the Perseid hourly rate was in the 20 to 30 range, whereas after 0^h35^m UT, the rates rose precipitously into the 80 to 100 category. I suspect that if specific mathematical corrections for the radiant altitude, moonlight and local weather were made, that the zenithal hourly rate (ZHR) "could" have been adjusted to read in excess of 200. Two other things were noted:

1. The *clumping effect* where Perseids seemed to come in short bursts or bunches, followed by a lull. In particular, it seemed that shower members followed each other; if you saw a Perseid streak through, say, Cygnus, a second Perseid would seem to closely follow along a similar track several seconds later. Sam Storch commented (off the record) that "They're like nuns on the subway."
2. There was a noticeable increase in the number of very bright meteors and fireballs during the latter stages of the observing session. From 22^h20^m to 0^h35^m UT, the lone very bright meteor seen came at 23^h57^m UT. After 0^h35^m UT, there were 9 such objects, 6 of these coming within less than one hour (1^h22^m to 2^h19^m UT) and 3 of these within less than two minutes (2^h13^m to 2^h15^m UT). So far as magnitude distributions are concerned, the greatest percentage of meteors brighter than −1 (13%) and meteors of magnitude +1 (37%) came between 1^h45^m and 2^h45^m UT. Thus, along with an increase in numbers, the Perseids also appeared to increase in brilliance after 0^h35^m UT.

3. Ham radio reports

As was the case last year, the undersigned contacted a number of amateur radio operators ("hams") who monitored the 66 and 2 meter wavelengths during this year's Perseid shower in hopes of observing enhanced radio propagation due to meteor scatter. All observations this year suggest that there were actually two maxima on August 12: one between 1^h00^m and 1^h30^m UT and a flatter secondary peak between 2^h30^m and 4^h00^m UT. Interestingly, most of the US amateurs who were interviewed (Doug Allen, Colorado; Joe Lynch, Oklahoma; Emil Pocock, Connecticut; Shelby Ennis, Kentucky; Paul Kelly, Maine; Mike Owen, New York State) all stated that while the radio activity was certainly better-than-average for a "normal" Perseid display, that the sharp radio "spike" that was noted the past two years was not observed in 1993. However, Paul Kelly (Milo, Maine) states that reports that he received from European amateurs were quite different: enhanced propagation and a *very distinct surge in activity* was noted between 1^h00^m and 1^h30^m UT! Perhaps there is indeed something to the idea or concept of localized filaments of activity?

4. What about 1994?

About a week prior to this year's maximum, a report was widely circulated through the media indicating that the absolute peak activity of the Perseids would occur not in 1993, but in 1994. This was based on a paper written by Zidian Wu and Iwan P. Williams of the Astronomy Unit, Queen Mary and Westfield College in London, England ("The Perseid Meteor Shower at the

Current Time"). In this paper, Wu and Williams assume that a stream of meteoroids ejected from P/Swift-Tuttle in 1862 would be primary responsible for any enhanced activity, and that such a stream's subsequent evolution under the effects of the gravitational perturbations of Earth, Jupiter, Saturn and Uranus could be used to determine when potential maxima could be expected in future years.

Wu and Williams provided three orbital models. The first, assumes that the orbit of P/Swift-Tuttle has a period of 120 years. Prior to its recovery in 1992, this was the generally accepted period for this comet. Were the 120-year period correct, P/Swift-Tuttle would have appeared sometime between 1979 and 1983 and the peak Perseid year would have been in 1986; The meteor rates would appear to decrease significantly away from that date. The second model assumes that the orbit of P/Swift-Tuttle in 1862 was that observed in 1992 integrated backwards, with gravitational perturbations but without any non-gravitational effects. In this case, peak activity would be reached in 1995, or perhaps not until 1997! Finally, Model 3 is a mean of Models 1 and 2. It is this model that suggests a significant peak for 1994.

However, orbital expert Dr. Brian G. Marsden of the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts, indicates that the orbit used to predict an "absolute" Perseid maximum in 1994 appears to be too small: that Model 2 and not Model 3 should be the "model of choice" for predicting future Perseid activity. The undersigned agrees with Dr. Marsden, additionally pointing out that Model 3 did very poorly in predicting the very strong outburst of activity that occurred in 1991. In fact, little or even non-existent activity is indicated for 1991 by Model 3 (Wu and Williams note a "...hint of a existent activity is indicated for 1990, but the model is not really capable of that fine a distinction") They also state that Model 3 indicates that Perseid activity rises "...from about 1991," when it is really 1992 that a significant rise in activity appears. Thus, it would appear that the forecast for maximum Perseid activity in 1994 is already, to a degree, flawed. The undersigned also feels that Wu and Williams placed too much emphasis on the 1862 apparition of P/Swift-Tuttle in regard to modeling particle distribution for current Perseid activity. It perhaps would have been even more prudent to also attempt examining particle ejections from the comet's 1737 apparition and quite possible going even one revolution earlier (into the early 17th century). As an example, it should be noted that the great Leonid storm of 1966 apparently resulted in debris shed from P/Tempel-Tuttle in 1899, and not 1932—in other words, not one, but two revolutions earlier.

It indeed was a great disappointment that the Perseids failed to put a better showing in 1993. Certainly the fact that one of the most intrinsically bright of all the periodic comets, coming within less than 0.001 AU of the Earth's orbit, just 8.5 months prior the Earth itself, should have produced a far greater display of meteors than what was observed worldwide. Perhaps the bulk of P/Swift-Tuttle's debris lies immediately outside its orbit (like the Leonids), rather than inside (like the Giacobinids). If this be the case, then we might never ever truly encounter a stupendous Perseid shower as Earth is positioned inside the orbit of P/Swift-Tuttle.

It is my opinion that while there is still a "possibility" of a spectacular meteor storm from the Perseids, the prospects are likely to diminish with each passing year. It might also be that a precise prediction of such a display may be a very difficult, if not impossible task, although the greatest chance of encountering a very significant shower (storm?) seemingly would be within a few hours of Earth crossing P/Swift-Tuttle's descending node.

That having been said, some very good news can be offered to all prospective meteor watchers across North America in 1994. The time that we will cross the comet's node will come on August 12 at 6^h58^m UT (2^h58^m a.m. EDT). This makes North America—especially the Eastern Seaboard—particularly favored for catching any possible enhanced Perseid activity. The best news of all is that the Moon will be of *absolutely no interference*! It will be a thin, waxing crescent, just 23% illuminated and completely out of the way by the nodal crossing time, having set earlier in the evening (just after 10^h00^m p.m. EDT). As they used to say annually in Brooklyn at the end of each baseball session: "Just wait till next year!"

The 1993 Perseids Photographed in Blieux, France

Peter Aneca

An overview is given of a photographic Perseid campaign conducted by Belgian observers in Southern France.

The 1993 Perseid display was likely to be fascinating. To avoid bad weather conditions and in order to participate in an international campaign, 5 Belgian observers went to Blieux, a very nice and small village in the vicinity of Castelanne, in the Provence, in Southern France. The observers were: Peter Aneca, Tristan Cools, Bart De Pontieu, Jean De Weerdt, and Jeroen Van Wassenhove. We were lucky that the bad weather ignored the Provence around the Perseid maximum. During but three nights the Provence sky was as brilliant as it normally is described by numerous observers. As I am writing this (August 31) we already have our quite astonishing photographic results.

Being aware of "storm" predictions and in spite of the local astronomical magazine and newspapers announcing as much as 100 000 Perseids an hour, making local people thrilled at first and disappointed afterwards, we were rather sceptical and did not expect more than an enhanced activity. On the night of August 11-12 we operated 4 cameras with standard 50 mm lenses and aperture ratio varying between $f/1.2$ and $f/2.0$ from 21^h UT to 3^h UT, pointed at a height of 50°. In these six-hours observing period, as many as 29 meteors were photographed, yielding an average of 500-minutes interval between two photographed meteors. These figures clearly confirm enhanced activity, which nevertheless was lower than that observed in 1991 by the Japanese.

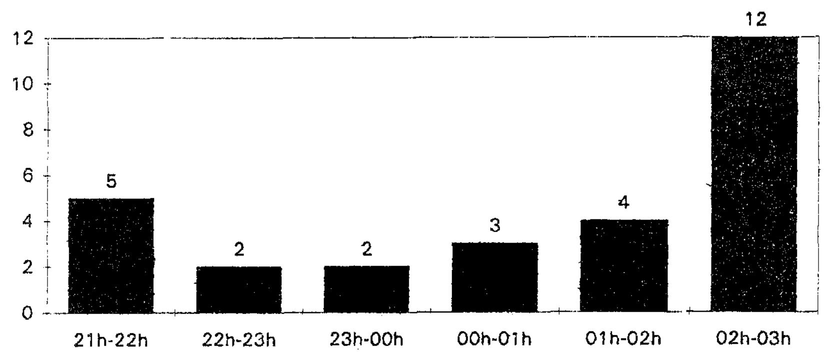


Figure 1 – Numbers of photographed meteors.

Figure 1 shows a one-hour period histogram with a remarkably high number of meteors in the first hour during which a fifth camera was still operational. The lack of fireballs photographed is striking: the brightest Perseid photographed is about magnitude −3. Neither did the visual observations indicate a high number of fireballs though the number of bright meteors might be elevated in comparison with other returns.

The night before the maximum (August 10-11) was as disappointing as August 11-12 was astonishing. No meteors were photographed at all. This corresponds with the visual observations indicating a high number of Perseids of which were faint and almost none were brighter than magnitude 0. August 12-13 was the last night of photographic observations. Only nine meteors were photographed which is less than one would expect from the "classic" Perseid peak. This is less than we expected looking at the quite elevated visual rates and magnitudes as well. Sometimes meteor observers are struck by a satellite crossing his/her observing field. Figure 2 shows a nice composition of a meteor and a satellite. Members of the *VVS Satellite Working Group* identified it as 71-89A. This code indicates it is the 89th launch in 1971. This mission was carried out by an Agena-D missile putting into orbit the US Airforce's ASTEX (Advanced Space Technology Experiment) with a length of 9.5 m and a diameter of 1.5 m. The brightness of the satellite is due to its span and its orbit at a height of 753 km.

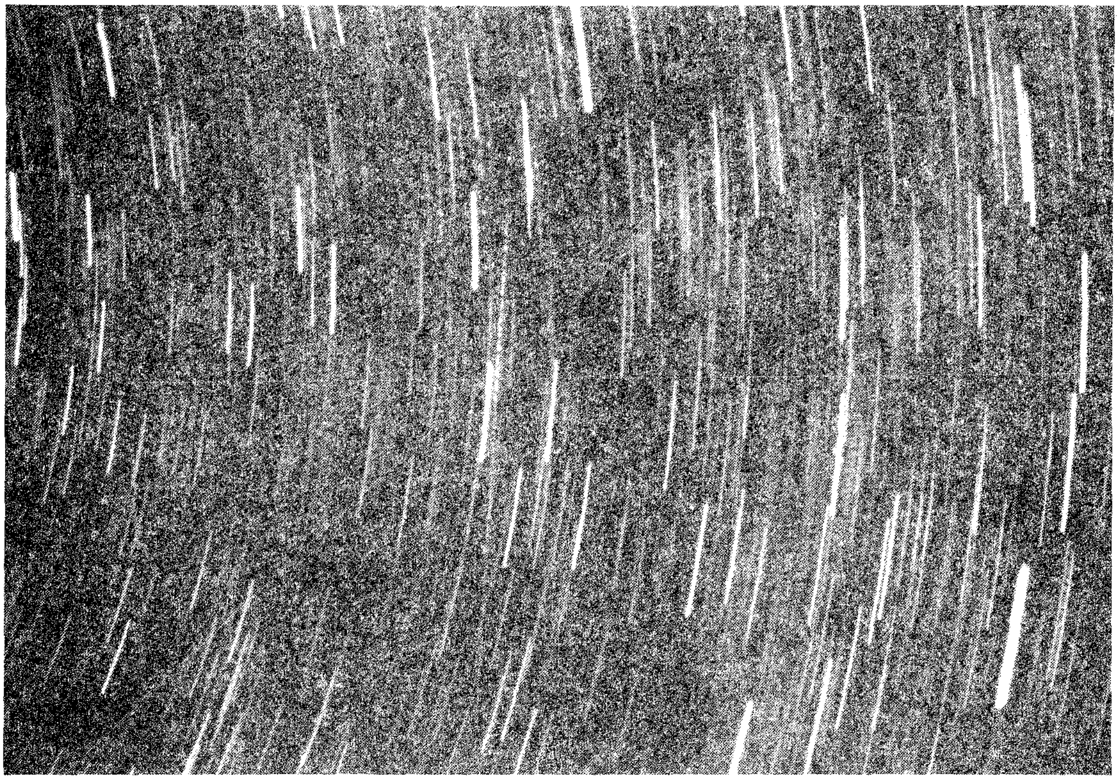


Figure 2 – This photograph was exposed from $20^h54^m12^s$ to $21^h10^m56^s$ UT on August 11, yielding a Perseid which appeared on $21^h10^m08^s$ and the satellite 71-89A. The bright star in the right bottom corner is β Cas.

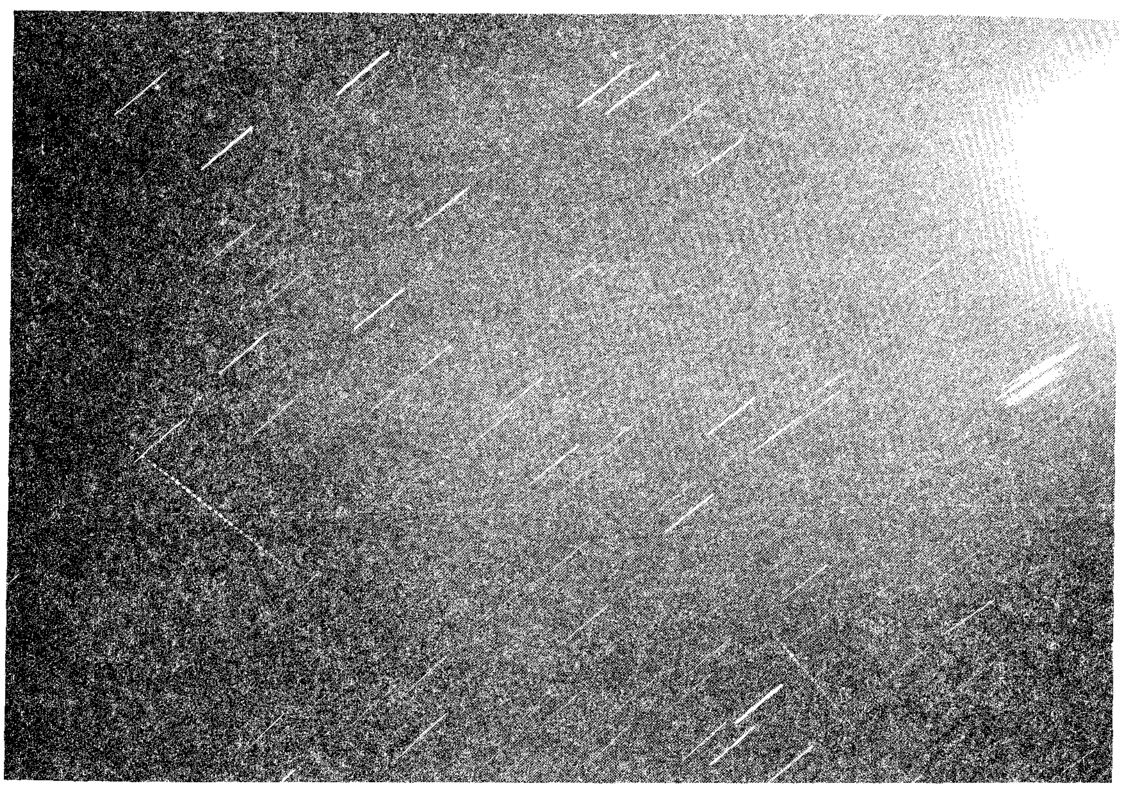


Figure 3 – This photograph was exposed from $02^h34^m56^s$ to $02^h43^m13^s$ UT on August 12, yielding 4 meteors 3 of which are Perseids. (The faintest one, the sporadic, is probably invisible on the print.). On the left, the Moon and the Pleiades can be seen.

High Orionid Activity on October 18, 1993

Koen Miskotte

From observations during the period of October 16 to 19, it seems that the Orionids displayed high activity on the night of October 17-18. Below is a report of the observations done by the author, member of the meteor observation team *Delphinus* in Harderwijk.

On the night of October 16-17, Orionid activity was striking, even when the radiant was still low. Between 22^h and 23^h UT, and 23^h and 0^h UT, I saw during each interval 6 Orionids. Striking was the relatively large number of bright meteors. In addition to the rather large numbers, the high average brightness attracted attention. Between 0^h and 1^h UT, the sky was half clouded, but between 1^h00^m and 1^h23^m UT it was totally clear, and I saw 6 Orionids, yielding an hourly rate of more than 15! It started to become more and more cloudy after 1^h23^m UT, so I had to stop observing. During the day, we waited anxiously for the following night; was there indeed an increased Orionid activity, and were they, on the average, brighter?

Luckily it was clear the whole night, and I was able to observe almost uninterrupted from 20^h25^m and 4^h36^m UT. The Orionids put on a spectacular show, with tens of meteors per hour, and many bright ones. I saw a maximum of 25 Orionids per hour, while we normally expect maximally 5 per hour. Also the higher mean brightness was striking: for the first time since 1979 (!), I saw Orionid fireballs. It happened a number of times that during five minute intervals not one Orionid was seen, and then two or three were visible in just a few seconds. Further noticeable was that the bright Orionids often had a blue-white color. In total, I saw 208 meteors that night with a limiting magnitude of +6.6.

The night of October 18-19 produced much lower hourly rates. The activity seemed a little higher than usual, but still a large number of bright Orionids were seen. That night, besides the author, also Robert Haas was active. In total, between 22^h30^m and 4^h30^m UT, we saw 196 meteors. The limiting magnitude was lower than the previous night (+6.5, later +6.4). Because of the previous night, simultaneous photographic observations were performed with a major *DMS* post in Sinderen (Hans Betlem et al.) and in Oostkapelle (Klaas Jobse). At the latter post, a video-camera with image intensifier was used. Hans Betlem confirmed my observations of October 17-18. He also noticed the high activity, and the many bright Orionids.

If you have noticed anything, please send your findings to the *IMO* and to the *DMS*!

Call for Observations

Koen Miskotte

On January 16-17, 1993, during 68 minutes, I saw 12 meteors, 8 of which seemed to radiate from the same point. The meteors were of a striking appearance: very slow, and in the form of a small "ball." The bright ones also showed fragmentation in the form of "sparks" traveling with them. Michiel Van Vliet, visual coordinator of the *DMS*, calculated a ZHR of 12 at 0^h30^m UT [1]. The plots indicate a radiant near Procyon ($\alpha = 115°$, $\delta = +10°$). The average brightness of the observed meteors is also fairly high: +2.0. Upon searching the Harvard Survey, Michiel found three other meteors with radiants very close to the visual radiant. The speed of the photographic meteors was 29 km/s, which is in close agreement with the visual observations. We should like to hear from other observers whether or not they have seen activity from Canis Minor during the said night. This is also a call to look out for this stream on January 17, around 7^h UT. Old and new observations can be sent to *M. Van Vliet, Postbus 451, NL-4380 AL Vlissingen, the Netherlands.*

[1] M. Van Vliet, "Meteoorzwerm aktief op 17 januari!", *Radiant* 15, 1993, p. 52.

Software Review

Meteor Diary Program

Alastair McBeath

"Meteor Diary", author Gordon Taylor, a 330 kB IBM-compatible program, suitable for a single floppy or hard disk drive, available in 5.25" or 3.5" formats, published by the BAA Computing Section, 1992. Price (UK/overseas): BAA members 5 GBP/10 GBP, non-members 10 GBP/20 GBP. Contact: Mr. R. Harrold, BAA Computing Section Program and Data Library, 10A Barker Avenue, Rose Heyworth Estate, Abertillery, Gwent, NP3 1SE, Wales, UK, for details (return postage appreciated).

"Meteor Diary" is the latest in a series of inexpensive computer programs published by the British Astronomical Association's Computing Section, and is the first to be of interest specifically to meteor astronomers. The program is capable of generating, in tabular form, basic details on the observability of a file of meteor showers from any location on Earth and for any year between 1992 and 2040.

When printed out, the documentation is brief—perhaps too brief for newcomers to computer use—at under two A4 pages, but on-screen prompts usually make operating the program relatively easy. Initially, a file with the working station data (latitude, longitude, etc.) must be created by altering that on the disk, much as most astro-software requires. This can be quickly amended before running the program if any further changes are needed.

The program itself uses a named meteor radiant data file to produce either a printed or on-screen output, and two such files are provided in the software, one with 32 radiants (`METRAD`) and another with 37 radiants (`DAYMETRD`). Both are based on the shower list in the annual BAA Handbook, but `DAYMETRD` also contains five supposed "day-light" streams too.

A variety of information is provided for each shower in the table, including its maximum solar longitude (epoch 2000.0), the corresponding calendar date, the maximum observed hourly rate for up to three times during the night (based on ZHR multiplied by the sine of the radiant altitude), the radiant's position and daily drift, an indication of likely telescopic activity (if known), the radiant's transit time, twilight limits (by inputing the twilight limit as 90, this column will give sunrise/set times instead), the radiant altitude for up to three times overnight, plus the Moon's percentage phase, and rising and setting times for three dates centered on the shower's peak. The data produced seem to be of good general accuracy, and are obviously very useful for forward planning or preparing notes on forthcoming showers, especially from specific locations. There are also excellent potential applications for new or theoretical shower visibilities.

Naturally, the radiant list is likely to prove somewhat contentious, since it derives directly from older shower lists, such as Cook's 1973 working list of showers, with little modification, and recent experiences have shown that the *IMO*'s working list is more appropriate for use today. A particular disappointment are the five additional "daylight" showers, since with one exception (the "Taurids-Perseids" peaking on June 18) these are simply minor showers not featured in the normal BAA Handbook list, and with this sole exception, can all be seen in a dark sky from many sites. With these remarks in mind, potential users will almost certainly wish to create their own radiant files, which the documentation claims can be easily done. Unfortunately, this has not proven to be entirely the case.

Although shower data can be deleted, added, or amended using an existing list as a start, the process is fraught with problems. Extreme care must be taken to avoid any errors, since shower names must be spelled absolutely identically to those on file in full and in solar longitude order. Even a minor error here will cause a crash before the file is saved—very annoying if the list of alterations is lengthy. Most frustratingly of all is that shower names cannot be changed without deleting the shower as a whole and re-inputing all the appropriate data, which adds considerably to the overall workload. This is particularly true as many showers in `METRAD` and `DAYMETRD` are labeled "1" and "2," not "N" or "S," as is more usual (e.g., "Delta Aquarids 1" approximates to the δ-Aquarids S shower in the *IMO* list). Producing a new file in this way is ultimately possible, but can take a long period of concentration to achieve, particularly at the first few attempts. Once created, however, new lists do run well with the program, and providing only showers with known ZHRs or the working list of daytime streams from the *IMO* Shower Calendar are used, the time and effort involved to produce these radiant files should not prove overly excessive (1.5–2 hours for the showers with stated ZHRs, for instance). The maximum stream list length is 100 radiants.

Overall, *IMO* observers should find the program of value, especially after creating their own radiant files—a process hopefully to be improved in promised future updates—although the data are of interest primarily to visual observers. As the cost includes registration, it compares very favorably with most shareware programs, and for what this program provides, it is essentially unique at the present time.

Workshop on Meteorites from Cold and Hot Deserts

Nördlingen, Germany, July 21–22, 1994

communicated by Paul Roggemans

During the last 25 years, many meteorites have been recovered from the Antarctic ice sheet, and during recent years several hot deserts have yielded considerable numbers of specimens. We plan to organize a *Workshop on Meteorites from Hot and Cold Deserts* prior to the *57th Annual Meeting of the Meteoritical Society* in Prague. This workshop will take place in the town of Nördlingen, located on the floor of the Ries Crater. Preliminary dates for the workshop are July 21–22, 1994.

The focus of the workshop should be on possible differences between modern falls and meteorites from hot deserts or Antarctica, weathering effects under different terrestrial conditions, meteorite infall rates, identification of fruitful areas for future meteorite searches, and other related topics. If you are interested, please return the attached indication of interest form to one of the conveners by *December 31, 1993*:

Ludolf Schultz, Max-Planck-Institut für Chemie, P.O. Box 3060, Saarstraße 23, D-55020 Mainz, Germany, phone: +49-6131-305-279, fax: +49-6131-305-483, e-mail: `schultz@mpch-mainz.mpg.d400.de`;

John Annexstad, College of Social and Natural Sciences, Bemidji State University, Bemidji, MN 56601, USA, phone: 1-218-755-4006, fax: 1-218-755-4107;

Michael Zolensky, Mail Code SN2, NASA Johnson Space Center, Houston, TX 77058, USA, phone: 1-713-483-5128, fax: 1-713-483-5347, e-mail: `zolensky@curate.jsc.nasa.gov`.

57th Annual Meeting of the Meteoritical Society

Prague, Czech Republic, July 25–29, 1994

communicated by Paul Roggemans

Contact: Dr. Peter Jakeš, Department of Geology of Mineral Deposits, Faculty of Sciences, Charles University, Albertov 6, CZ-128 43 Praha 2, Czech Republic, phone: +42-2-24915472, ext. 2426; fax: +42-2-29-60-84; e-mail: `jakes@prfdec.natur.cuni.cz`.

You are cordially invited to attend the *57th Annual Meeting of the Meteoritical Society*, which will be held July 25–29, 1994, in Prague, Czech Republic, in the Congress Palace (Palác Kultury). Pre- and post-conference excursions and tours are planned and an accompanying members' program will offer visits to historic sites and cultural activities before, during, and after the week of the meeting.

Prague and the Czech Republic have many historic and cultural attractions to offer meeting attendees and their guests. Prague is a lively and lovely city on the Vltava (Moldau) River; it has numerous landmarks and sightseeing spots, and the meeting should be both professionally rewarding and memorable.

Rooms have been reserved at the five-star Forum Hotel (approximately 170 USD per night), adjacent to the Congress Palace (where the meeting will take place), and in the more moderately priced ILF Hotel (approximately 45 USD for a single room; 54 USD for a double), about 5 minutes from Congress Hall by Metro line. We are currently trying to book student dormitories to provide less-expensive accommodation.

Interested persons should contact the organizers without any further delay!

Erratum

Interview with Dr. Hasegawa

communicated by Jürgen Rendtel

I received the following list of some misprints in the Hasegawa interview (*WGN* 21:2):

p. 71. Read "Joe Ueta" instead of "Joa Ueta;"

p. 72. Read "Susumu Imoto" instead of "Susumo Imoto;"

p. 72. Read "Zhuang Tian-shan" instead of "Shaucing"

p. 72. On the last line, read "collected" instead of "corrected."

We apologize for the inconvenience.

The International Meteor Organization

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