ISSN 1016-3115

wgn

19 – 5

october 1991

bimonthly journal of the international meteor organization

A 68 minute fish-eye exposure between 15^h08^m an 16^h16^m UT on August 12, 1991 taken by Mr. Tatsuo Nakagawa (Shinshu University, Astro OB Club) illustrates the short but strong Perseid outburst witnessed in Japan. The photograph was taken from Takane Village (λ = 137°29′25″ E, φ = 35°57′09″ N, h = 1710 m). On the negative, 26 meteors can be distinguished. Of these, the print from which this picture has been reproduced still shows 16 meteors, all being of at least magnitude −3 to −4. In the upper right corner, a bright fireball of −8 was captured, just south of the square of Pegasus.

In this issue:

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

Afgiftekantoor: 2540 Hove

WGN, volume 19, nr 5, October 1991, pp. 169–218

Contents

Useful Information

The December Issue *(WGN 19:6)*

The *December issue* is expected to be mailed early to avoid the traditional Christmas jam in the mail, i.e, at the end of November. Therefore, contributions are due *November 5*. They should be sent to *Marc Gyssens* or to any member of the editorial board (addresses: inside of back cover).

WGN Subscription/IMO Membership 1992

The subscription rate for volume 20 (1992) is 25 DEM for six issues. Additional gifts are of course welcome. It is anticipated that volume 20 will contain over 240 pages. More concrete subscription information can be found on pp. 169–170 of this issue.

From the Editor-in-Chief

Marc Gyssens

The concurrence of several circumstances of various origins caused a considerable delay in producing this issue, for which we apologize. In compensation, we are able to offer you once again a thick issue; we hope you will enjoy it. Anyhow, we promise that the December issue (which will have to be a "normal" one) will be sent out early!

There is however one delay-causing circumstance for which we are not *sorry: a spectacular one-hour outburst of the Perseids on August 12 around* 16^h *UT witnessed by several observers in Japan. For this hour, ZHRs of up to 400 and more were recorded! One of the reasons for which we postponed the publication of this issue was to provide you with as much accurate information about this event as is possible this early. In particular, we are grateful to the Japanese observers for the photographs they supplied us with, one of which you already saw on the front cover.*

Apart from its intrinsic scientific value, I think there are two lessons to be learned from this event. First, it should be emphasized that several Japanese observers were already alerted to some extent by Paul Roggemans in an article in Sky and Telescope, *discussing the double Perseid peak found in 1988 and 1989. It is safe to say that the good coverage of the outburst in Japan is largely due to observers trying to confirm this year the first peak of the double maximum. Admittedly, the outburst would probably have been recorded anyway, but without the existence of an international organization such as the* IMO *it would have been impossible to place this event in a proper context as we can do now! And second, the 1991 Perseid outburst proves once again that surprises are always among the possibilities during meteor watches. It should remind observers that they should never weaken their attention in monitoring meteor activity. It would really be a shame that important events such as this most recent one would be missed simply because expectancy is low!*

We also need to say a few words about the IMC. *Although the number of participants was slightly down this year, the event was once again a high level exchange of information and ideas between meteor workers, both amateurs and professionals. The very smooth organization of the conference added to this general feeling. Those that stayed at home really missed something and should consider coming next year, especially since the* IMC *will be held in conjunction with the* International Astronomical Symposium on Meteoroids and their Parent Bodies *in Czechoslovakia. So, a lot of professionals are expected to attend the* IMC. *Moreover, being able to participate in both events will probably attract several overseas* IMO *members to attend. Therefore we hope that the 1992* IMC, *the first one that will also officially be organized by the* IMO, *will become the first really intercontinental* IMO *meeting as well. Make sure you will be there!*

Finally, IMO *members should find enclosed a voting bulletin regarding the change in membership status to voting member effective January 1, 1991, of several of our associated members. If you are a voting member* now*—and only in this case!—you should cast your vote as indicated on the form.*

1992 Membership and Subscription Renewal

Ina Rendtel and Marc Gyssens

On September 19, 1991 the *IMO* Council has decided at its meeting in Potsdam to raise the annual **membership/subscription dues** to **25 DEM**. People outside Europe wishing **airmail delivery** pay **40 DEM**. We remind you that we have been able to maintain the old fee for four consecutive years now and we therefore ask for your understanding for this increase.

Preferably, payments should be made in in German marks (DEM) to the **postal (giro) account** of Ina Rendtel, Gontardstraße 11, D-O-1570 Potsdam, Germany. The account number is 5472 34-107 and the post office code is 100 100 10 (Postgiroamt 1000 Berlin). **Please note that post office code and postgiroamt must always be mentioned together with the postal account!**

If you do not have access to a postal account yourself, we advise you to inquire at your local post office as to how to make the transfer. However, you could also consider sending the required amount to Ina **cash**, in bank notes. Although involving some risk and not always being allowed by postal regulations, this is by far the easiest way to pay! To reduce the risk you take by paying cash, make sure that the banknotes are not visible through the envelope! Please **do not send international postal money orders** since the *Deutsche Post* of the former GDR is still not able to handle these!

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). In this case you pay 18 USD (without airmail delivery) or 28 USD (including overseas airmail delivery for destinations outside Europe). Both amounts contain 2 USD for banking costs. Please, **do not send checks to Ina Rendtel!**

For some nationalities, there exist special arrangements. Belgian members/subscribers can pay 500 BEF through Paul Roggemans, using the transfer form we included for them in this issue. British readers can pay 9 GBP through Alastair McBeath. Finally, Japanese subscribers can pay 2100 JPY (without airmail delivery) or 3400 JPY (including airmail delivery) through Masahiro Koseki. All addresses appear on the inside of the back cover.

Apart from this bimonthly journal, the *IMO* has a lot of other publications to offer. A price list is printed on the back cover. We take the liberty of suggesting you to order the publications you are interested in **together** with your renewal; in this way, you minimize the hardships involved in international payments. Please note that **all** publications can be ordered through any of the above persons, provided you pay in the prescribed manner.

Finally, two more words. First, we want to remind our readers that as a matter of principle we run *WGN* on a tight budget. Therefore, additional gifts are very welcome. Please pay a little extra to support your journal, if you can. Second, renewals came in very late last year. As a consequence, we had serious difficulties in determining the number of copies that had to be printed of the February issue. Therefore, we urge you to renew early this year. Thank you for your cooperation!

Letters to WGN

compiled by Marc Gyssens

On bended meteor tracks

In the August issue (WGN 19:4)*, p. 136, Gotfred Kristensen reported his observation of a bended meteor track. In an editorial comment it was added that a meteor entering the atmosphere under a very low angle can bounce back on a denser layer of air, thus causing a bended meteor track. From Ralf Koschack, we received the following criticism to this suggestion.*

The editorial remark concerning the unusual meteor track is generally true, but such an effect can only be the result of a meteoroid moving parallel to and in the vicinity of the horizon. Otherwise the perspective does not allow to detect the slight change of direction. In the reported case the meteor moved nearly exactly along an azimuthal great circle. For such meteors changes in the altitude above the Earth's surface cannot possibly be detected as changes in the direction.

Generally, dramatic changes in a meteor's direction are impossible. This follows from the simple rules of mechanics. The impulse as vectorial property is defined by $\vec{J} = m\vec{v}$. Any change in $\vec{J}$ requires a force $\vec{F}$ given by:

$$\vec{F} = \frac{\mathrm{d}\vec{J}}{\mathrm{d}t} = \frac{\mathrm{d}m\vec{v}}{\mathrm{d}t}$$

In the reported case the component of $\vec{J}$ in the original direction of flight became zero as the meteor changed its direction by 90°. Let us estimate the necessary force. The change of direction took place within about 0.05 seconds. In this time span a force:

$$\vec{F} = \frac{\Delta(m\vec{v})}{\Delta t}$$

must have been exerted. Since the component of $\vec{v}$ in the initial direction of flight became zero we can write the vectorial equation for this component i as:

$$F_i = -\frac{mv_i}{\Delta t}$$

For a meteor of magnitude +2.5, the mass is about 0.05 g for $v_i = 30$ km/s and 0.0025 g for $v_i = 60$ km/s. In the first case a force of 30 N and in the second case one of 3 N would have been necessary. We see there are many impossibilities:

1. Where should a well-defined, short-acting force of this order come from?
2. A particle would not survive the action of such a force.

This means that only very slight changes in meteor direction can be considered possible. More dramatic changes in the direction have their origin in the perception by the observer. A short, reflex-like closing of the eyes for instance can cause parallel shifts (as reported) or tilts.

Ralf Koschack, September 9, 1991

Errata

compiled by Marc Gyssens

- Alastair McBeath reports that in *WGN* 19:4, p. 166, he inadvertently gave the wrong year for the last BAA Meteor Section meeting in Britain. It should be 1986 instead of 1985. We apologize to the BAA Meteor Section for any discommodity this may have caused.
- In the process of editing the article "Large-Scale Structure of the Perseid Meteor Shower from Long-Basis Observations", *WGN* 19:4, pp. 142–147, a notational inconsistency slipped in, for which we apologize. Please substitute the three occurrences of "C_{12}" on p. 146 by "L_{12}".

The 1991 International Meteor Conference

Potsdam, Germany, September 19–22

Cis Verbeeck

This year, the *International Meteor Conference (IMC)* took place near the city of Potsdam, in Hotel "Am Schwielowsee", at a lake with the same name. The first participants arrived in the early afternoon on September 19. Jürgen Rendtel was already waiting for them in the reception hall of the hotel. Gradually, more people gathered and a lot of informal contacts were made. Dinner was served at 18^{h}, and the President opened the *IMC* officially at 20^{h}.

After this, Rainer Arlt chaired an introductory session. An overview was given of the activities of the AKM group at Potsdam, illustrated with many slides. Also the city of Potsdam, with its many beautiful and interesting sites, was "visited" by means of a number of slides. This introduction was planned to last until 22^{h}, but because of the enthusiasm of the participants, Casper ter Kuile and Axel Haas decided to show some of their slides too. Casper's slides covered the photographic Geminid campaign in Lardiers he had performed last year with some colleagues, while Axel's slides reported on last year's *IMC* in Violau. Finally, the session was finished well after 23^{h}. While several people already went to bed, the Council Members started their meeting. They finished around 1^{h}.

The lecture program started Friday morning at 9^{h}. Marc de Lignie opened with a report on his double-station photographic work on the Perseid radiant. Then, Petr Pravec reported on his simultaneous Perseid observations, telescopically and by means of a TV camera. Casper ter Kuile told us more about his photographic Geminid campaign of 1991, and Dr. Bel'kovich put forward his comments on processing visual observations. Finally, Dr. Andreev discussed the spatial structure of the Leonid meteor stream. After a short break, Mark Vints talked about meteor trains and telescopic meteors. Responding to questions of the audience, Mark decided to start collecting train data in *IMO*. Then, Ralf Koschack pointed out which types of plotting errors can occur in visual observations and the consequences these can have for shower association. His work is based upon a lot of observations performed by some *IMO* members, who joined in the project. They invented different types of radiants (different altitude, size, ...) and tried to observe these "showers".

At 13^{h}, we enjoyed lunch and the program restarted at 15^{h}. Workshops were held till 23^{h} (with a lot of breaks in between), and various *IMO* and other publications could be purchased. The workshops included the demonstration of a computer program simulating telescopic meteors (by Jaroslav Gerbos et al.), the program *RADIANT* (by Rainer Arlt) which detects radiants when given enough positional meteor data by *PosDat*, computer-aided meteor observations (by Mirko Nitschke et al.), a discussion on the observability of minor showers by Ralf Koschack and an evaluation of *IMO*'s publication policy chaired by Marc Gyssens. Finally, Dr. Andreev gave an account on the Second International Tunguska Expedition, richly illustrated with slides. Friday was a quite heavy day, full of lectures and workshops, but thanks to the good timing and the almost perfect organization, nobody became bored. On the contrary, the whole conference was characterized by a general feeling of enthusiasm among all participants.

Saturday's lectures commenced at $8^{h}45^{m}$. Jürgen Rendtel commented on the 1991 "Asteroids, Comets, Meteoroids" conference, and Dr. Andreev continued his account on the Second International Tunguska Expedition. He also told us that plans are being made to set up a third expedition, and he kindly invited everyone present to join the expedition. There was also a poster session. A lot of people had presented their work, results, their team or other interesting items in the form of posters. For the exact contents of this poster program, I refer to the proceedings of this *IMC*.

We had lunch at $11^{h}30^{m}$, and at noon we departed for a trip through the region. We walked for about fifteen minutes, and then boarded a boat on the Schwielowsee. We had a 50 minutes' boat trip on this and other lakes to arrive at Potsdam. First, we visited the astrophysical observatory and the "Einsteinturm", a solar observatory, where Jürgen (who works there) guided us. We also visited the Nikolai Church of Potsdam, which looked puzzlingly new, being so big and majestic. The boat brought us back to the hotel for *IMO*'s Third General Assembly. A report on this meeting can be found elsewhere in this issue. Afterwards, we enjoyed a barbecue and stayed outside until late, chatting, drinking and laughing.

Sunday started at 8^h30^m with a lecture of Vladimir Porubcan on the Taurid meteor complex. Unfortunately, Dr. Porubcan could not attend the conference, so Daniel Očenas read his report. Malcolm Currie presented the lecture of Graham Wolf on the Taieri Plains fireball of May 6, 1985, in New Zealand. A lot of people had reported this fireball as being electrophonic. Dr. Alexandra Terentjeva closed the series of lectures with some fascinating meteor puzzles. Around noon, the conference was closed. Paul Roggemans thanked the organizers on behalf of the participants and hoped to see everybody again at the next *IMC* in Smolenice, Czechoslovakia which will be held in connection with a professional conference. Soon, people started to leave for home, but some stayed a bit longer to enjoy the beauty of Potsdam or Berlin.

I think every participant will agree that this *IMC* was outstanding, as well scientifically as socially. Although the number of participants was lower than in Violau (a lot of people could not attend), the level was high and probably even more appreciated by this smaller core of meteor workers. We were also glad that three professional meteor astronomers participated. It is clear that such an inspiring weekend could not have taken place without the thorough and skillful organization of Jürgen and Ina Rendtel, André Knöfel, and Rainer Arlt. In name of all the participants, I thank you very much for this splendid *IMC*!

The Third General Assembly of the IMO

Potsdam, Germany, September 21, 1991

Paul Roggemans

At about 19^h on September 21, 1991, the Third General Assembly of the *International Meteor Organization* was opened by Jürgen Rendtel. This General Assembly was announced as a purely administrative meeting according to the *IMO* Constitution. Some decisions taken by the Council were to be announced as well.

The Secretary-General, Paul Roggemans first gave an overview of the administrative activities of the *IMO*. The main point here was the creation of different publications. Three *IMO* info booklets were prepared: the "1992 Observing Calendar" (A. McBeath), the "*IMO* Commissions" booklet (A. McBeath) and the "Hints for Visual Observers" (R. Koschack). Some members thought that they did not receive all issues since the numbering did not follow. The secretary explained that every *IMO* info booklet has a number and that, while periodically a new edition may be prepared, the original number is kept (the year indicating the version). In 1991, a lot of work has been put into the preparation of three handbooks: the Photographic, the Radio and the Visual Handbook. These handbooks will appear in early 1992. The proceedings of the 1990 *IMC* were planned to be the first edition in a new *IMO* series that will cover the proceedings of every *IMC* in a standard presentation. Despite very concrete arrangements the final editor modified the presentation as a consequence of which these proceedings were not yet a real *IMO* publication. The Secretary-General finally emphasized the importance of the immense correspondence kept by different *IMO* responsibles. One problem mentioned was that so far letters are often addressed to the wrong person, instead of to the person responsible for the subject concerned.

The Treasurer, Ina Rendtel, gave an overview of the current financial situation. One important announcement was that the Council decided to increase the *IMO* membership fee (and subsequently the *WGN* subscription) from 20 DEM to 25 DEM. Ina explained the rather uncertain condition of the printing device used by *WGN*'s printer. This facility offered so far very cheap printing possibilities, but if a *major malfunction* would occur, forcing *IMO* to step towards a commercial printer, we would see our production costs increase enormously at once. Since also some small price increases in postage and printing can be expected, it was wiser to take a more realistic attitude towards the membership fee, also taking into account the amount of information we offer in return. The administration costs show a big deficit caused by the fee *IMO* had to pay to obtain the official publication of its Constitution and also because of the rather much increased banking costs which did not occur in previous years. The publications' fund has a big positive balance due to the sale of previous years. In the budget for 1992 most of this reserve will be used to print the three handbooks. *WGN* also keeps a considerable reserve fund, although three issues for 1991 still had to be paid. There were no questions about the financial report on 1991 or about the budget for 1992.

Next, the Commission Directors were invited to describe their activities since the last General Assembly. First, André Knöfel reported on the achievements of the *FIDAC*. Radio fireballs were added and several people contributed with new material. The second Director, Malcolm Currie, sketched the plans of the Telescopic Commission. Attempts had been made to produce charts for telescopic plotting of meteors and positional data were obtained for a number of observational sessions. Finally, Ralf Koschack summed up the work of the Visual Commission. The classic *VMDB* reports were collected and the analyzing programs of the *VMDB* were rewritten and applied to some analyses. Further, the posional plotting data were collected in ***PosDat***, a database in which visual positional data are stored. The accuracy of visual plottings was studied during the Orionids of 1990. For analyses of positional data a program called *RADIANT* was developed and tested. The directors of the other commissions were not present and did not provide us with a report.

The change in membership status of new associate members to voting membership posed no problems: nobody had any comments on the list of proposed new voting members. Jürgen Rendtel could then summarize the announcements to be made as a consequence of the Council meeting.

First, the Council had decided to discontinue the Computer Commission. The reason was that everybody had to write his own programs and no support was provided by the Computer Commission. There were also some complaints about the functioning of the Computer Commission. It was therefore considered that it did not make much sense to continue having this commission. Second, three new Council tasks were defined: Publication Supervisor, a task that will be shared by M. Gyssens and A. McBeath. They will proofread and correct all *IMO* publications, they will also coordinate the editing and the production of the *IMO* publications (attribute ISBN numbers, supervise layout standards, etc.). P. Roggemans will act as Commission Supervisor, in order to keep an overview over the material accumulated by the commissions (archive, publications, databases, software, ...). This should also improve the cooperation between the various commissions. Third, Jürgen Rendtel will act as Conference Supervisor, in order to avoid that local organizers would forget important aspects of *IMO* conferences.

In connection with this last point it was also decided that the *IMC* will become an *IMO* conference. This way, the status of the *IMC*s will be much clearer and *IMO* will have its meeting like all other associations. In practice nothing will change in the character of the *IMC*s. In particular, everybody is welcome, also non-*IMO*-members. The next *IMC* is already planned as an *IMO* conference to be held in Czechoslovakia from July 3 to 6, 1992. A local organizing committee has already been established and is presently working hard to prepare the meeting. Next year's *IMC* will be followed by a professional symposium "Meteoroids and their Parent bodies" from July 6 to 12. Both the *IMC* and the Symposium are in the same location, namely the castle of Smolenice. This formula offers the possibility to all people to attend both events and will bring together professional and amateurs, also from beyond Europe.

Since no further questions or remarks were raised, the General Assembly could be closed at about 20^h.

The 1992 IMO International Meteor Conference

Smolenice Castle, Slovakia, CSFR, July 3–6

communicated by Paul Roggemans

The price of the 1992 *IMC* is estimated to be 150 DEM; a prepayment will be requested at the time of final registration. The *IMC*'s final day will parallel the first day of the professional **International Astronomical Symposium (IAS)**, titled **Meteoroids and their Parent Bodies**, in the same building. The *IAS* is held from July 6 till July 12. *IMC* participants can also register for the *IAS*, which will cost about 250 USD per person. Conversely, participants of the Symposium interested in amateur work are expected to attend the *IMC*, too. Bringing these two events together, a unique occasion is created for all professional and amateur meteor workers to meet and to organize mutual cooperation. The longer period running from July 3 to 12 will also make it more worthwhile for people overseas to come, opening perspectives for a first intercontinental *IMO* meeting. Send the preliminary registration form on the next page to **Mr. Daniel Očenas** in order to receive more information.

Computer virus infection at the IMC in Potsdam

Rainer Arlt informed us that he detected a computer virus in his copy of the *RADIANT* program. Most probably, the infection occurred at the latest *IMC* in Potsdam. The virus is called "Tequila" and affects the boot sector of the system as well as executable files. However, it does not show up in, e.g., the size of the file. The only programs we know of that detect the virus are called "PC Police" and "SCAN 7.6V80".

IMC participants that copied software on the PC present there are hence urgently requested to check their system in order to prevent serious damage to their software!

International Meteor Conference, July 3–6, 1992
International Astronomical Symposium, July 6–12, 1992

Smolenice Castle, Slovakia, CSFR

Preliminary registration form

The undersigned wishes to receive further information about the *IMC* and/or the *IAS* in order to participate at these events:

Name: ______________________________

Address: ______________________________

____

Phone: ______________ Fax: ______________ E-Mail: ______________

Interested to attend: *IMC* only, July 3–6 Yes/No
IAS only, July 6–12 Yes/No
IMC and *IAS*, July 3–12 Yes/No

Wishes to present a poster/lecture/workshop (can be given later too), the title of which is:

____

Date and signature: ______________________________

Send this form to *Daniel Očenas, M. Razusa Street, CS*-97 400 *Banska Bystrica, Czechoslovakia*, phone: +42-88 54 264.

New Earth-Grazing Asteroids and Comets

Christian Steyaert

The number of new EGAs discovered the last three months is fairly representative for the current rate of discovery. This time there are two comets as well with short approaches to the Earth's orbit (not necessarily to the Earth for the current perihelion passage): 1991 *q* Levy and 1991 *t* Hartley 2. Attention for the case of 1991 *q* Levy was already drawn in [1]. To the knowledge of the author, no observations have been obtained.

Table 1 – Closest approaches of new Earth-grazing asteroids and comets.

Name	IAU Circ	$\lambda_\odot$ (2000.0)	Date	Shortest distance (AU)	V_∞ (km/s)	α (1950.0)	δ (1950.0)
1991 EE	5326	225°34	May 06.3	0.1470	18.6	205°0	−15°4
		339°92	Sep 02.8	0.0276	19.0	185°8	+20°0
1991 OA	5322	279°40	Jul 01.7	0.0571	14.1	153°7	−11°1
1991 RB	5344	152°58	Feb 21.9	0.1850	20.6	319°5	+09°6
		353°36	Sep 16.7	0.0422	21.1	12°5	−41°1
1991 RC	5338	71°84	Dec 04.5	0.1289	24.8	86°5	+16°6
		313°69	Aug 06.6	0.0703	25.0	121°2	+23°4
1991 q	5325	337°10	Aug 30.9	0.0750	21.0	326°0	−59°2
1991 t	5324	52°08	Nov 14.9	0.0327	16.2	296°1	+12°7

[1] P. Brown, "Possible Meteor Activity Associated with Comet Levy", *WGN* 19:4, August 1991, p. 141.

Visual Observers' Notes: November–December 1991

Jeff Wood

1. Introduction

The months of November and December are characterized by the large number of major showers that are active at this time of the year. The Geminids, Puppid/Velids, Ursids, Taurids and Leonids together with a host of minor streams make for an excellent period of viewing. Even though southern hemisphere observers are favored by summer weather, northern hemisphere observers are to be encouraged to get out and brave the cold winter nights. Table 1 lists some of the more important showers that occur during November and December and Table 2 shows the observing conditions moon-wise.

Table 1 – A list of visual meteor showers to be seen during November and December. Streams marked with an asterisk only produce the indicated ZHR in certain years, and otherwise produce much lower activity.

Shower	Activity	Max	Radiant			Drift		V_∞	r	ZHR
			α	δ	Diam.	$\Delta\alpha$	$\Delta\delta$			
Orionids	Oct 02–Nov 07	Oct 21	95°	+16°	10°	+1.°2	+0.°1	66	2.9	25
Taurids S	Sep 15–Nov 26	Nov 03	51°	+13°	10°/5°			27	2.3	10
Taurids N	Sep 13–Dec 01	Nov 13	59°	+23°	10°/5°			29	2.3	8
Leonids*	Nov 14–Nov 21	Nov 18	152°	+22°	5°	+0.°7	−0.°4	71	2.5	storm
Monocerotids (Nov)	Nov 15–Nov 25	Nov 20	117°	−06°	5°	+1.°1	−0.°1	60	2.7	5
χ-Orionids	Nov 16–Dec 15	Dec 02	82°	+23°	8°	+1.°2	0.°0	28	3.0	3
Phoenicids* (Dec)	Nov 28–Dec 09	Dec 05	18°	−53°	5°	+0.°8	+0.°1	18	2.8	100
Puppid/Velids	Oct 15–Jan 22	several	120°	−45°	20°/15°			40	2.9	12
Monocerotids (Dec)	Nov 27–Dec 17	Dec 10	100°	+14°	5°	+1.°2	0.°0	42	3.0	5
σ-Hydrids	Dec 03–Dec 15	Dec 11	127°	+02°	5°	+0.°7	−0.°2	58	3.0	5
Geminids	Dec 07–Dec 17	Dec 14	112°	+33°	4°	+1.°0	−0.°1	35	2.6	110
Coma Berenicids	Dec 12–Jan 23	Dec 17	175°	+25°	5°	+0.°8	−0.°2	65	3.0	5
Ursids*	Dec 17–Dec 26	Dec 22	217°	+75°	5°			33	3.0	50

Table 2 – Moonlight and observing conditions in November–December 1991.

Date	k	Date	k
Friday October 25	0.97−	Friday November 29	0.46−
Friday November 1	0.31−	Friday December 6	0.00−
Friday November 8	0.02+	Friday December 13	0.37+
Friday November 15	0.54+	Friday December 20	0.97+
Friday November 22	1.00−	Friday December 27	0.62−

New Moon:	November 6, December 6
First Quarter:	November 14, December 14
Full Moon:	November 21, December 21
Last Quarter:	November 28, December 28

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

2. Taurids

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

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

Although the Moon affects viewing after the middle of November, the Taurids are generally free of its influences for most of the period of major activity. Observers are encouraged to carry out an extensive Taurid watch this year. They should center their field of view some 20°–30° east or west of the radiant positions at a declination of +10° to +20°. All possible Taurid meteors should be plotted.

3. Leonids

The Leonids are the second November meteor shower that has produced a meteor storm, the last occasion of which was in 1966. They are a young stream, being produced by the debris of comet P/Tempel-Tuttle which means that, like the parent comet, they have a 33-year periodicity in their maximum activity. As we are now within 8 years of the next return of the parent comet and hence the next predicted storm, Leonid rates should be on the increase.

In 1991, the Leonids will be subject to some interference from a waxing moon that reaches Full Moon phase on November 21. They should be observed during the last few hours before dawn at maximum (November 17) after moon set when the radiant is high above the horizon.

4. Phoenicids

The Phoenicids are active from November 28 through to December 9, with a maximum occurring on December 5. The Phoenicids produce variable activity which ranges generally from 2 to 10 meteors per hour. On a couple of occasions, notably 1956 and 1974 the rates reached 100 and 25 per hour respectively. The Phoenicids are not affected by the moon in 1991. Southern hemisphere observers should endeavor to get as many observations of this shower as possible. They should center their field of view within 40° of the radiant position and plot all possible Phoenicids seen.

5. Puppid/Velids

From late October to late January there are a series of radiants active in the constellations Carina, Puppis and Vela. These are known as the "Puppid/Velids". Since there are several sub-streams in the complex, the Puppid/Velids exhibit several maxima. The strongest of these occur during the month of December and in early January. Rates at this time can reach 12 to 15 meteors per hour. On some occasions, notably during the period December 3 to 12, rates of 20 to 25 meteors per hour have been recorded!

As with all long duration showers, the moon is invariably going to affect some of the activity period. With this in mind, the *IMO* requests that southern hemisphere observers concentrate on this shower over the following dates: November 1 to 18 and December 1 to 16. Observers should plot all possible Puppid/Velids seen unless the rate exceeds 10 per hour when classified counts should be made.

From November 14 to 18, southern observers should choose a field center around $\alpha = 120°\text{–}150°$ and $\delta = -20°$ so that they can monitor the Leonids, November Monocerotids and the Puppid/Velids simultaneously. From December 1 to 16 they should look close to the radiant area and observe the Puppid/Velids only when the Geminid radiant is below 20° in altitude. Once the Geminid radiant reaches this altitude, they should then concentrate on this shower. On other dates, the Puppid/Velids may be monitored all night with the observer having a field center on or within 35° of the radiant position.

Table 3 – Radiant positions of the Puppid/Velids in November and December.

Date	α	δ	Date	α	δ
Nov 05	111°	−43°	Dec 09	123°	−45°
Nov 12	113°	−43°	Dec 14	127°	−45°
Nov 17	114°	−43°	Dec 19	128°	−45°
Nov 22	116°	−43°	Dec 24	134°	−46°
Nov 27	117°	−45°	Dec 29	136°	−47°

6. Geminids

This is one of the major calendar events of the meteor year. The Geminids are visible from both hemispheres and provide excellent rates of around 100 meteors per hour each year. The Geminids are active from December 7 to 17 and reach maximum on December 14. They are noted for their many bright yellow-orange meteors. With the Full Moon occurring on December 21, conditions are very favorable for viewing the Geminids in 1991. Observers should only plot any Geminids seen if the ZHR is less than 10 and this will be the case outside the period December 10–15. Otherwise classified counts should be made.

The Geminids are good viewing for most of the night in the northern hemisphere. In the southern hemisphere they are best observed from midnight through the dawn when the radiant reaches an elevation of 20° or more. Before midnight, southern observers should monitor the Puppid/Velid stream. Observers should have a field center situated no more than 40° away from the radiant position.

Table 4 – Radiant positions of the Geminids.

Date	α	δ
Dec 07	107°	+33°
Dec 12	111°	+33°
Dec 16	115°	+33°

7. December Monocerotids

This shower is active from November 27 to December 17 with a maximum ZHR of 5 on December 11. The *IMO* requests that observers give this shower attention after the Full Moon period of late November. The shower should be observed in conjunction with the Geminids. Care should be taken to distinguish between meteors from both showers. To aid this, the observer's center of field of view should be located at $\alpha = 105°–120°$ and $\delta = 00°–+20°$. All possible December Monocerotids as well as meteors possibly belonging to the Geminids or Monocerotids (i.e., those difficult to distinguish) should be plotted. Meteors belonging to the Geminids or sporadics should be counted only.

On the nights of December 12-13 and 13-14 it is senseless to analyze the Monocerotids since the activity of the Geminids is vastly superior and the ZHR of the December Monocerotids becomes polluted by the high Geminid activity. Therefore, observers are asked to concentrate on the Geminids on these dates.

Table 5 – Radiant positions of the December Monocerotids.

Date	α	δ	Date	α	δ
Nov 30	89°	+14°	Dec 10	100°	+14°
Dec 05	94°	+14°	Dec 15	106°	+14°

8. Coma Berenicids

The Coma Berenicids are active from December 12 through to January 23. The maximum of 5 meteors per hour occurs on December 17. They are best seen during the last few hours before sunrise from the northern hemisphere. Northern observers should endeavor to monitor the Coma Berenicids after the period of maximum Geminid activity (December 12–14) from December 14 to 17 before the Moon prevents further observation. They may also be observed the last few days of the month. Observers should center their field of view within 40° of the radiant position and plot all possible Coma Berenicid meteors.

Table 6 – Radiant positions of the Coma Berenicids.

Date	α	δ	Date	α	δ
Dec 12	174°	+26°	Dec 22	179°	+24°
Dec 17	175°	+25°	Dec 27	183°	+22°

9. χ-Orionids

This shower is active from November 6 to December 15. A maximum ZHR of 3 is reached in early December. The χ-Orionids are characteristically very slow brightly colored meteors. The *IMO* requires urgent observations of this shower in 1991. They should watch from December 1 to 15 with a center of field of view at about $\alpha = 90°$ and $\delta = +20°$ so that the other showers, the Geminids and Monocerotids can be monitored simultaneously. All possible χ-Orionids should be plotted.

Table 7 – Radiant positions of the χ-Orionids.

Date	α	δ	Date	α	δ
Dec 01	81°	+23°	Dec 10	91°	+23°
Dec 05	85°	+23°	Dec 15	97°	+23°

10. σ-Hydrids

The σ-Hydrids radiate out from the head of Hydra during the period December 3–15. Maximum ZHR is 5 and this occurs on December 11. This shower can be monitored simultaneously with the Monocerotids, χ-Orionids and Geminids if a center of field of view of around $\alpha = 105°$ and $\delta = +15°$ is used. All possible σ-Hydrids seen should be plotted.

Table 8 – Radiant positions of the σ-Hydrids.

Date	α	δ
Dec 05	123°	+03°
Dec 10	126°	+02°
Dec 15	130°	+01°

Telescopic Notes: 1991 November–1992 Quadrantids

Malcolm J. Currie

Bad weather during August at a number of sites hampered Perseid watches. Personally, it was the worst Perseid season I could recall. Only a night and a half was possible. Fortunately, Mark Vints tells me that he saw about 500 meteors during a campaign from Lardiers in Southern France. However, only a few percent of these appear to be Perseids. Mark's quick inspection does not reveal any *strong* activity from other radiants. In 1989 the northern radiants were subtle deviations from the sporadic noise. This could easily be the case this year and therefore will require more detailed analysis with the *RADIANT* program.

As far as the near future is concerned, the phase of the lunar cycle is again favorable during the period under consideration, and provides many opportunities for the telescopic fan.

Although the moon is just two days before full at the maximum of the *Leonids*, it sets not long after midnight from mid-northern latitudes just as the Leonid radiant attains an observable altitude. In the days leading up to maximum, the moon does not interfere at all. As we approach the possible storms of 1998 and/or 1999 we should not neglect the showers prior and subsequent to the headline years. The points made in the last of these *Notes* concerning the Draconids applies also to the Leonids—we have a concentrated core of meteoroids that is gradually being dispersed due to external forces and their slightly different orbits. It is important for the *IMO* to map the distribution of a range of meteoroid masses around the orbit in order to test theories of stream evolution. In this respect the telescopic data are as important as the visual. Since rates and luminosity functions are the most-important goals, wide-field instruments are preferred. Watches outside the normal activity dates would also be of interest. It is often forgotten that the vast majority of meteors in the 1966 storm were faint—people recall the trained fireballs—and so the Leonid shower is a good candidate for telescopic investigation. You may also be lucky and see some train phenomena in detail. Field centers should be above the radiant, thus from the north here are a couple of suggested pairs: Praesepe and $\alpha = 155°$, $\delta = +41.°5$; $\alpha = 140°$, $\delta = +35°$; and $\alpha = 173°$, $\delta = +44°$. In the south it may be possible to double up and observe both Leonids and the Puppids/Velids simultaneously.

Early December is a "must" for the telescopic watcher's calendar. Like the Leonids, the *Geminids* appear at first glance to be unfavorable, however the moon sets around midnight at the maximum. The *Monocerotids* are also well placed during the first fortnight of December. See [1,2] for more details. This year I hope we can obtain data for both showers during the period up to December 11 to complement the 1990 work currently being reduced. The ***σ-Hydrids*** and ***χ-Orionids*** both possess a high population index of 3.0 and are quite evident telescopically. A shower with distinctive slow meteors are the ***ζ-Aurigids***. I should like to know its activity period, and if rates permit. 1988 observations appear to show ζ-Aurigid activity as early as $\lambda_\odot = 255°$, though subjectively the angular velocity exhibited seemed much slower than would be expected for $V_\infty = 32$ km/s [3]. Watches during early December and January should determine its activity period and radiant position. There may be a number of sub-components in a diffuse radiant complex according to Kronk [3]. The fields used for the Geminids and Monocerotids will cater for these three minor radiants.

For the southern-hemisphere observer there is the *Puppid/Velid* complex to map. Activity lasts from October through January. Many of its components are rich in faint meteors, particularly the ***ζ-Puppids I*** which has a population index of 3.4. I do not know the reliability of this figure or whether this translates into high telescopic rates, but it looks excellent on paper. Choose ***at least*** three field centers around the complex so that individual components are unlikely to be occluded. In the first instance use the radiant coordinates given in Table 1 of [4]. Also the ***Phoenicids*** peak at December's New Moon. These meteors will be quite obvious due to their very slow speed. The radiant locations mitigate against accurate data for both "showers". Given a choice I would investigate the Puppid/Velid complex, except possibly for a few days around the Phoenicid maximum on December 5. On a general point I have received no southern-hemisphere reports since *IMO* was formed. Considering the vast potential for discoveries I find this quite amazing.

At the turn of the new year skies are dark for the *Quadrantids*. The maximum, predicted for 05^h UT, is ideally placed for visual observers in western Europe; telescopically, maximum occurs earlier—some 1.2 hours for each magnitude difference in mean meteor brightness. Thus the telescopic maximum favors observers further east, say in the Soviet Union and Japan. See [2] for background information (I can supply copies on request). The main goals of the *IMO* project are to investigate the size and structure of the radiant throughout the shower; determine the magnitude distribution, and the time of maximum. Michael Nolle's investigations of the sub-components within the diffuse radiant have yet to show a pattern. If you have any telescopic data for the Quadrantids, we both would be most interested in acquiring copies for inclusion in the analysis. Since the shower is so brief and weather so fickle, in order to obtain complete coverage of this shower we shall need some luck and observers scattered around the northern hemisphere. Please contact me soon if you are interested in contributing. Already all leading telescopic observers in western and central Europe have said they will participate. Watches should be made between December 31 and January 7. As the radiant has a wide range of elevations during the night it is hard to specify a simple list of suggested field centers, though some are given in [5]. Since the Quadrantid radiant is too low for observations in the first half of the night, watches for the *Coma Berenicids* and detecting any minor showers should be made at these times.

References

[1] M.J. Currie, *WGN* 18:5, October 1990, pp. 182–183.

[2] M.J. Currie, *BAA Meteor Section Newsletter, Telescopic Appendix* 31, 1988, pp. 3–6.

[3] G.W. Kronk, "Meteor Showers: a Descriptive Catalog", Enslow, Hillside, NJ, 1988, pp. 1–3.

[4] A. McBeath, "IMO 1992 Meteor Shower Calendar", pp. 9–10.

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

Revision of "Who is Who?" – Edition 1992

Paul Roggemans

At the end of 1991 we will prepare a new edition of the *IMO* info booklet "Who is who?". New members will be added, while those who did not renew their *IMO* membership will be removed. I have noticed several changes in addresses and other data and I assume that some people may wish to see some information changed in the booklet. The aim is to provide some information about you, so that other people may get some idea about your interests, work and activities. Therefore complete information should be provided by each member. If the information published in the previous edition is not complete or incorrect please send the corrections to the Secretary-General. For instance, for some people we do not know birth date, occupation or phone number. Also fax numbers, e-mail addresses or telex numbers you can be contacted at are very useful to include. Please, send your information to the Secretary-General. Thank you!

Possible Activity from Earth-Grazing Asteroids

Dirk Artoos

1. 1991 GO

The Earth-grazing asteroid 1991 GO is a good candidate for producing meteors. The closest approach takes place around October 26 (0.02198 AU) with a possible radiant at $\alpha = 32°$ and $\delta = -02\overset{\circ}{.}8$. The estimated maximum occurs just after the passage of the Orionids, and therefore I would ask you to keep observing a little longer and more particularly to be alert for meteors coming out of the Cetus region!

Table 1 – Observability function for a four-element antenna elevated at 45° for each hour of the day (local time), four cardinal directions and four latitudes. For the calculations a transmitter distance of 1000 km and a transmitter power of 30 kW were assumed.

Lat.	Dir.	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
+50	S	95	100	95	75	48	19	0	0	0	0	0	0	0	0	0	0	0	0	0	29	58	83	98	99
+50	W	100	97	93	85	69	34	0	0	0	0	0	0	0	0	0	0	0	0	0	50	82	99	97	100
+50	N	89	100	90	63	40	16	0	0	0	0	0	0	0	0	0	0	0	0	0	23	46	69	93	100
+50	E	100	99	95	95	73	34	0	0	0	0	0	0	0	0	0	0	0	0	0	49	76	88	94	98
+35	S	65	85	100	89	61	26	0	0	0	0	0	0	0	0	0	0	0	0	2	39	72	95	98	76
+35	W	93	90	83	81	71	38	0	0	0	0	0	0	0	0	0	0	0	0	3	54	84	100	95	96
+35	N	83	100	94	69	46	20	0	0	0	0	0	0	0	0	0	0	0	0	2	29	45	75	97	100
+35	E	89	91	100	90	72	37	0	0	0	0	0	0	0	0	0	0	0	0	2	50	73	79	82	86
00	S	0	78	100	95	71	35	0	0	0	0	0	0	0	0	0	0	0	0	0	8	48	80	99	95
00	W	0	7	38	67	70	45	0	0	0	0	0	0	0	0	0	0	0	0	10	59	85	98	100	85
00	N	0	78	100	93	70	34	0	0	0	0	0	0	0	0	0	0	0	0	8	47	79	98	97	60
00	E	0	93	100	93	76	44	0	0	0	0	0	0	0	0	0	0	0	0	10	59	74	59	25	2
−35	S	87	100	85	73	53	28	1	0	0	0	0	0	0	0	0	0	0	0	8	35	59	77	98	100
−35	W	88	83	79	80	73	47	0	0	0	0	0	0	0	0	0	0	0	0	13	59	86	100	93	92
−35	N	48	77	100	92	68	35	0	0	0	0	0	0	0	0	0	0	0	0	12	47	77	97	96	63
−35	E	85	88	100	92	75	44	0	0	0	0	0	0	0	0	0	0	0	0	14	56	74	75	76	80

1991 JW

1991 JW was discovered on April 19, 1991, by a group of astronomers at Mount Palomar Observatory with a 46 cm Schmidt camera. This body could well produce meteors. Its distance to the Earth is minimal on November 21 (0.02076 AU). Unfortunately the northern hemisphere will not see much of the possible activity produced by this asteroid. The possible radiant is active for four days after the Leonid maximum at $\alpha = 217\overset{\circ}{.}4$ and $\delta = -73\overset{\circ}{.}2$. This radiant lies in the vicinity of the border of Apus and Musca. It is best observable below the equator. Be aware of possible fireballs!

Table 2 – Observability function for a four-element antenna elevated at 45° for each hour of the day (local time), four cardinal directions and four latitudes. For the calculations a transmitter distance of 1000 km and a transmitter power of 30 kW were assumed.

Lat.	Dir.	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
00	S	0	0	0	0	0	16	46	71	88	97	100	100	97	88	71	46	15	0	0	0	0	0	0	0
00	W	0	0	0	0	0	14	40	64	82	94	100	100	94	81	63	40	13	0	0	0	0	0	0	0
00	N	0	0	0	0	0	17	49	74	91	100	100	100	100	90	73	48	16	0	0	0	0	0	0	0
00	E	0	0	0	0	0	14	40	64	82	94	100	100	94	81	63	40	13	0	0	0	0	0	0	0
−35	S	81	87	92	96	98	100	96	90	81	73	68	68	73	81	91	96	100	98	96	92	87	80	75	75
−35	W	50	55	62	70	78	86	92	97	100	100	100	99	97	96	94	89	84	76	69	61	55	50	48	48
−35	N	62	68	74	80	86	92	95	98	100	100	96	96	100	100	98	95	91	86	80	74	68	62	51	51
−35	E	50	55	61	69	76	84	89	94	96	97	99	100	100	100	97	92	86	78	70	62	55	50	48	48

One-Hour Outburst of the 1991 Perseids Surprises Japanese Observers!

Paul Roggemans, Marc Gyssens and Jürgen Rendtel

While overall Perseid activity was rather normal in 1991, a short one-hour outburst was witnessed in Japan at $\lambda_\odot = 139.^\circ56$ (2000.0), yielding ZHRs of over 400. The position of this outburst in the Perseid activity profile coincides with the first peak of the double maximum found in 1988 and 1989 and points towards the presence of a new filament of particles connected with the return of the Perseids' parent comet P/Swift-Tuttle.

Japanese observers witnessed a short outburst of Perseid activity at $\lambda_\odot = 139.^\circ56$, almost exactly at the position of the first peak of the double Perseid maximum, first found in *IMO*'s global analysis of the 1988 data [1] and convincingly confirmed in 1989 [2,3].

It should be mentioned that the time of the first peak was announced by the first author in an article in the August issue of *Sky and Telescope* [4], as a consequence of which several observers paid special attention to this event. However, nobody could ever have reasonably expected the exceptional strength of this peak in 1991, which is the highest level of Perseid activity recorded this century.

Although the outburst was seen by many observers at several sites independently, most observers lost track of the activity because it was simply too strong, as was kindly reported to us by Mr. Yasuo Taguchi and Mr. Yasuo Yabu.

Especially the results of the Shinshu University Astro OB Club, who had obviously prepared for a sharp maximum, are interesting. Between 15^h20^m and 16^h20^m UT, they obtained an hourly rate of 352, from an observing site in the Nagano Prefecture, at a height of 1720 m. They observed under very good circumstances, with a limiting magnitude of +6.5 in the center of the field of view. This count corresponds to a ZHR value of over 400! Before and after this period the activity was much lower: hourly rates of 64 and 62 respectively were recorded in the intervals 14^h20^m–15^h20^m UT and 16^h20^m–17^h20^m UT.

Also Mr. Yabu's observations under lm = +5.2 yielded rates between 16^h and 17^h UT that were 3 to 5 times stronger than at the beginning or the end of the night. From Mr. Yabu's data, the ZHR values of Table 1 could be computed.

Table 1 – Perseid ZHR values obtained by Yasuo Yabu on August 12, 1991.

Interval (UT)	T_{eff}	Lm	Per	Other	ZHR
14^h00^m–15^h00^m	$0.^h94$	4.8	12	6	128 ± 37
15^h00^m–16^h00^m	$0.^h86$	5.2	39	7	254 ± 41
16^h00^m–17^h00^m	$0.^h80$	5.3	62	10	335 ± 43
17^h00^m–18^h00^m	$0.^h88$	5.1	35	7	182 ± 31
18^h00^m–19^h00^m	$0.^h93$	5.0	19	6	94 ± 22

The difference in maximal ZHR value between Mr. Taguchi and Mr. Yabu is most probably due to a difference in perception; nevertheless, both observations are very well in agreement.

The outburst seen in Japan was rich in bright meteors. Of the 352 meteors observed by the Astro OB Club, eleven were brighter than −5. The negative of the all-sky photograph shown on the front cover shows no less than 26 meteors of which the 16 still visible on the print are brighter than −3, the brightest being −8! On the photograph shown in Figure 1, 12 meteors were captured.

Figure 1 – This guided exposure of the Perseid radiant region (h and χ Persei and M31 can easily be distinguished) was taken by Mr. Tatsuo Nakagawa (Shinshu University, Astro OB Club) from Takane Village (λ = 137°29′25″ E, φ = 35°57′09″ N, h = 1710 m) between 15^h45^m and 16^h16^m UT on August 12. Twelve meteors were captured using an Asahi Pentax 67 camera with a 50 mm $f:4$ lens and a Sakura 3200 film.

The Japanese outburst was also confirmed by some radio observations in other parts of the world. Shelby Ennis, an American radio observer from Kentucky, reported that he recorded increased Perseid activity from August 12, 14^h onwards. By 15^h30^m UT, the activity level was so intense that only the Leonids in 1966 performed better. Everything was pretty much over by 17^h UT, although it took until 19^h UT before the level had reached normal rates for a Perseid maximum. A UK-based radio amateur, Colin Morris, noticed a small peak between 15^h and 17^h UT [5], despite the very low radiant elevation of the Perseids at that time.

At 19^h UT, a team of *IMO* observers, members of the *Arbeitskreis Meteore*, was already monitoring the sky in Bulgaria, where the radiant was still at a very low position in the sky. Many Perseids were seen, despite the low radiant elevation. Unfortunately, such low radiant position do not favor calculations. Although it is known that ZHR calculations become unreliable for radiant elevations below 20°, we did make an attempt anyway. Surprisingly, the values obtained by the six observers of the Mt. Rozhen team agree very well among each other. For the interval 18^h50^m–20^h00^m UT, with a radiant elevation of about 20° in the middle of the interval, a ZHR of 93 ± 10 and a population index of 2.2 were found. The limiting magnitude was 6.5 or slightly better. For each observer, the Perseid sample on which the calculations were based contains at least 30 Perseids and may thus be regarded as statistically significant. It is interesting to note that this ZHR value agrees very well with the ZHR obtained from Mr. Yabu's observations during the last hour of his night.

All reports received thus far from the contiguous United States and Canada indicate a good maximum, but nothing extraordinary, neither on August 11-12, nor on August 12-13. So far, also the European observers consistently reported "normal" maximum rates for the Perseids.

Over 4000 meteors were observed by 6 observers in Bulgaria during the night of August 12-13. Furthermore, we also received reports from Belgium, France, Germany, the Netherlands, Romania, Spain, the United Kingdom and Yugoslavia. All in all, the European observing window was very well covered and showed no sign of exceptionally high activity. The ZHR stayed around 100 all through the night (19^h00^m–02^h00^m). The most one can say is that activity was maybe slightly above average (ZHRs of 100 compared to an average 90 for the last few years), but this needs further confirmation.

An abundance of fainter meteors however was apparent, explaining the somewhat disappointing rates reported by people observing under poorer sky conditions. This is consistent with Japanese radio observations indicating that the August 12.7 UT peak was due to large particles, although more small particles were observed 24 hours later [6].

In view of this general picture, we were very surprised to see *IAU Circular 5330* mention that P. Aneca, B. de Pontieu, J. Deweerdt and J. Van Wassenhove of the *Vereniging voor Sterrenkunde (VVS)* observed ZHRs of up to 200 under good conditions in Southern France. This puzzling message was in contradiction with all other data from Europe. Fortunately, the confusion was resolved at the *International Meteor Conference* in Potsdam where Mr. Aneca presented the *VVS* observations in a poster session. Probably due to the limited experience of most of the observers, Mr. Aneca's graphs showed a very large spread on the data points, with ZHR-values varying roughly between 50 and 200. The average value of about 100–130 however was consistent with the other European observations.

In answer to further inquiries, Mr. Aneca told us that the message to Dr. Marsden was sent out by Mr. C. Steyaert, only basing himself on preliminary impressions of Aneca and ignoring the request of the observers not to publish anything yet. Moreover, Mr. Steyaert neglected to verify the result or to consult other observers for confirmation. Although the confusion caused by Mr. Steyaert's message has now been cleared, the fact remains that erroneous information has been disseminated to the astronomical press, yielding the possibility that a completely false picture of the 1991 Perseids will be given to the astronomical community, which is very unfortunate. To avoid similar problems in the future, *IMO* will stay in close touch with Dr. Marsden to prevent incorrect information on meteor showers from being spread.

We deeply regret the acts of Mr. Steyaert, who is also an *IMO* Council Member. However, Mr. Steyaert acted on behalf of the Belgian *VVS* which is solely responsible. It should be clear that the *IMO* cannot always prevent unexperienced or irresponsible amateurs in local or in national societies from making big mistakes. Of course, the *IMO* will continue to work on the reliability of amateur work and to act as an interface between the amateur and the professional community, thus trying to minimize the chances that similar situations reoccur in the future.

Returning to the 1991 Perseid activity profile, we can say in summary that the observations support the conclusion of the 1989 Perseid analysis [2], where the first peak of the Perseid maximum was described as a rather recent feature on the activity, probably caused by the intersection of the Earth with a new young stream of meteoroids, formed parallel and very near to the old core of the Perseid meteor stream, and probably connected with the return of the parent comet P/Swift-Tuttle.

Although many astronomers believe that P/Swift-Tuttle may have passed unnoticed several years ago, it is interesting to note that Dr. Marsden has another opinion regarding this matter [6]. Dr. Marsden is becoming more and more convinced that P/Swift-Tuttle might be identical to the comet observed by Kegler in 1737, yielding a return in 1992 (perturbations increase the period by 5 years). This hypothesis is further strengthened by the fact that the nodal longitude of this comet is only about $0\overset{\circ}{.}1$ from the solar longitude of the Japanese peak. (Also the Leonid peak in 1966 was practically identical with P/Tempel-Tuttle's nodal longitude in 1965). Furthermore, Chinese chronicles report that high Perseid activity was also seen in 1861 and in 1862, the year that P/Swift-Tuttle passed perihelion [7]. The records mention that *countless numbers of meteors were seen*, a description that matches very well the impression most Japanese observers got from the most recent Perseid outburst.

Hence it is very important that, despite the poor conditions moonwise, the Perseid maximum is closely monitored in 1992, especially by the European observers who will have the honor of witnessing the first peak next year.

References

[1] Roggemans P., "The Perseid Meteor Stream in 1988: A Double Maximum!", *WGN* 17:4, August 1989, pp. 127–137.

[2] Roggemans P., Koschack R., "The 1989 Perseid Meteor Stream", *WGN* 19:3, June 1991, pp. 87–98.

[3] O.I. Bel'kovich, A.I. Grishchenyuk, A.S. Levina, V.V. Martynenko, "The Activity and Structure of the Perseids", *WGN* 19:2, April 1991, pp. 53–57.

[4] Roggemans P., "Watching the Perseid Meteor Stream", *Sky and Telescope* 82, 1991, pp. 172–174.

[5] C. Morris, "Radio Communication 67", *VHF-UHF News* 10, October 1991, pp. 19–20.

[6] B. Marsden, *personal communications*, September 1991.

[7] Zhuang Tian-Shan, "Ancient Chinese Records of Meteor Showers", *Acta Astronomica Sinica* 14, 1966, pp. 37–58.

The 1990 Geminids

Paul Roggemans and Ralf Koschack

A global analysis of the 1990 Geminids is presented, based on 11 255 meteors seen by 83 observers from 13 countries. The results confirm the general picture of the stream's activity profile. At first, the Geminid rates increased gradually to reach a ZHR of about 87 around $\lambda_{\odot} = 261\overset{\circ}{.}75$ (2000.0). Then, the activity stayed around the same value for about $0\overset{\circ}{.}5$ in solar longitude before rising sharply to a peak value of about 110 on $\lambda_{\odot} = 262\overset{\circ}{.}26$. This maximum lasted until $\lambda = 262\overset{\circ}{.}42$ after which the ZHR plunged to sporadic background levels in less than 24 hours. Noteworthy though are the facts that peak rates were reached several hours later than in past years and that overall, activity levels were at least 10% lower than "normal".

1. Introduction

The Geminids, a major stream which is so much more impressive than any other stream is by no means the most observed shower. The winter month December scares off many people at the northern hemisphere and many observing sites suffer from chronical bad weather around that time of the year. 1990 was not better compared to previous years. Despite the New Moon and all the publicity to observe the stream, only a very limited amount of data was collected by the *IMO*. Altogether, the 1990 Geminid data allowed an analysis and therefore we are grateful to the following observers:

Joe Aboud (ABOJO, 11, $0\overset{h}{.}80$), S. Anazawa (ANZSE, 31, $0\overset{h}{.}75$), Rainer Arlt (ARLRA, 264, $4\overset{h}{.}91$), Luis Rubio Bellot (BELLU, 42, $3\overset{h}{.}00$), Lance Benner (BENLA, 299, $5\overset{h}{.}34$), Guy Blackman (BLAGU, 129, $4\overset{h}{.}42$), Mark Burns (BURMA, 62, $2\overset{h}{.}69$), Beata Cabakova (CABBE, 151, $3\overset{h}{.}67$), Jiang Chang-Gui (CHAJI, 36, $4\overset{h}{.}08$), Li-Chung Chen (CHELI, 158, $4\overset{h}{.}00$), Ya-Fen Chen (CHEYA, 185, $4\overset{h}{.}00$), Martin Coroneos (CORMA, 470, $7\overset{h}{.}44$), Mark Davis (DAVMA, 56, $4\overset{h}{.}00$), Kenneth Eakins (EAKKE, 102, $4\overset{h}{.}00$), Phyllis Eide (EIDPH, 14, $1\overset{h}{.}00$), Raul Fernandez (FERRA, 355, $4\overset{h}{.}40$), K. Fukui (FUKKE, 106, $3\overset{h}{.}00$), George Gliba (GLIGE, 37, $2\overset{h}{.}00$), Daniel Glomski (GLODA, 89, $5\overset{h}{.}15$), Mark Glossop (GLOMA, 241, $3\overset{h}{.}16$), Takema Hashimoto (HASTA, 120, $10\overset{h}{.}36$), Craig Hinton (HINCR, 186, $1\overset{h}{.}57$), Chris Innes (INNCH, 70, $2\overset{h}{.}70$), Daiyu Ito

(ITODA, 35, $1^{\rm h}.00$), Kiyoshi Izumi (IZUKI, 80, $2^{\rm h}.75$), Petri Jaäskelainen (JAAPE, 27, $2^{\rm h}.47$), Norihito Kawamuro (KAWNO, 29, $1^{\rm h}.67$), Michael Keating (KEAMI, 97, $2^{\rm h}.77$), Timo Kinnunen (KINTI, 95, $3^{\rm h}.54$), Bernhard Koch (KOCBE, 1413, $29^{\rm h}.03$), Robert Lunsford (LUNRO, 639, $10^{\rm h}.50$), Shane Majoros (MAJSH, 18, $1^{\rm h}.76$), Katsuhiko Mameta (MAMKA, 106, $3^{\rm h}.72$), Adam Marsch (MARAD, 72, $5^{\rm h}.22$), Alastair McBeath (MCBAL, 271, $5^{\rm h}.00$), Norman McLeod (MCLNO, 682, $14^{\rm h}.27$), Michael Morrow (MORMI, 27, $2^{\rm h}.17$), K. Murata (MURKE, 26, $0^{\rm h}.77$), Markku Nissinen (NISMA, 34, $1^{\rm h}.38$), K. Noze (NOSKU, 6, $0^{\rm h}.98$), Daniel Ocenas (OCEDA, 150, $2^{\rm h}.67$), H. Okayasu (OKAHI, 5, $0^{\rm h}.98$), M. Oka (OKAMA, 50, $2^{\rm h}.84$), T. Ono (ONOTA, 30, $0^{\rm h}.75$), K. Osada (OSAKA, 50, $1^{\rm h}.86$), Gregg Pasterick (PASGR, 389, $9^{\rm h}.39$), George Platt (PLAGE, 316, $5^{\rm h}.91$), José Ponce (PONJE, 465, $2^{\rm h}.85$), Leo Rajala (RAJLE, 349, $9^{\rm h}.11$), Jürgen Rendtel (RENJU, 417, $9^{\rm h}.12$), Francisco Reyes Andres (REYFR, 105, $6^{\rm h}.60$), Rodney Tranter (RODTR, 16, $1^{\rm h}.60$), Paul Roggemans (ROGPA, 2336, $46^{\rm h}.58$), Toru Sagayama (SAGTO, 83, $2^{\rm h}.65$), Kotaro Sakuma (SAKKO, 11, $1^{\rm h}.47$), Hiromi Sato (SATHI, 203, $7^{\rm h}.87$), T. Sato (SATTA, 11, $1^{\rm h}.90$), Daan Schroyens (SCHDA, 291, $5^{\rm h}.06$), René Scurbecq (SCURE, 18, $4^{\rm h}.09$), Takashi Sekiguchi (SEKTA, 348, $8^{\rm h}.04$), Miguel Serra Martin (SERMI, 49, $1^{\rm h}.36$), Yasuo Shiba (SIBYA, 18, $0^{\rm h}.95$), Karl Simmons (SIMKA, 37, $1^{\rm h}.00$), Wanda Simmons (SIMWA, 44, $1^{\rm h}.08$), H. Sirai (SIRHI, 19, $0^{\rm h}.95$), Juraj Skvarka (SKVJU, 161, $3^{\rm h}.67$), James Smith (SMIJN, 48, $5^{\rm h}.25$), Siegfried Stapf (STASI, 1073, $29^{\rm h}.12$), David Swann (SWADA, 33, $1^{\rm h}.94$), Richard Taibi (TAIRI, 66, $4^{\rm h}.36$), S. Tanaka (TANSY, 60, $0^{\rm h}.67$), E. Tomita (TOMET, 33, $0^{\rm h}.73$), Hiroyuki Tomioka (TOMHI, 102, $5^{\rm h}.07$), Sebastia Torrell (TORSE, 66, $2^{\rm h}.29$), Toriyama (TORYA, 31, $0^{\rm h}.58$), José Trigo (TRIJO, 787, $9^{\rm h}.73$), S. Uehara (UEHSA, 48, $5^{\rm h}.71$), Toshihiko Ueno (UENTO, 255, $5^{\rm h}.00$), Tracy Lynn Wit (WITTR, 74, $5^{\rm h}.14$), Jeff Wood (WOOJE, 656, $7^{\rm h}.50$), Yasuo Yabu (YABYA, 14, $2^{\rm h}.52$), K. Yamamoto (YAMKA, 6, $0^{\rm h}.62$), Peter Zimnikoval (ZIMPE, 118, $3^{\rm h}.00$).

The Visual Commission thanks all the observers who contributed to this analysis. Table 1 shows how the observations were distributed over the world, according to the location where the observation took place.

Table 1 – Total numbers of observers and meteors and total effective observing time per country.

Country	Observers	Meteors	$T_{\rm eff}$
Germany	4	3167	$72^{\rm h}.18$
United States	15	2588	$71^{\rm h}.34$
Australia	13	2344	$47^{\rm h}.54$
France	1	2336	$46^{\rm h}.58$
Japan	28	1916	$76^{\rm h}.16$
Spain	7	1869	$30^{\rm h}.23$
Czechoslovakia	4	580	$13^{\rm h}.01$
United Kingdom	2	562	$10^{\rm h}.06$
Finland	4	505	$16^{\rm h}.50$
Taiwan	2	343	$8^{\rm h}.00$
Canada	1	48	$5^{\rm h}.25$
China	1	36	$4^{\rm h}.08$
Belgium	1	18	$4^{\rm h}.09$
Total	83	16312	$405^{\rm h}.02$

From the 16312 meteors reported by the 83 observers, 11255 were Geminids. Moreover, several minor streams were recorded as well. The number of meteors for each radiant is listed in Table 2.

Table 2 – Total number of meteors observed per shower.

Shower	N	Shower	N	Shower	N
δ-Arietids (ARI)	11	σ-Hydrids (HYD)	144	χ-Orionids S (ORS)	55
Coma Berenicids (COM)	148	Monocerotids (MON)	158	Other showers (DIV)	363
Geminids (GEM)	11255	χ-Orionids N (ORN)	72	Sporadics (SPO)	4106

2. The population index

The population index r was calculated from the available individual cumulative magnitude distributions $\Phi(m)$ by linear regression $\log \Phi(m) = m \log r + b$ according to [1]. The criteria for including a magnitude distribution in the analysis were set as follows:

a) the faintest magnitude class used had to be brighter than lm−2 for the nights with sufficient data. Near the limits of the activity period, lm − 1.2 was taken as the faintest class;
b) from the faintest class onwards there had to be at least five consecutive classes containing at least three meteors each;
c) the total number of shower meteors had to be greater than 25;
d) no $\Phi(m)$ differs by more than 40% from the regression line;
e) the correlation coefficient is higher than 0.98.

Table 3 – The r-profile for the 1990 Geminids.

Date	$\lambda_\odot$ (2000.0)	Obs	Met	$\overline{\text{lm}}$	r
Dec 12	259°58	1	23	6.37	2.50 ± 0.57
Dec 13	260°08	3	154	6.46	2.55 ± 0.03
Dec 13	260°58	7	836	6.51	2.64 ± 0.22
Dec 13	261°08	9	1187	6.20	2.62 ± 0.19
Dec 14	261°58	32	6294	6.14	2.53 ± 0.07
Dec 14	262°08	31	6486	6.15	2.52 ± 0.07
Dec 14	262°58	14	1763	6.21	2.35 ± 0.09
Dec 15	263°08	12	1124	6.28	2.30 ± 0.08
Dec 15	263°58	4	136	6.52	2.26 ± 0.06
Dec 16	264°08	3	101	6.52	2.29 ± 0.09

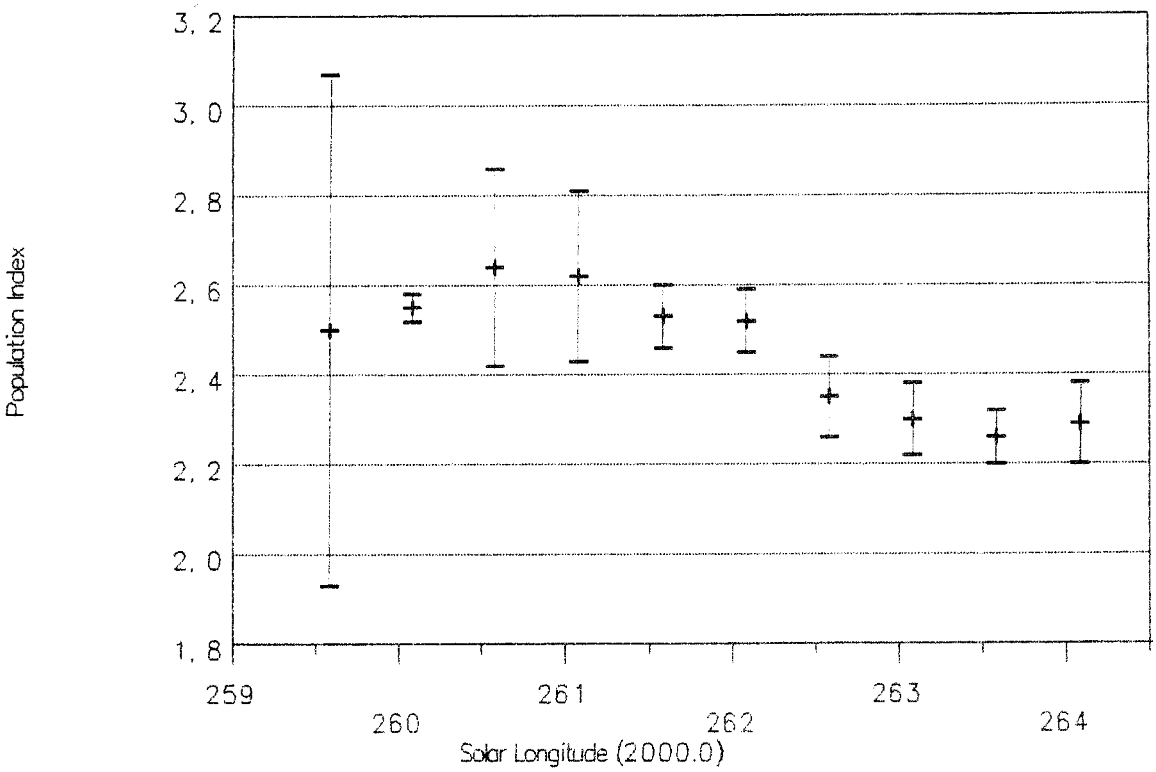

Figure 1 – Profile of the population index r for the 1990 Geminids.

The further procedure was the same as for the Orionid analysis [2], except that the averaging procedure was reprogrammed to obtain a sliding mean. The r-values were averaged over 1° in solar longitude with steps of 0°5. A more detailed picture of the population index profile was not possible because of the limited number of useful magnitude distributions that were available. The resulting r-values are listed in Table 3 and plotted in Figure 1.

The results show a slightly decreasing r-value during the activity period, a finding which is in perfect agreement with all previous studies on the Geminid Meteor Stream [3,4,5]. The faint Geminids are indeed more dominant in the pre-maximum period while the real bright events are relatively more frequent after the main Geminid maximum.

3. The ZHR profile

In total, 348 ZHRs were calculated with a limiting magnitude better than 5.0, an effective observing time of at least $0\overset{h}{.}8$ or longer, a cloud cover correction factor of at most 1.2 and the Geminid radiant at least 20° above the horizon. The zenith correction factor was calculated as in [6], correcting for the geometrical conditions only, i.e., the zenith exponent γ was set to 1.

The next step of the analysis is the derivation of the perception coefficients P, also expressed as limiting magnitude corrections Δlm. The values of Table 4 were obtained according to the method described in [6,7]. For the perception coefficient determination, the interval $\lambda_\odot = 260\overset{\circ}{.}5$ to $\lambda_\odot = 262\overset{\circ}{.}5$ was selected with a sampling interval of $0\overset{\circ}{.}33$ and a step of $0\overset{\circ}{.}16$. The reason for the limitation on the sampling interval is that

- too few observations are available at the beginning and at the end of the activity period; and
- a preliminary profile had shown that past $\lambda_\odot = 262\overset{\circ}{.}5$, when still enough observations were available, the activity drops from maximum levels to below the sporadic background in less than 24 hours, which would require too short a sampling interval to derive perception coefficients.

Furthermore, the observations had to fulfill the following criteria:

a) total correction factor less than 3;
b) radiant elevation greater than 20° for the center of the observing interval.

Moreover, observations with sporadic HRs greater than 40 were ignored. (In general, these were observations with lm < 5.5.). All observing methods and field centers were allowed.

Table 4 – Perception coefficients P and corrections Δlm for the limiting magnitude derived from the 1990 Geminid observations.

Observer	Obs.	P	Δlm	Observer	Obs.	P	Δlm
Arlt Rainer	8	0.61	-0.55 ± 0.14	Reyes Andres Francisco	2	0.37	-1.00 ± 0.01
Benner Lance	5	1.07	$+0.07 \pm 0.08$	Roggemans Paul	33	1.24	$+0.22 \pm 0.15$
Cabakova Beata	7	0.80	-0.24 ± 0.06	Sagayama Toru	2	1.34	$+0.30 \pm 0.07$
Chang-Gui Jiang	2	0.33	-1.20 ± 0.00	Sato Hiromi	12	0.72	-0.40 ± 0.37
Chen Li-Chung	2	1.75	$+0.60 \pm 0.13$	Schroyens Daan	9	0.75	-0.32 ± 0.23
Coroneos Martin	6	1.32	$+0.27 \pm 0.16$	Sekiguchi Takashi	2	1.82	$+0.62 \pm 0.04$
Fernandez Raul	11	1.00	-0.02 ± 0.24	Shiba Yasuo	2	1.07	$+0.06 \pm 0.03$
Fukui K.	2	1.13	$+0.13 \pm 0.13$	Sirai H.	2	1.14	$+0.14 \pm 0.04$
Izumi Kiyoshi	2	1.25	$+0.23 \pm 0.03$	Skvarka Juraj	7	1.23	$+0.21 \pm 0.19$
Koch Bernhard	30	0.93	-0.09 ± 0.17	Stapf Siegfried	18	1.03	$+0.01 \pm 0.27$
Lunsford Robert	11	1.17	$+0.17 \pm 0.15$	Swann David	5	1.19	$+0.16 \pm 0.19$
Mameta Katsuhiko	6	0.81	-0.23 ± 0.17	Taibi Richard	4	0.92	-0.15 ± 0.43
Marsch Adam	2	0.56	-0.64 ± 0.09	Tomioka Hiroyuki	7	0.87	-0.19 ± 0.33
McBeath Alastair	9	0.96	-0.05 ± 0.09	Trigo José	7	1.58	$+0.49 \pm 0.13$
McLeod Norman	12	0.48	-0.81 ± 0.17	Uehara S.	4	0.79	-0.30 ± 0.39
Ocenas Daniel	5	1.52	$+0.44 \pm 0.16$	Ueno Toshihiko	12	1.12	$+0.10 \pm 0.22$
Pasterick Gregg	4	1.07	$+0.07 \pm 0.11$	Wood Jeff	6	1.74	$+0.56 \pm 0.15$
Ponce José	2	1.04	$+0.05 \pm 0.02$	Zimnikoval Peter	8	1.04	$+0.03 \pm 0.19$
Rendtel Jürgen	10	0.69	-0.41 ± 0.15				

Table 5 – Intervals for the computation of the final ZHR profile and criteria set

$\lambda_\odot$	Width	Shift	h_{min}	C_{max}	D_{max}	Method
254°0–260°0	1°50	0°75	15°	3	–	all
260°0–262°5	0°33	0°16	15°	3	–	all
262°5–263°2	0°16	0°08	15°	3	–	all
263°2–266°0	0°50	0°25	15°	3	–	all

Once the perception properties were determined all the ZHRs were corrected with:

$$\mathrm{ZHR_{corr}} = \mathrm{ZHR_{obs}} \times r^{-\Delta \mathrm{lm}}$$

For some observers no perception information could be obtained and in such cases their Δlm was set to zero. The final ZHR profile was obtained according to the method described in [7]. The parameters used to average the final ZHR profile are listed in Table 5. The width and the step length of each averaging interval were chosen in function of the number of observations available as well as in function of a preliminary profile that was obtained before. For very skew activity profiles with a very steep decrease as is the case for the Geminids, the large rate variation in a few hours time requires rather short sampling intervals. In order to include only high quality data in the analysis, only ZHRs obtained with a minimum radiant height of 15° (h_{min}) and a maximum correction factor of 3 (C_{max}) were used. Observers with a rather poor limiting magnitude could still obtain an acceptable correction factor if their effective observing time (T_{eff}) was sufficiently long, for instance 2 hours or more. For the Geminids, the method used and the position of the center of the field of view do not matter. The results are shown in Figures 2 and 3. The error bars correspond to the 68% confidence interval $\sigma/\sqrt{n}$ with n the number of observations.

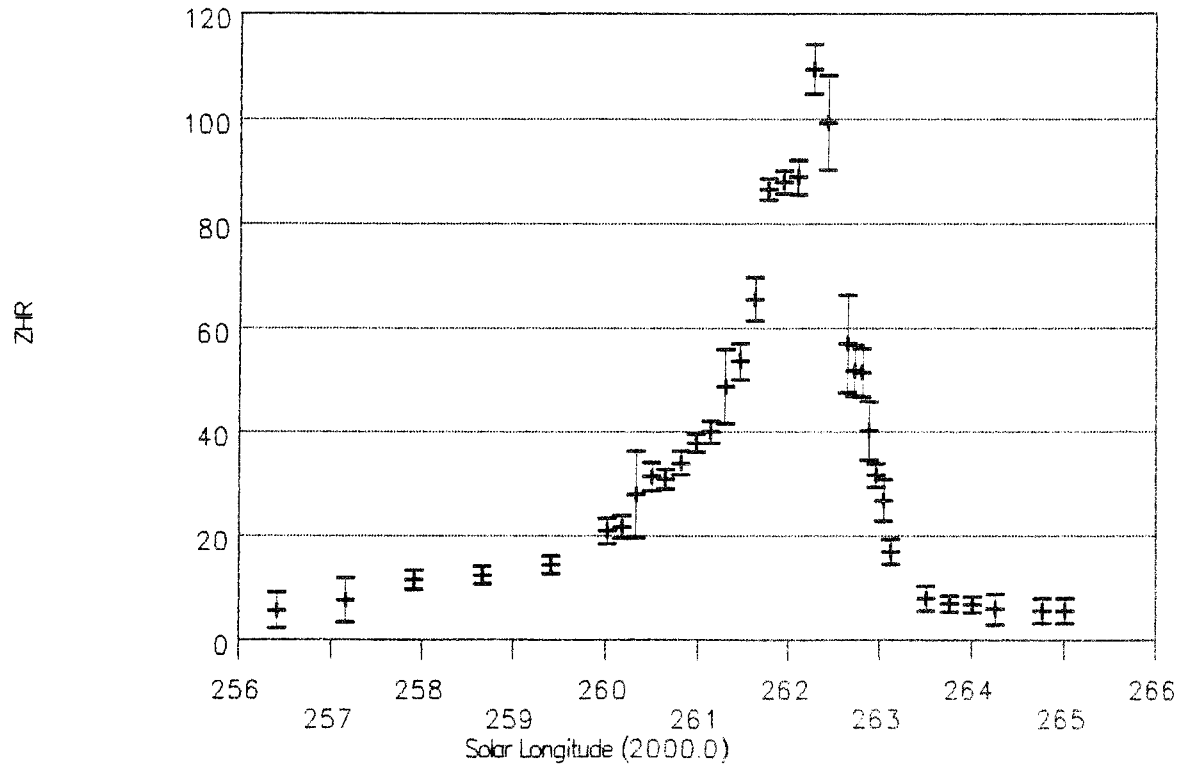

Figure 2 – ZHR profile of the 1990 Geminids

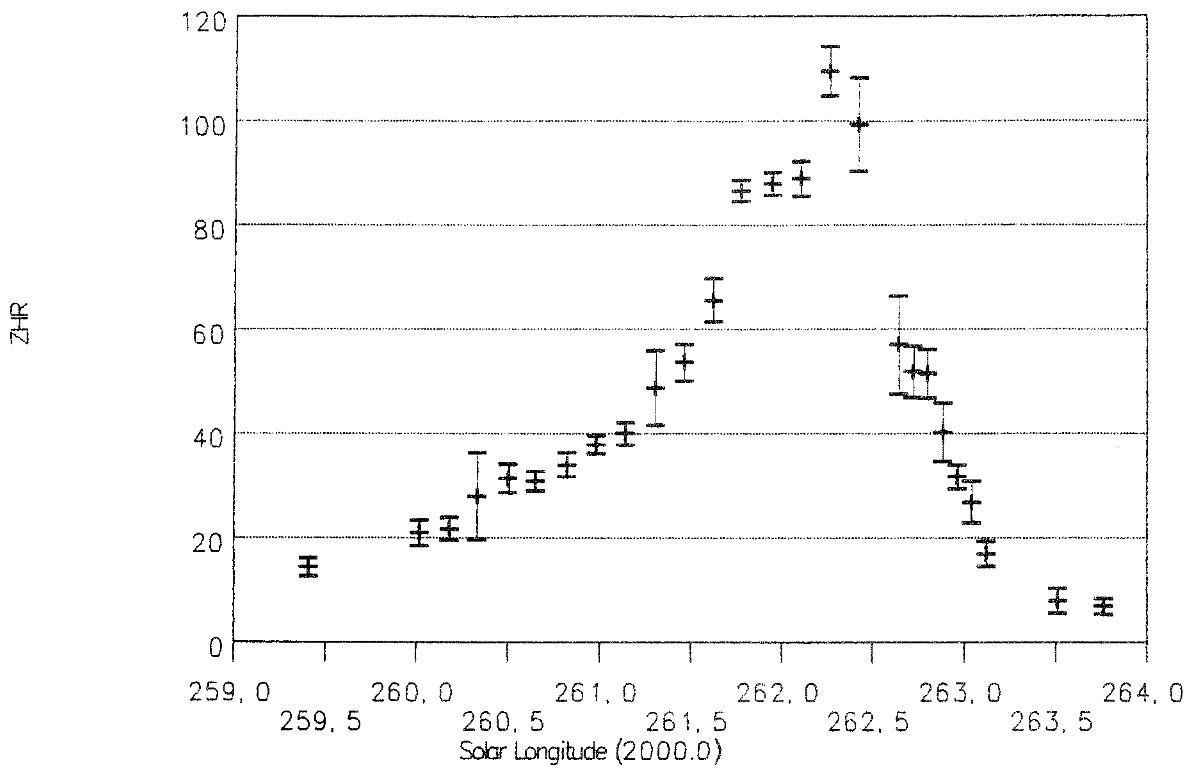

Figure 3 – Detail of Figure 2, around maximum

From $\lambda_\odot = 260°$ onwards, the Geminid activity exceeds the sporadic background level and increases gradually to reach the ZHR value of about 87 around $\lambda_\odot = 261\overset{\circ}{.}75$. The activity then stays around the same value for about $0\overset{\circ}{.}5$ in solar longitude before rising sharply to a peak value of about 110 on $\lambda_\odot = 262\overset{\circ}{.}26$. This maximum lasts until $\lambda_\odot = 262\overset{\circ}{.}42$ after which the ZHR drops dramatically: in less than 24 hours the activity falls back to sporadic background levels, which are reached around $\lambda_\odot = 263\overset{\circ}{.}25$.

The general shape of the Geminid activity profile agrees very well with previous studies [5,8,9, 10,11]. In [8], the 1988 *IMO* data on the Geminids were analyzed. In that year, a high activity was seen at $\lambda_\odot = 260\overset{\circ}{.}8$, but this pre-maximum peak was based on only a few observers. In 1990, no such isolated sub-maximum was found. Only a very modest shoulder appears in the 1990 profile, a feature with insufficient statistical significance. Nevertheless, this area in the stream should be monitored in future years, in order to shed more light on this issue.

In 1988, the peak was determined at $\lambda_\odot = 262\overset{\circ}{.}1 \pm 0\overset{\circ}{.}1$, with a decreasing activity already starting at $\lambda_\odot = 262\overset{\circ}{.}2$. Hence in 1990 the peak occurred 4 hours later than in 1988. In 1985 the maximum lasted from $\lambda_\odot = 261\overset{\circ}{.}94$ to $\lambda_\odot = 262\overset{\circ}{.}46$ [12], in very good agreement with the 1990 results. Porubcan et al. [5] found a peak at $\lambda_\odot = 261\overset{\circ}{.}7 \pm 0\overset{\circ}{.}2$ for the period 1944–1974. Stohl et al. [11] located the maximum at $\lambda_\odot = 262\overset{\circ}{.}02$ in 1974, about 6 hours earlier than in 1990. So it looks as if the Geminid maximum has been shifting slightly in solar longitude, appearing later in time now. Up to now, it was often stated that the Geminid maximum did not show any shifting in time over the years.

Another noteworthy fact about the 1990 Geminids is that the peak rates are lower than in 1980, 1985 as well as 1988, by at least 10%. Future observations will be necessary in order to see whether this will become a trend. Indeed, computer models [13] suggest that somewhere in the future the Earth will no longer cross the densest part of the Geminid stream. For the observers, we hope that the slightly lower maximum rates in 1990 are not yet a first sign of this unavoidable separation between the core of the Geminid stream and the Earth's orbit.

As in 1990, the 1988 results also show a plateau announcing the peak activity. In 1988, this plateau started at $\lambda_\odot = 261\overset{\circ}{.}7$, with the maximum occurring at $\lambda_\odot = 262\overset{\circ}{.}1$. This plateau in the Geminid activity profile supports the hypothesis of a double maximum, suggested in many studies [14,15], but the activity from the first submaximum and the second can be simply superimposed with as a result that the two maxima cannot be seen any more as two clearly independant peaks on the curve, like for the Perseids or the Orionids.

We do not want to repeat the background information on the Geminids in this article. A good comparison to different research projects was described in [8] and a very complete overview of the history and characteristics of the Geminid meteor stream was given by Roggemans in [16].

4. Spatial number densities

First, we consider the spatial number densities $\rho_{6.5}$ of particles causing meteors of absolute magnitude brighter than +6.5. The calculations were carried out according to [1]; for the calibration the standard observers ARLRA, RENJU and ROGPA were used. The average correction of the standard observers is $\Delta lm_{\text{avg}} = -0.124 \pm 0.012$.

The profile of the spatial number density $\rho_{6.5}$ is shown in Table 6 and in Figures 4 and 5 (Figure 5 is a detail of Figure 4 around maximum; for clarity, the error bars were omitted.)

If the initial relation between the particle mass M, the geocentric velocity V_∞, and the meteor magnitude m is known, it is possible to compute number density profiles for particles of different masses. In [1], the following relation, given in [6], was used:

$$m = 40 - 2.5 \log \left(2.732 \times 10^{10} \,.\, M^{0.92} \,.\, V_\infty^{3.91}\right)$$

with M in grams and V_∞ in km/s. Using this relation the spatial number density $\rho(M \geq M_0)$ of particles having masses greater than a certain limit M_0 results from $\rho_{6.5}$ by:

$$\rho(M \geq M_0) = \rho_{6.5} r^{9.775 \log(5.726 M_0^{-0.2353}/V_\infty)}$$

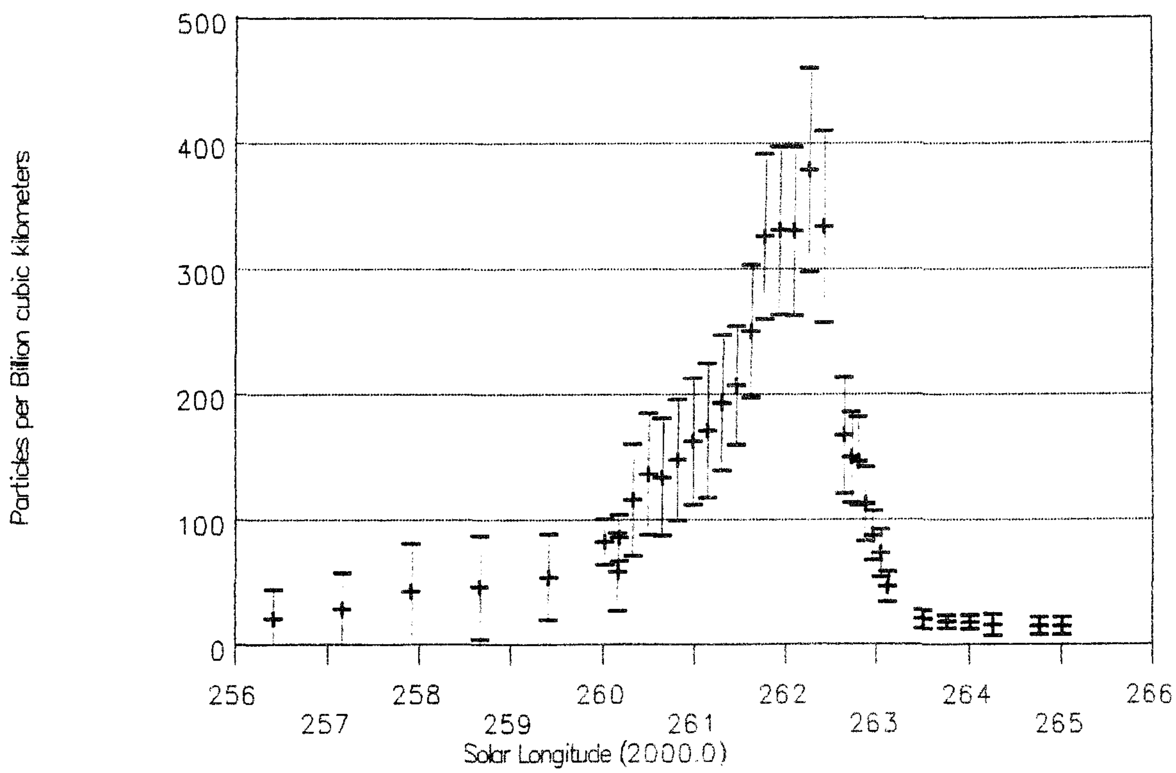

Figure 4 – Profile of the spatial number density $\rho_{6.5}$ of particles causing meteors of absolute magnitude at least +6.5 (corresponding to a mass of about 0.5 mg or greater). On the vertical axis, numbers of particles per 10^9 km^3 are shown.

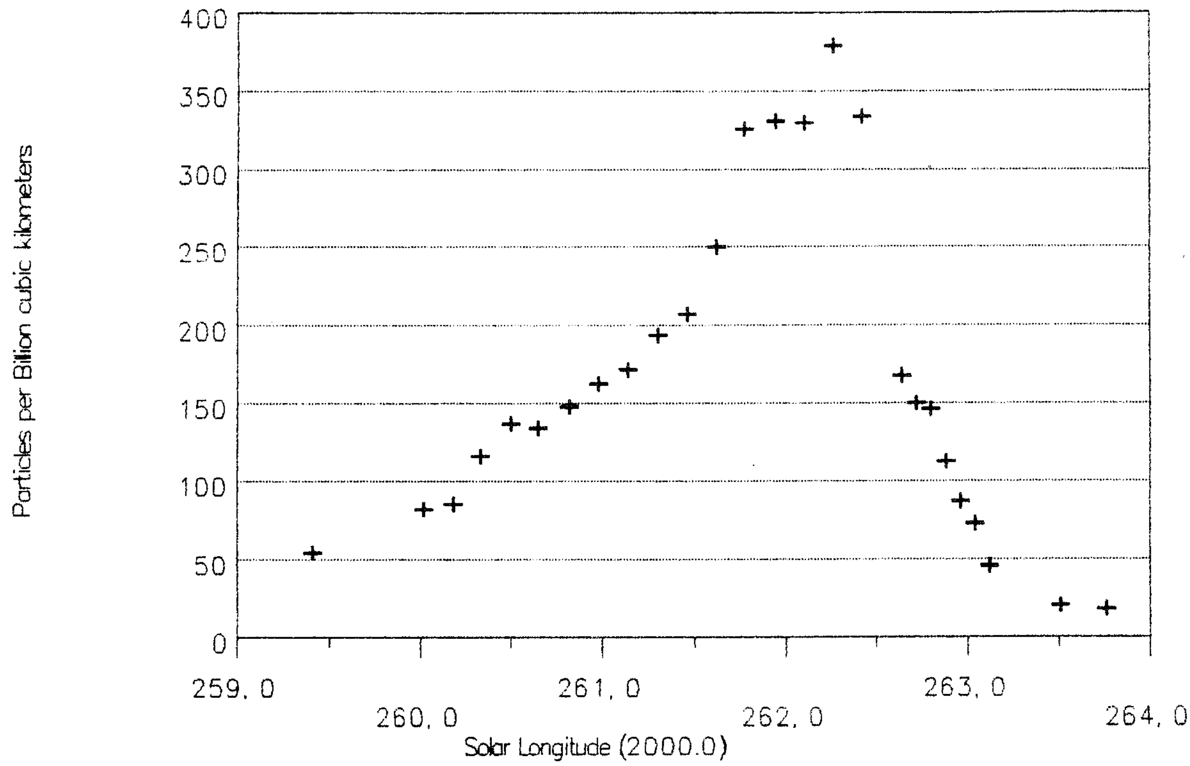

Figure 5 – Detail of Figure 4, around maximum. For clarity, error bars were omitted.

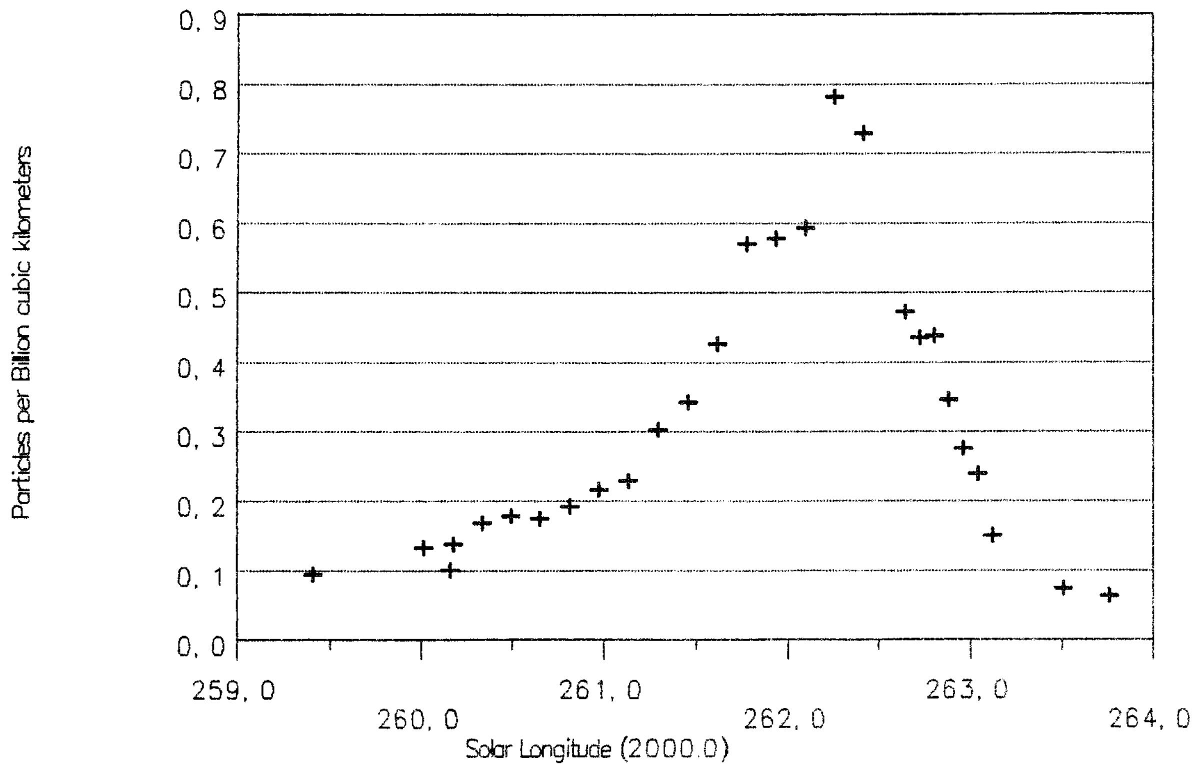

Figure 6 – Spatial number density $\rho(M \geq 0.5$ g) of particles heavier than 0.5 g, which corresponds to meteors brighter than magnitude -0.4.

As the variations in the population index profile are rather moderate, there are no considerable differences in the shape of number density profiles for different masses. Comparing Figures 5 and 6 it can be seen that due to the higher r before the maximum the relative level of $\rho_{6.5} = \rho(M \geq 0.5$ mg) is then a bit higher than that of $\rho(M \geq 0.5$ g), while the decrease after the maximum is steeper in the $\rho_{6.5}$-profile.

Looking at Figure 4, the result of the great uncertainty of the population index r for $\lambda_\odot < 260°$ can be clearly seen. The relative error on $\rho_{6.5}$ amounts to about 100%, despite the high accuracy of the ZHR at that time.

Table 6 – Numeric values for r, s, ZHR, $\rho_{6.5}$ and $\rho_M = \rho(M > 10^{-3}$ g) for the 1990 Geminids.

$\lambda_\odot$ (2000.0)	r	s	Obs	Met	$\overline{\mathrm{lm}}$	ZHR	$\rho_{6.5}$	ρ_M
256°41	2.50 ± 0.57	1.92	2	7	6.05	5.7 ± 3.5	20.9 ± 23.3	11.2
257°16	2.50 ± 0.57	1.92	5	24	6.26	7.7 ± 4.2	28.2 ± 29.3	15.2
257°91	2.50 ± 0.57	1.92	14	78	6.24	11.6 ± 1.9	42.5 ± 38.4	22.9
258°66	2.50 ± 0.57	1.92	17	113	6.22	12.5 ± 1.7	45.8 ± 41.4	24.7
259°41	2.52 ± 0.41	1.92	18	192	6.33	14.4 ± 1.7	54.2 ± 34.6	29.0
260°16	2.52 ± 0.34	1.92	12	140	6.36	15.4 ± 1.9	58.0 ± 31.2	31.1
260°02	2.55 ± 0.06	1.94	7	112	6.05	21.0 ± 2.4	82.3 ± 18.6	43.7
260°18	2.55 ± 0.06	1.94	8	135	6.05	21.8 ± 2.2	85.4 ± 18.8	45.4
260°34	2.59 ± 0.12	1.95	3	52	6.05	28.1 ± 8.3	116.0 ± 44.9	61.0
260°50	2.63 ± 0.20	1.97	8	146	5.95	31.5 ± 2.7	136.7 ± 48.9	71.2
260°66	2.63 ± 0.21	1.97	12	243	6.15	30.9 ± 1.9	134.1 ± 47.2	69.8
260°82	2.63 ± 0.20	1.97	12	358	6.34	34.0 ± 2.3	147.6 ± 48.6	76.8
260°98	2.62 ± 0.19	1.96	15	632	6.40	37.9 ± 1.7	162.5 ± 50.7	84.8
261°14	2.62 ± 0.19	1.96	9	379	6.39	40.0 ± 2.1	171.5 ± 53.8	89.5
261°30	2.56 ± 0.11	1.94	5	127	6.11	48.7 ± 7.1	193.3 ± 54.2	102.5
261°46	2.54 ± 0.09	1.93	12	350	6.10	53.6 ± 3.5	207.2 ± 47.6	110.4
261°62	2.53 ± 0.07	1.93	16	577	6.12	65.6 ± 4.2	250.3 ± 53.0	133.7
261°78	2.52 ± 0.07	1.92	37	2336	6.26	86.6 ± 2.0	325.9 ± 65.6	174.6
261°94	2.52 ± 0.07	1.92	49	3484	6.27	87.9 ± 2.2	330.8 ± 66.6	177.2
262°10	2.51 ± 0.07	1.92	28	2126	6.26	88.9 ± 3.3	330.1 ± 67.1	177.3
262°26	2.46 ± 0.08	1.90	10	931	6.24	109.5 ± 4.7	379.2 ± 81.2	206.5
262°42	2.44 ± 0.08	1.89	6	520	6.26	99.3 ± 9.0	334.1 ± 76.4	182.9
262°64	2.35 ± 0.09	1.85	3	90	6.31	57.0 ± 9.4	167.4 ± 46.5	94.0
262°72	2.34 ± 0.09	1.85	7	251	6.33	51.8 ± 4.9	149.8 ± 36.3	84.3
262°80	2.33 ± 0.09	1.84	9	433	6.34	51.4 ± 4.7	146.2 ± 35.3	82.6
262°88	2.32 ± 0.09	1.84	10	409	6.29	40.2 ± 5.6	112.6 ± 29.9	63.8
262°96	2.31 ± 0.08	1.84	9	284	6.31	31.7 ± 2.3	87.3 ± 19.7	49.6
263°04	2.30 ± 0.08	1.83	8	218	6.37	26.9 ± 4.0	72.9 ± 18.9	41.5
263°12	2.30 ± 0.08	1.83	4	71	6.35	17.0 ± 2.4	46.1 ± 11.8	26.3
263°51	2.27 ± 0.06	1.82	6	23	6.14	8.0 ± 2.4	20.6 ± 7.4	11.9
263°76	2.28 ± 0.07	1.82	11	52	6.41	7.0 ± 1.5	18.3 ± 5.4	10.5
264°01	2.28 ± 0.08	1.82	7	37	6.45	6.8 ± 1.5	17.8 ± 5.5	10.2
264°26	2.29 ± 0.09	1.83	3	10	6.14	5.9 ± 2.9	15.7 ± 8.6	9.0
264°76	2.29 ± 0.09	1.83	3	21	6.42	5.7 ± 2.4	15.2 ± 7.3	8.7
265°01	2.29 ± 0.09	1.83	3	21	6.42	5.7 ± 2.4	15.2 ± 7.3	8.7

5. Comparison with other streams

The quantity $\rho_M = \rho(M \geq 1$ mg) (see Table 6) allows us to compare real number densities of different meteor streams. While the Perseids reached $\rho_M = 15.2 \times 10^{-9}$ km^{-3} at their 1989 maximum (i.e., 15 particles of mass at least 1 mg in a cube with edges of 1000 km length) [6], and the Orionids only $\rho_M = 1.4 \times 10^{-9}$ km^{-3} in 1990 [2], the 1990 Geminids attained $\rho_M = 206 \times 10^{-9}$ km^{-3}! The Geminids can be considered as the densest annual meteor stream: despite their low velocity, they produce rates comparable to or better than those of other major meteor showers.

References

[1] Koschack R., Rendtel J., "Determination of Spatial Number Density and Mass Index from Visual Meteor Observations (II)", *WGN* 18:4, August 1990, pp. 119–140.

[2] Koschack R., Roggemans P., "The 1990 Orionids", *WGN* 19:4, August 1991, pp. 115–130.

[3] McIntosh B.A., "Geminid Meteor Stream: Structure from 20 Years of Radar Observations", *Bull. Astr. Inst. Czech.* 31, 1980, pp. 39–50.

[4] Šimek M., "Geminid Meteor Shower as Observed on the Long Base", *Bull. Astr. Inst. Czech.* 33, 1982, pp. 349–358.
[5] Kresáková M., Porubcan V., Stohl J., "The Geminid Meteor Shower: Activity and Magnitude Distributions", *Skaln. Pleso Obs.* 9, 1980, pp. 125–143.
[6] Roggemans P., Koschack R., "The 1989 Perseid Meteor Stream", *WGN* 19:3, June 1991, pp. 87–98.
[7] Roggemans P., "The 1988 Perseid Meteor Stream and Observers' Perception Coefficients", *WGN* 17:5, October 1989, pp.189–193.
[8] Roggemans P., "The Geminid Meteor Stream in 1988", *WGN* 17:6, 1989, pp. 229–239.
[9] Šimek M., "Geminid Meteor Stream: Activity as a Function of Particle Size", *Bull. Astr. Inst. Czechosl.* 40, 1989, pp. 288–298.
[10] Spalding G., "The Geminid Meteor Stream in 1980", *JBAA* 92, 1982, pp.227–233.
[11] Porubcan V., Stohl J., "Observations of the Geminids 1974 at the Skalnate Pleso Observatory", *Contr. Astr. Obs. Skaln. Pleso* 8, 1979, pp. 71–79.
[12] Roggemans P., "On the Geminid Meteor Stream in 1985", *WGN* 14:2, April 1986, pp. 48–62.
[13] Fox K., Williams I.P., Hughes D.W., "The Rate Profile of the Geminid Meteor Shower", *Mon. Not. R. Astr. Soc.* 205, 1983, pp. 1155–1169.
[14] Jones J., "The Structure of the Geminid Meteor Stream I - The Effect of Planetary Perturbations", *Mon. Not. R. Astr. Soc.* 217, 1985, pp. 523–532.
[15] Ryabova G., "On the Bimodality of the Geminid Meteor Shower", *WGN* 17:6, December 1989, pp. 240–241.
[16] Roggemans P., "The Geminid Meteor Stream and 1983 TB", *WGN* 12:4, August 1984, pp. 114–130.

Bulletin 1 of the International Leonid Watch

Peter Brown

An overview is given of primary and secondary aims of the *International Leonid Watch (ILW)*. An inventory of useful observing techniques is made. Finally, some instructions are given for Leonid observations in 1991.

1. Introduction

Since the initial suggestion for an *International Leonid Watch (ILW)* was made one year ago feedback from commission directors of the *IMO* and others interested in an *ILW* has been received with the overwhelming consensus being that such a project would be useful. As a result you see before you the first bulletin of the *ILW* and some initial instructions as to how to make a meaningful scientific contribution during the first *ILW* period in 1991. This bulletin will be issued every 6–12 months over the coming 6 years or thereabouts as we approach those years expected to give strong activity during the 1999 Leonid epoch.

It is hoped that a complete *ILW* booklet detailing the shower and how to observe it will be produced within the next 3–4 years for general distribution.

2. Scientific Aims

After a great deal of discussion by letter and during a round table discussion at the "Asteroids, Comets and Meteors" Conference in Flagstaff, Arizona, during June 1991, a final list of the main aims of the *ILW* has been prepared from a long list of possible topics for investigation. Additional worthwhile areas of investigation in connection with the Leonids are presented after this primary list and may serve to interest individuals and groups who may contact the coordinator for further information.

The primary goals of the *ILW* are:

1. to determine spatial number densities and mass densities distributions of the Leonid stream on a year-by-year basis throughout its period of activity;
2. to ascertain the position and size of the radiant during all returns on all days of Leonid activity;
3. to determine the orbit of individual stream particles.

These primary goals were chosen as being most achievable by the system of global amateur meteor observing existing at present. The goals are broad and hence observations are likely to overlap in several areas. In addition it is hoped that a number of the secondary goals (which are generally more ambitious) can also be achieved.

The secondary goals of the *ILW* include:

1. investigating the fine-scale structure of the ortho-Leonids;
2. to determine height distributions as a function of magnitude of the Leonids;
3. to investigate Leonid fragmentation and light curves;
4. to obtain compositional data of the Leonids through meteor spectra;
5. to investigate spectra in the wake and train of Leonids;
6. to investigate the nature and occurrence of meteoric glow in the visible and infrared associated with dense Leonid condensations;
7. to investigate the possibility of electrophonic sound phenomena associated with bright Leonid fireballs;
8. to study the effect of strong Leonid returns on the Earth's ionosphere;
9. to study the effect of strong Leonid returns on the appearance of noctilucent clouds and the distribution of rainfall;
10. to determine if newly ejected particles easily fragment in space due to the presence of volatiles by studying microstructure in the ortho-Leonids.
11. to use high Leonid rates to clarify the need for a ZHR exponential factor;
12. to study high altitude dust after strong Leonid returns to determine composition of stream particles in a direct manner;
13. to use an orbiting impact laboratory to study the distribution of dust in the ortho-Leonids directly;
14. to attempt direct imaging of Leonid particles using faint object cameras;
15. to investigate the psychological effects of strong Leonid returns on animals and humans.

All of these goals are not realizable by amateur observations and equipment alone. Therefore, particularly for the high altitude and space based observations, it is hoped that a national space organization can be interested in setting up such experiments or modifying existing ones in a suitable manner.

3. Method of Observation

It is obvious that many of the aims of the *ILW* are achievable in the fullest sense only through utilization of several modes of observation. Indeed, beyond visual observations it is hoped that data can be collected by means of telescopic, radio/radar, photographic, and video observations.

The following describes what format to use in making observations and when such observations should be undertaken.

Visual

Since visual observations are the easiest to make, this form of data will constitute the majority of the data collected by the *ILW*. The question of how to visually observe during a meteor storm has arisen before and after some discussion a conclusion has been reached. Since the rate of meteors which can be recorded by a human visual observer are necessarily limited and use of "divided" regions in the sky produces very high correction factors leading to uncertain results the best recommended method is to use a camera to record the flux. In effect, once the meteor rate has reached a human saturation level there is no guaranteed accurate way to precisely record the needed data. Hence each observer lucky enough to witness such a phenomenon is encouraged to take in the view and let the camera do the work.

The level at which visual observing should cease and photographic recording should start is specific to each observer. Generally the more inexperienced the observer the sooner this level is reached. Since rate data and magnitude data are needed to fully characterize the different regions of the ortho-Leonid stream, it is recommended that camera observations begin when magnitude and rate data can no longer be successfully registered together. Observers should still perform counts alone (to correlate the visual and photographic flux) until this too becomes impossible, but the camera should be the "center of attention" after rate and magnitude data is no longer simultaneously obtainable. The camera technique to use is described in the section on photographic observations.

For returns where the visual rates are not near storm level the method of visually counting is one that should be familiar. Use of the *IMO* rate summary forms is useful, but a brief description of the absolutely needed quantities to record will be given.

First and foremost, all observers should report their own data. Do not report group observations lumped together. Each observer should make his/her own limiting magnitude measurements and report these for all intervals. The data should be divided into blocks at least one hour long but no longer than 3 hours; near the time of maximum activity for normal returns (ZHR < 40) interval size should not exceed 1.5 hours. The number of meteors observed in each shower as well as sporadics should be given for each interval. All times should be in UT. Please report the total effective time observed during each interval. The weighted percentage of the sky covered during each interval should also be recorded. For normal returns magnitude data for each observer for each night should be listed by shower. Do not include just Leonid magnitude data, all meteor magnitudes should be estimated and recorded for each night. Data such as latitude and longitude of the observation site should be recorded at least to the nearest degree.

For those who have some plotting experience, this method is preferred when total rates do not significantly exceed 20 to 30 meteors per hour. If you are interested in making plots during the Leonid returns, please acquire some practice on nights before the Leonid peak. Plots should be made on large scale gnomonic charts, such as those of the *Atlas Brno*, with angular velocity noted as well as magnitude. All sky conditions as well as the total effective time that are usually noted during counting should also be noted during plotting.

Bright Leonids (magnitude -4 or brighter) should have particular data recorded such as altitude and azimuth as well as duration, colors, magnitude, and other notable features.

When Leonid rates do increase, the reporting interval sizes should be decreased.

Photographic

As an ILW participant you should make sure to have a camera on a fixed tripod during every Leonid maximum as a standby for possible storm activity. This is an absolute must.

Exposure times will be short, generally less than several minutes. Since the activity level will become difficult to accurately establish once rates reach storm level only general guidelines can be recommended for exposure times. For activity where both counting and magnitude estimates are possible (but where activity has obviously increased well above normal Leonid returns), exposures of 5 to 10 minutes are recommended. When activity has reached the stage where only counting visually becomes possible (and where the camera *must* be used to record both magnitude and rate data) exposures of 2 to 3 minutes should be used. Once rates have exceeded visual counting, exposures less than 2 minutes should be used. Be sure to very accurately record the exact begin and end time of each exposure.

The simplest camera setup for this mode of photographic work is a 35 mm camera with a non-battery operated shutter, a 50 mm lens and 400 or faster black and white film such as Kodak Tri-X. When using the camera during storm returns, have at least one camera which does not use wide angle lenses. If another camera is available at a single site, a wide angle lens should be used. In this way the rate data for large particles over a large area can be determined with the wide-angle lens while regular flux densities are recorded by the 50 mm lens.

The 50 mm lens camera should be pointed toward the zenith when the radiant is below 45°. This minimizes the spread in angular velocities across the field and hence the photographic meteor limiting magnitude. Once the radiant exceeds roughly 45° altitude, the camera should be pointed 50° from the radiant, but in a direction as close as possible to the zenith that still respects this restriction. For camera fields away from the zenith, the long side of the negative should be parallel to the horizon to minimize range and hence extinction effects. All angular measures are with respect to the center of the camera field.

For single station photographic work outside of maximum activity, the camera should be pointed about 50° away from the radiant. Exposures here will vary according to the darkness of the observing site. The purpose of this mode of photographic observation is to obtain highly precise begin and end points for Leonids to study the radiant. The camera exposure times should be carefully noted and the exposure stopped when a bright Leonid is seen to pass through the field, or the precise time of each bright Leonid can be noted.

Other forms of photographic observations are possible and will be discussed in detail in a later bulletin.

Radio

The use of radio observations in the forward scatter mode for observations during a meteor storm is obviously very limited. At a certain point, the echoes become so numerous and so much ionization results (from drifting trails etc.) that one gets a condition analogous to sporadic-E. The times during which this condition persists can be useful and should be noted when a meteor storm occurs.

Beyond this limitation, radio observations are very useful for checking the activity of the smaller particle sizes and are a good backup to poor weather.

During non-storm intervals, radio observers are asked to follow some general guidelines. Reporting intervals of about one hour long are suggested, in particular several hours should be checked during the day if possible. For observers listening to signals, headphones are strongly recommended, during possible high activity periods those who might use pen recorders attached to the voltage output of the radio system are encouraged to do so. If activity increases, the speed of the pen recorder should be increased to ensure good time resolution. When activity is relatively low, the time, duration and description of each echo should be noted.

Of great importance to radio observers is to keep your equipment set-up and frequency the same during each run. In particular for those able to use the same path and equipment set-up from year to year along with similar antenna directions this is recommended to provide a consistent data set from one station. Also, do not process your raw number of recorded reflections in any way, always report the numbers you recorded.

As activity increases, but before near continuous propagation conditions are reached, the reporting intervals should be decreased to 3–5 minute intervals.

Telescopic

Telescopic observations are useful to determine radiant size and structure, the spatial and mass distributions of the small-particle populations of the Leonids, and to study train phenomena. There is little experience of telescopic watches during a storm. For high, but not storm rates, computer-simulated observing could help assess various strategies as a function of activity. The restricted field of view should permit study further into the core of the Leonid stream than visually, but like in the visual, accurate investigation is likely to be impossible at storm rates. Also, human nature dictates that it would require an exceptionally disciplined observer to continue making scientific measurements during the spectacle of a lifetime. Therefore the faint-meteor population during a storm is best studied using LLLTV, both single and double station. More details on this technique will be presented in a future bulletin.

When telescopic rates are relatively low (less than 30 meteors per hour), the standard method of plotting meteor paths should continue to be used. Plotting must be made on charts with a gnomonic or approximately gnomonic projection and which have an adequate scale (at least 1.5 mm per apparent degree within the field), such as the *IMO* set. Observers should choose a pair of fixed fields some 10°–25° from the Leonid radiant, such that the paths of Leonid meteors seen within the fields would intersect at about a right angle when traced back to the radiant. Also it is preferable that the fields are at a higher elevation than the radiant. Observers must alternate between the fields approximately every half an hour. For each of these watches the observer should record the field and/or naked-eye limiting magnitude; the observing conditions; the start and end times of the watch (in UT), noting any breaks, and compute the total effective observing time; and note the aperture, magnification, and true field of view of the telescope or binocular. For each meteor the path is carefully plotted recording whether the start and end points were within or beyond the field, the magnitude estimated, speed on a scale of 1 to 5, the time of appearance noted, and if there is a train, its duration is estimated.

As rates increase there are number of options which will depend on the observer's goal. Firstly, plotting may continue in order to study the radiant structure, though the observer must concentrate on recording one meteor at a time and should ignore subsequent meteors until this is done. This will require practice. At very high rates plotting of a random sample will probably not be possible due to the distraction, though it requires investigation via simulation. It could be feasible to determine a mean orientation and its spread in a number of fields to yield the radiant position and size. Secondly, observation can switch into simply counting meteors and estimating magnitudes, as described in the section on visual observations. If rates increase significantly, a purely counting mode should be adopted unless the number of telescopic meteors proves overwhelming. For counting methods a single fixed field of view is preferred.

The use of small cameras or CCDs attached to telescopes for making the same kind of photographic flux estimates as the 50 mm camera for the visual observer might be useful if the sensitivity of the system can record many of the faint meteors.

4. The first ILW period: November 5–25, 1991

To study the Leonid stream it is obvious that observations of returns well away from the likely storm periods are needed. To start the process this year will mark the first official *ILW* period. Additional data from the past 4 to 5 years is being sorted and collected for an analysis of the pre-*ILW* period to ascertain characteristics during quiet time periods.

All observers are encouraged to observe in 1991 despite the fact that the moon will be 4 days past first quarter during the maximum since it will be largely out of the way for most northern hemisphere observers during the best time in the early morning hours from 4^h to 5^h a.m. local time. The radiant for the Leonids is at $\alpha = 152°$ and $\delta = +22°$ with a daily motion of $\Delta\alpha = +0.^\circ7$ and $\Delta\delta = -0.^\circ4$. The best time for observers will be on the morning of November 18. Please send recorded data in the format described above to the coordinator of the *ILW* or through presently established *IMO* Commission channels. Use of IMO report forms is highly encouraged for all modes of observing.

Shower Meteor Colors

Alastair McBeath

An analysis of visual colors for the δ-Aquarid, Perseid, Taurid and Geminid meteor showers as recorded by the *JAS Meteor Section* observers in recent years is presented and discussed. A general confirmation of the trends shown by sporadic meteors is found, though Geminid meteors appear somewhat richer in their variety of colored meteors than other types.

1. Introduction

In an analysis of visual sporadic meteor colors [1], it was concluded that the observed color distribution could be accounted for by the effects in the eye alone and thus provided no real insight into the nature of the meteoroids producing the meteors. That paper left open the question of whether shower meteor colors could be regarded as being any more useful in this respect, and it is this topic which the current work addresses.

Four showers were selected as suitable for examination, both in terms of the numbers of meteors observed from each, and also giving as wide a spread in their physical characteristics as possible. These four streams comprised the δ-Aquarids, the Perseids, the Taurids and the Geminids. A brief overview of the main physical parameters for each shower's meteors is given in Table 1 along with the equivalent sporadic data for comparison.

Table 1 – Main physical characteristics for selected shower and sporadic meteors. Mean density (ρ) and pre-atmospheric velocity (V_∞) figures are from [2]; corrected mean magnitude ($\overline{m}_{6.5}$) data are taken either from the current analysis or [1].

Source	ρ (g/cm^3)	V_∞ (km/s)	$\overline{m}_{6.5}$
δ-Aquarids	0.27	42.5	+3.13
Perseids	0.32	59.9	+2.33
Taurids	0.27	30.0	+2.53
Geminids	1.14	36.2	+2.40
Sporadics	0.28	41.5	+3.21 [1]

Contributing observations were selected from those people deemed reliable observers made in conditions where the limiting magnitude was at least +5.5 and where less than 20% cloud cover existed. As in [1], those meteors recorded as being "white" or those which had no color noted were treated as effectively colorless, while those showing multiple colors were placed in the first-named color category only (e.g., "blue-green" or "blue-white" is blue).

2. δ-Aquarids

Table 2 – δ-Aquarid color magnitude distribution from 1984 to 1990. The "%" column gives the percentage of all δ-Aquarid shower meteors showing colors.

Color	-3^-	-2	-1	0	+1	+2	+3	+4	$+5^+$	Tot	$\overline{m}_{6.5}$	%
Red	0	0	0	0	0	0	1	0	1	2	+4.70	0.7
Orange	0	0	2	0	0	1	0	0	0	3	+0.70	1.0
Yellow	1	4	2	4	12	22	13	2	0	60	+2.18	20.1
Green	0	0	0	0	0	0	0	0	0	0		
Blue	1	1	1	3	0	0	2	0	0	8	+0.70	2.7
Violet	0	0	0	0	0	0	0	0	0	0		
Total	2	5	5	7	12	23	16	2	1	73	+2.03	24.4

Fewer than 70 δ-Aquarids were reliably observed in any given year available for examination, so a combined color analysis from both stream branches was carried out on the 299 suitable candidate meteors from results made between 1984-1990. Their color distribution is given in Table 2.

Almost 29% of the colored total showed multiple colors, mostly a color plus white. Subtracting these latter leaves 11% (8 meteors) with contrasting colors orange-yellow (2), yellow-red (3), yellow-blue (1) and blue-green (2).

Table 3 gives the proportion of all δ-Aquarids which were colored by magnitude class.

Table 3 – δ-Aquarid color proportions by magnitude class.

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$
Percentage	66.7	100	62.5	53.9	41.4	31.1	15.5	3.9	7.7

In many ways, this is the weakest of the four showers analyzed, since the overall number of meteors was small, thus any conclusions reached will be rather tentative. However, some points can be made. The color magnitude distribution is comparable to that of the sporadics overall, and the same features are seen—an overabundance of yellow meteors and a lack of green meteors, with the remaining color classes falling roughly into line with the scotopic eye's sensitivities in general.

3. Perseids

A total of 2329 Perseids were examined for colors from results obtained in 1985, 1988 and 1989, and the overall color distribution is shown in Table 4.

Table 4 – Perseid color magnitude distribution from results made in 1985, 1988 and 1989.

Color	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$	Tot	$\overline{m}_{6.5}$	%
Red	0	0	0	0	4	2	3	0	0	9	+2.58	0.4
Orange	0	1	0	6	1	1	2	2	0	13	+1.85	0.6
Yellow	23	41	61	112	116	108	46	9	1	517	+1.25	22.2
Green	1	0	0	1	0	0	0	0	0	2	−0.81	0.1
Blue	10	12	26	50	24	4	2	0	0	128	+0.26	5.5
Violet	1	0	0	0	0	0	0	0	0	1	−5.31	0.04
Total	35	54	87	169	145	115	53	11	1	670	+1.07	28.8

Multi-colored meteors amounted to 22.2% of all colored Perseids, though only 5.1% (34 meteors) exhibited contrasting shades. These latter comprised: orange-red (2), yellow-red (5), yellow-orange (16), yellow-green (7), yellow-blue (3) and blue-green (1).

Table 5 presents the proportion of colored Perseids for each magnitude interval.

Table 5 – Perseid color proportions by magnitude class.

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$
Percentage	57.4	65.9	62.6	52.3	35.9	25.7	10.2	4.0	1.4

The correlation between these results and the sporadics is again striking, with similar percentages of the meteor population in the red, orange and green categories, the red and orange magnitude suppression relative to the mean, and the yellow excess. The chief differences come with the overall percentage of colored Perseids, which is above the sporadic range, and the larger proportions of yellow and blue meteors.

4. Taurids

As with the δ-Aquarids, too few Taurids were allocated to their respective stream branches to make anything other than a combined analysis of the 368 shower members seen between 1984 and 1990 possible. The Taurid color distribution thus derived is illustrated in Table 6.

Table 6 – Combined Taurid color magnitude distribution from 1984 to 1990.

Color	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$	Tot	$\overline{m}_{6.5}$	%
Red	0	0	0	0	0	0	1	0	0	1	+3.73	0.3
Orange	1	0	0	0	3	1	0	0	0	5	+1.13	1.4
Yellow	7	6	10	18	32	18	13	0	2	106	+1.41	28.8
Green	0	0	0	0	0	0	0	0	0	0		
Blue	2	1	1	0	2	1	2	0	0	9	−0.16	2.5
Violet	1	0	0	0	0	0	0	0	0	1	−4.27	0.3
Total	11	7	11	18	37	20	16	0	2	122	+1.26	33.2

Sixteen meteors (13.1%) were multi-colored, ten of these (8.2%) contrasting ones: orange-yellow (1), yellow-red (3), yellow-orange (3), yellow-green (1), yellow-blue (1) and blue-red (1).

In Table 7 are the colored Taurid proportions per magnitude bin.

Table 7 – Taurid color proportions by magnitude class.

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$
Percentage	84.6	63.6	61.1	52.9	58.7	25.6	18.6	0	13.3

The similarities in the Taurids color distribution compared to the sporadics are again quite notable, much of the difference in the overall colored percentage a result of an apparent increase in the amount of yellow meteors.

5. Geminids

Results from 716 Geminids observed in 1990 were re-examined for colors as part of this analysis. The data reduced to Table 8.

Table 8 – 1990 Geminid color magnitude distribution.

Color	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$	Tot	$\overline{m}_{6.5}$	%
Red	0	0	1	0	1	2	1	0	0	4	+1.74	0.6
Orange	0	1	2	1	4	2	1	0	0	11	+1.38	1.5
Yellow	4	12	19	42	45	31	14	3	0	170	+1.36	23.7
Green	1	0	0	1	0	0	0	0	0	2	−2.26	0.3
Blue	9	9	6	9	2	3	0	0	0	38	−0.47	5.3
Violet	0	0	0	0	0	0	0	0	0	0		
Total	14	22	28	53	52	38	15	3	0	225	+1.03	31.4

The multiply-colored meteor totals were: overall 37 (16.4%), contrasting colors 29 (12.9%). These contrasting colors were: red-yellow-green (1), orange-red (1), yellow-orange (10), yellow-green (14), yellow-blue (1), green-red (1) and blue-green (1).

Table 9 shows the proportions of colored Geminids per magnitude group.

Table 9 – 1990 Geminid color proportions by magnitude class.

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$
Percentage	100	81.5	77.8	63.9	38.5	24.1	13.0	3.3	0

The correlation between Geminid and sporadic meteors is much as already found with the other showers in this study, though the color distribution is perhaps closest to that of the Perseids. The chief exception is the higher quantity of orange events. The Geminids also showed the highest proportion of objects giving rise to contrasting colors, those in the yellow-orange category giving added interest to the somewhat higher orange results, while the yellow-green meteor numbers perhaps suggest the slightly larger fraction of green Geminids is not simply a statistical nuance. There is also a tendency for Geminids of magnitude 0 and brighter to show colors more frequently than other showers or the sporadics. As Geminid meteors have the highest density yet known—perhaps as high as 3.8 g/cm^3 [3]—it is perhaps surprising that their color distribution should be so similar to the other types of meteors examined.

6. General discussion

Shower meteors showing a perceptible color, while generally commoner than colored sporadics, were nonetheless not especially abundant. Even the Taurids, which showed colors almost one third of the time from these results, featured white or uncolored meteors in the negative magnitude classes some 15%–40% of the time. Whether the fact that more shower meteors were seen as colored is a genuine shower trait is less easy to determine. The proportions of meteors in the magnitude +2 to +3 ranges were mostly considerably higher than for sporadic meteors. In theory, these meteors and those in fainter groups should appear colorless, except where the magnitude is artificially suppressed thanks to the scotopic eye's poor perception of certain colors, particularly red and orange, but faint yellow and in some cases blue meteors still seemed relatively common, which should not be the case. There may be an element of observer bias involved in this, where either the observer is more willing to believe a color occurred for a stream meteor than for a sporadic, or where more attention to detail is being paid to meteor shower members.

Although the shower groups gave higher percentages of colored meteors than the mean sporadic value, the δ-Aquarid total of 24.4% fell within the maximum annual sporadic spread (10.4% to 25.3%), so only the remaining three shower results can be regarded as at all significant. In addition, the δ-Aquarid physical parameters are quite similar to the sporadics, so a correlation between the two is not unexpected. All three other streams had a mean magnitude significantly brighter than the sporadics, and if, as is borne out by Tables 3, 5, 7 and 9, brighter meteors are more likely to appear colored, this facet of the distributions can be readily explained.

The showers all gave similar color trends to those found with sporadics generally, and so the remarks concerning why such a distribution occurs from [1] can be applied with equal weight here, without need for repetition. The general homogeneity found with all meteor colors is somewhat surprising in view of their disparate physical characters, and perhaps in the case of the Geminids even totally different origins, which tends to suggest that the colors are produced by atmospheric rather than meteor chemistry.

The following sections summarize the overall findings on shower and sporadic colors, and highlight the deviations of shower colors from the sporadic norms.

7. Red

Red meteors were rare in all cases, and the shower results fell within the sporadic annual spread of 0.3%–0.8% of the total meteors seen. They were generally recorded as being fainter than expected, in line with the scotopic eye's poor red appreciation.

8. Orange

These meteors were apparently quite rare, with only the Geminid proportion being fractionally outside the sporadic spread of 0.5%–1.4%. Further treatment of the Geminids is in Section 13. Orange meteor brightnesses seemed to be somewhat suppressed, though not as greatly as red's, probably again a result of the dark-adapted eye's color perception.

9. Yellow

Yellow events were exceptionally common. Almost 80% of all meteor types covered in this survey which showed a noticeable color were given as being yellow. The proportions of δ-Aquarid and Perseid meteors fell within the sporadic upper limit for yellow meteors (range 7.8%–22.5%), the Geminids were slightly above this limit, while the Taurids were higher still. That all the shower proportions were much higher than the mean sporadic level for these meteors is interesting. It may be this is a general shower trait, though why a shower like the δ-Aquarids should show it is not easy to explain, as their meteors are very similar in character to the sporadics. Although exhibiting the lowest proportion of yellow meteors of the four showers, the δ-Aquarids were actually closer to the Perseid and Geminid yellow totals than the mean sporadic value. Alternatively, observer bias, commented upon already, may have played a role here, probably coupled with the poor contrast seen between white and yellow, especially while the eye is saturated with dark blue light from the night sky, possibly leading to an erroneous after-image color (blue versus yellow) being ascribed to actually colorless meteors.

The apparent brightness suppression giving rise to many faint (weaker than magnitude +2) yellow meteors fails to fall into line with the scotopic eye's sensitivity to this hue, and gives support to the idea that poor yellow-white contrast coupled with the problem of after-image colors may be important. The very large range in annual proportions of yellow sporadic meteors lends some further credence to this, while other color proportions remained relatively stable from year to year, and it is also worth noting that much of the difference in overall colored percentages between the sporadic and shower meteors examined here can be directly attributed to the higher quantity of yellow shower meteors alone.

With the Taurids, there is possibly a case for stating that the shower may be genuinely rich in yellow meteors, since their percentage of such events was rather higher than for any other source examined. The chief obvious difference between Taurids and other meteors is their relatively low velocity, which perhaps gives the eye more time and opportunity to register any color present, though not necessarily to do so with any greater certainty. As the sampled Taurid meteors totaled only just over 350, it would be wrong to read too much into this result, however.

10. Green

Meteors showing this color were exceptionally rare, so it is very difficult to draw any conclusions from the few reported. If the color is produced by, say, atmospheric oxygen, the relatively small amount of energy released by the ablation of most meteoroids may be insufficient to generate the necessary ionized state over a large enough area to be seen visually. Many green meteors do appear to be of a negative magnitude, for instance. The Geminids seem to be the richest source of green events, with one for every 333 stream members recorded. Further discussion of the Geminids can be found below under Section 13.

11. Blue

This was a moderately common color, second only (by a very large margin) to yellow. The sporadic annual spread of 1.3–3.0% covers all the showers except the Perseids and the Geminids, which latter both showed over 5% of their meteors as blue. Blue is registered quite well by the dark-adapted eye, and both Perseid and Geminid numbers were large, so this may well be of some significance. Comparing the two showers using their physical characteristics superficially shows little similarity except in terms of mean magnitude. However, there are a variety of ways of changing the equation which governs meteor brightnesses by altering the meteoroid's mass, density or velocity. Increasing any of these will increase the eventual meteor magnitudes seen. With the Perseids, velocity is important, while with the Geminids, it is density, so perhaps high velocity or high density meteoroids are more likely to produce the color blue. If this is so, it implies the component is atmospheric rather than meteoritic, as the Perseids and Geminids probably have rather different origins, and also that it requires more energy than most meteors produce to liberate it (possibly ionized nitrogen).

Various positive factors mean blue meteor magnitudes were probably estimated more or less accurately, so the overall mean magnitude from all sources of +0.2 is likely to be approximately correct. Blue meteors were therefore predominantly bright, and were thus probably produced by more massive, denser or higher velocity particles, as already suggested.

12. Violet

These meteors were incredibly rare, a mere 0.02% (2 out of 9372) of all the meteors surveyed. As the eye's sensitivity to the color violet at night is similar to yellow (0.08 for violet, 0.09 for yellow), there seems to be a genuine absence of meteors of this color. While on average about 1 in 5 meteors appeared yellow, only 1 in 5000 were violet, even fewer than the 1 in 1000 found for green, and even allowing for the fact that many yellow events may be actually uncolored, there is still a large discrepancy between these amounts. Contrast effects may well account for some of the violet loss, pushing some of these events into the blue category, or contrasting so poorly with the dark-blue sky that they are seen simply as white. The two violet meteors were of magnitude −5 and −6, a level perhaps bright enough to be less affected by contrast effects. An atmospheric origin for this color cannot be ruled out (e.g., ionized nitrogen).

13. Multiple colors

All the showers examined produced greater proportions of multiple-colored meteors than the 1% found with sporadics, the δ-Aquarids and Geminids being most prominent in this, though the δ-Aquarid numbers were low enough to make the validity of their result questionable. Observer bias may again play some part in this, though for some reason not readily determined, the two most popular sporadic multiple colors, yellow-blue and orange-red, do not feature especially prominently with the showers.

Most of the shower meteors seen as multiply-colored would change the recorded distribution figures only slightly if they were to be divided evenly among their respective color classes. The two exceptions to this occur for the Geminids, with the colors orange and green. Adjusting both totals by the appropriate amounts to allow for multi-colored meteors yields figures of 2.2% and 1.3% for orange and green meteors respectively. This makes the Geminids the most variety-productive meteor color shower of any examined here. As their main difference from other meteor types is their greater density, it seems likely that this facet is helping to produce this range of colors, though whether they are atmospheric or meteoric in origin cannot be determined from this. It is perhaps more probable that they are atmospheric and are being produced through a greater energy release by some undefined physical and/or chemical reactions from the Geminids' denser particles, but this cannot be stated unequivocally.

14. Comparison with Australian results

Few comparable color analyses have been carried out in recent times, but reports on the work of Australian observers by Jeff Wood have regularly included color data for many years. Details on 1284 δ-Aquarids [4], 206 Taurids [5] and 3490 Geminids [6,7] were available for examination from a similar period to those in the present paper.

All except the δ-Aquarid analysis featured colored percentages only for meteors falling into the category of at least as bright as magnitude +2, which may have resulted in the loss of some genuine red and orange meteors (see Sections 7 and 8 above). This also necessitated the recalculation of the Australian Taurid and Geminid colored percentages to bring them into line with this present work. A combined set of δ-Aquarid colors using data from both Northern and Southern branches was also recomputed. This means there may well be some inaccuracies in the reworked southern hemisphere figures, but they should generally be compatible with the UK data. Table 10 shows the Australian colored meteor proportions.

Table 10 – Australian meteor shower colors. "N_c" is the approximate number of colored meteors in each class, recalculated from percentage figures. "%" gives the percentage of all meteors from each shower showing colors. Based on data from [5,6,7,8]. Compare to Tables 2, 6 and 8.

Shower	δ-Aquarids (1987)		Taurids (1983)		Geminids (1987–88)	
Color	N_c	%	N_c	%	N_c	%
Red	5	0.4	0	0	13	0.4
Orange	11	0.9	4	1.9	110	3.2
Yellow	240	18.7	33	16.0	630	18.1
Green	11	0.9	1	0.5	42	1.2
Blue	53	4.1	2	1.0	53	1.5
Violet	0	0	0	0	3	0.1
Total	320	24.9	40	19.4	851	24.4

Overall, the color distribution is very similar to that discussed under Sections 7–13 above, though green meteors seemed a little less uncommon. The main discrepancy apparent with both the Taurids and Geminids is the lower percentage of yellow meteors, which also accounts for much of the difference in the total percentages. The fact that no faint (weaker than magnitude +2) yellow meteors appeared in the Australian results could easily account for this however. The δ-Aquarid results, where all colored meteors were used are virtually identical for yellow, despite the far smaller numbers of shower members seen in the UK, for instance.

On closer inspection, the Australian results show a somewhat greater quantity of green and blue δ-Aquarids and a smaller amount of blue Geminids (using the modified orange and green meteor proportions for the UK, given in Section 13), though the amounts involved are probably not large enough to be too significant, especially bearing in mind the computational complications outlined earlier. The general trends—even to the greater spread of Geminid colors compared to the other showers—are remarkably similar, despite the data being obtained by two completely separate groups of observers in opposite hemispheres of the globe under different conditions.

15. Conclusion

From the sporadic and shower color analyses performed, all meteor activities seem to follow a similar pattern, which can largely be explained by the sensitivities and failings of the human eye, and thus tell us little about the nature of meteoroids. Some showers have previously been noted as being rich in yellow meteors, but from the above, all types of meteors are apparently rich in events perceived as yellow. Green and violet meteors are rare, though the Geminid meteor shower seems to be relatively abundant in its variety of colors generally, more so than other forms of meteor activity, perhaps because of its denser particles. The possibility is also raised that at least some meteor colors may be atmospheric in origin, produced by high-energy ablation rather than some effects of meteor chemistry.

Although meteor colors can be viewed as being unhelpful in furthering a study of their parent meteoroids, they are still of interest and may, for example, reveal details of meteor energies or factors of the human eye's perception of color as yet unsuspected.

Acknowledgment

I would like to pay tribute to the unstinting efforts of the many *JAS Meteor Section* observers which have made this analysis possible.

References

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

[2] P. Roggemans (ed.), "Handbook for Visual Meteor Observations", Sky Publishing Corporation, 1989.

[3] Z. Ceplecha, "Meteors Depend on Meteoroids", in *1990 IMC Proceedings*, D. Heinlein and D. Koschny, eds., 1991, p. 20.

[4] J. Wood, "1987 Aquarids in Australia", *WGN* 16:5, October 1988, pp. 158–159.

[5] J. Wood, *WGN* 12:3, 1984, p. 75.

[6] J. Wood, "The 1987 Geminids in Australia", *WGN* 16:6, December 1988, pp. 234–235.

[7] J. Wood, "The 1988 Geminids and Phoenicids in Australia", *WGN* 17:2, April 1989, pp. 57–58.

Why Do We Do It?

Richard Taibi

Perhaps because I am interested in abnormal mental states, I wonder: "What makes me get up out of a comfortable bed, at 1 a.m., and drive 30 km to an isolated farm to observe meteors?" My seventeen year old son tells his friends and our relatives that I go out to "watch rocks fall out of the sky". My friends and colleagues make sympathetic sounds and say: "That sounds fascinating!" when I tell them about my hobby. But they also look a bit concerned that I will become violent while I stand speaking to them.

So, I am turning to you, a far more sympathetic and understanding audience to attempt to explain why I do what I do. If you are of an introspective mind too, you might consider why you endure observationally-caused hardships. I would be glad to hear from any of my fellow fireball fans. We are all for more alike than different, I believe.

Firstly, I do it because 1 a.m., in the dark, usually alone, is *peaceful*. There are very few demands made upon the observer. It is quiet. Or, only natural animal and insect sounds intrude on my awareness. The hustle and bustle of the day is suspended. There is a hypnotic illusion that the daytime with its duties and cares will never come. I am there, alone with the sky. And, hopefully, many meteors. But whether the meteors "materialize" or not the quiet undoes the tension of the day.

Closely related to peacefulness is the setting's delights to the senses. When I am sitting in my lounge-chair at my tobacco-farm site, I am aware of the dampness in the air, the scent of tobacco, and the sound of nearby farm animals. Occasionally, an owl will soundlessly fly by, occulting the stars, and observe *me*. And what a spectacle for my eyes! The myriads of stars and transitory planets are old, reassuring friends. Each meteor seen well is an unexpected delight. When they are bright, colorful and have a train the joy is increased exponentially. I seldom have time and the serenity necessary to enjoy daytime sensory delights. So, meteor observing is a delight to the senses!

Lastly, meteor observing is being able to indulge in a comparatively simple activity. What we need to do, notice magnitude, stream, color and time, is close to automatic. It feels effortless. When I compare my daytime judgement and planning tasks to what I do when I observe I realize that observing is like being on vacation. Also I can predict what I will be doing when I observe. I cannot predict what Life will present me with during the day. The day is filled with complexity and unfathomable uncertainties. At night, there is the familiar sky and a pleasant routine. Meteor observing helps me to reclaim my equilibrium.

Well, there are my reasons "why I do it". Are they similar to your reasons? I would be surprised if you could not agree with at least one.

I doubt I will ever "progress" on to more automated, more objective (i.e., photographic or radio techniques) and less personal forms of meteor observing. All the reasons above tell me that. When techniques are automated and objective they are necessarily more complex and less sensory. I believe that my motto for meteor observing is: "Keep it simple and sensory".

Some Results from Five Years of Danish Radio Observations

Gotfred Møbjerg Kristensen

The author gives an overview of his radio meteor observations during the last five years.

When I started my radio observations on September 1, 1985, I did not intend to continue these observations for more than a year. But as the results were so interesting, my curiosity increased and I kept observing. At the end of August 1991 I had registered 1 062 544 meteor reflections by pen recorder (during two years), and observed some 328 000 signals during active listening in the course of six years.

Maybe the following graphs could contribute to a better understanding of meteor activity.

Figure 1 shows the average hourly rate of radio meteors for every day of the year (averaged over the period September 1, 1985–August 31, 1990). The observations were carried out by direct listening and totaled 259 150 meteors.

Figure 2 shows the highest and lowest hourly rate for each day of the year (observed during the same five years), also based on direct listening.

I do not intend to comment on these graphs in detail. I would only like to point out that all known major showers and a lot of the known minor showers are represented. Furthermore, several periods with high activity are visible, which as to yet are unaccounted for.

Figure 3 is more complex. It was compiled from three Danish sources:

1. *Catalogue of Bright Meteors*, compiled by Axel V. Nielsen (1903–1970), a Danish astronomer of the Århus University. This catalogue contains a number of bright meteors from all over the world, mostly from the 19th and 20th century.
2. *A list of fireballs compiled by Thorvald Køhl (1852–1931)*, an amateur astronomer interested in meteors. He collected Danish fireball observations for more than 50 years.
3. *Radio fireballs I observed* by pen recorder and by direct listening between September 1, 1985, and August 31, 1990.

The graphs show the daily totals of meteors/meteorites from the three sources for each day of the year.

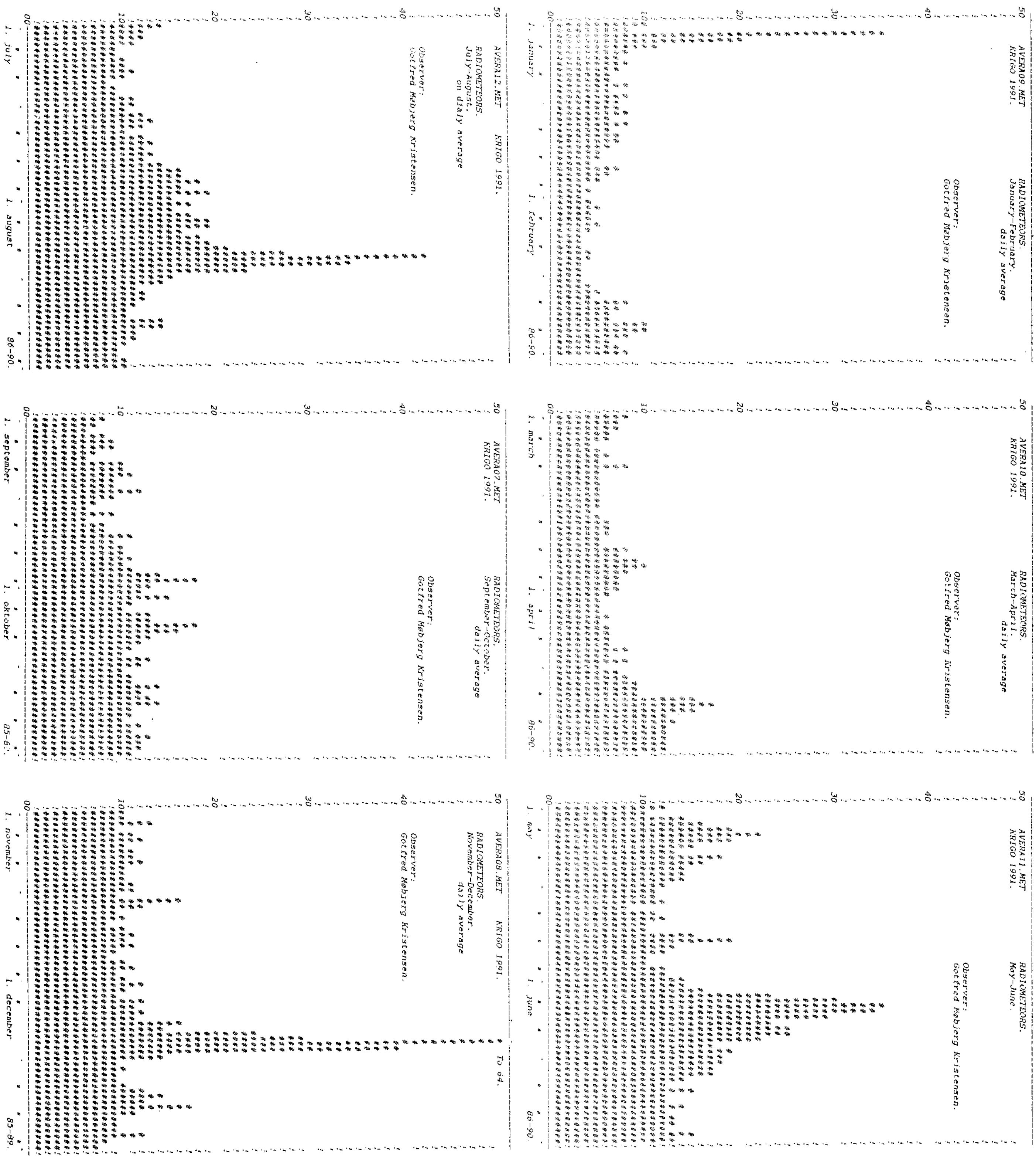

Figure 1 – Daily average numbers of radio reflections.

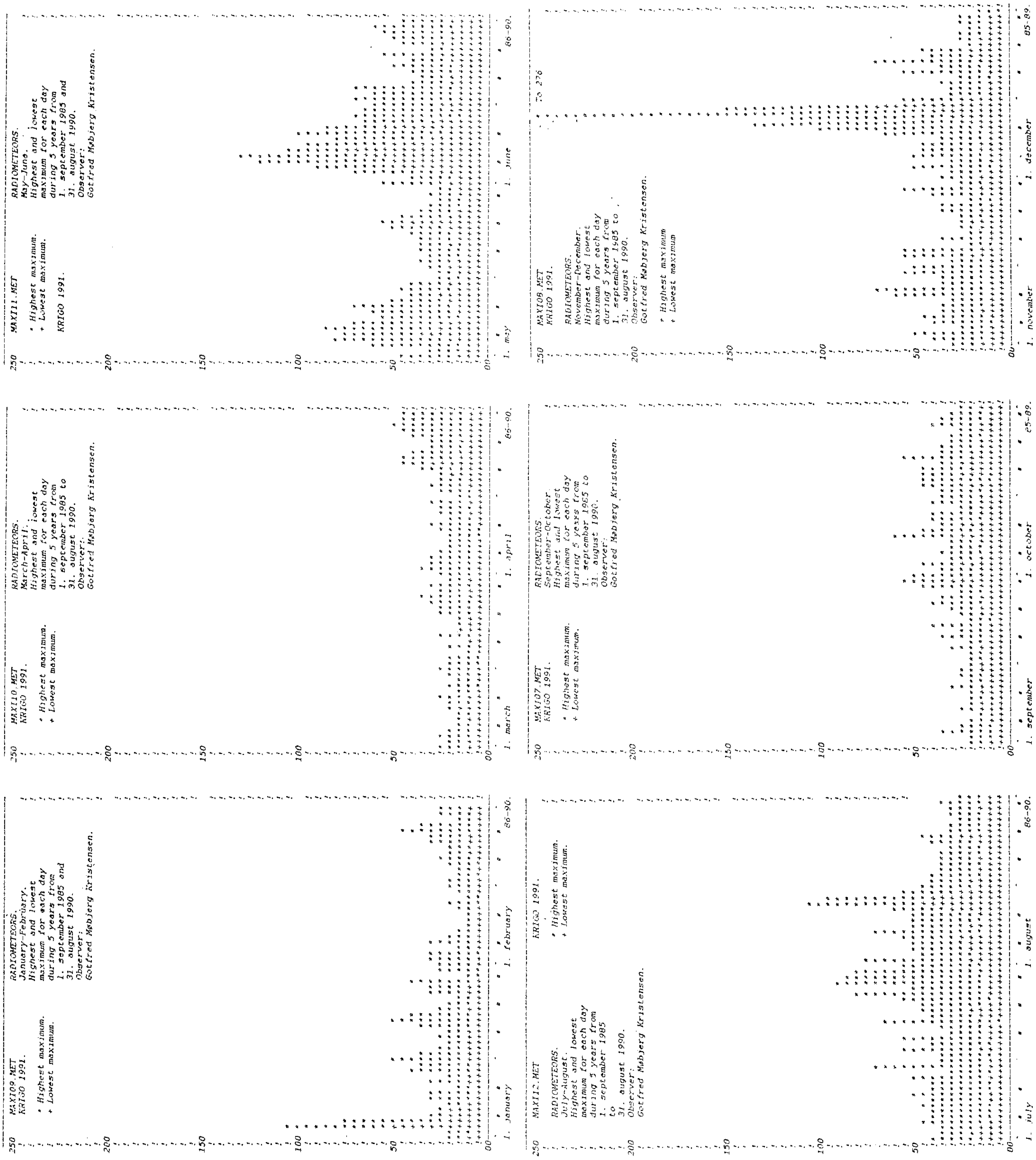

Figure 2 – Daily maximal and minimal numbers of radio reflections.

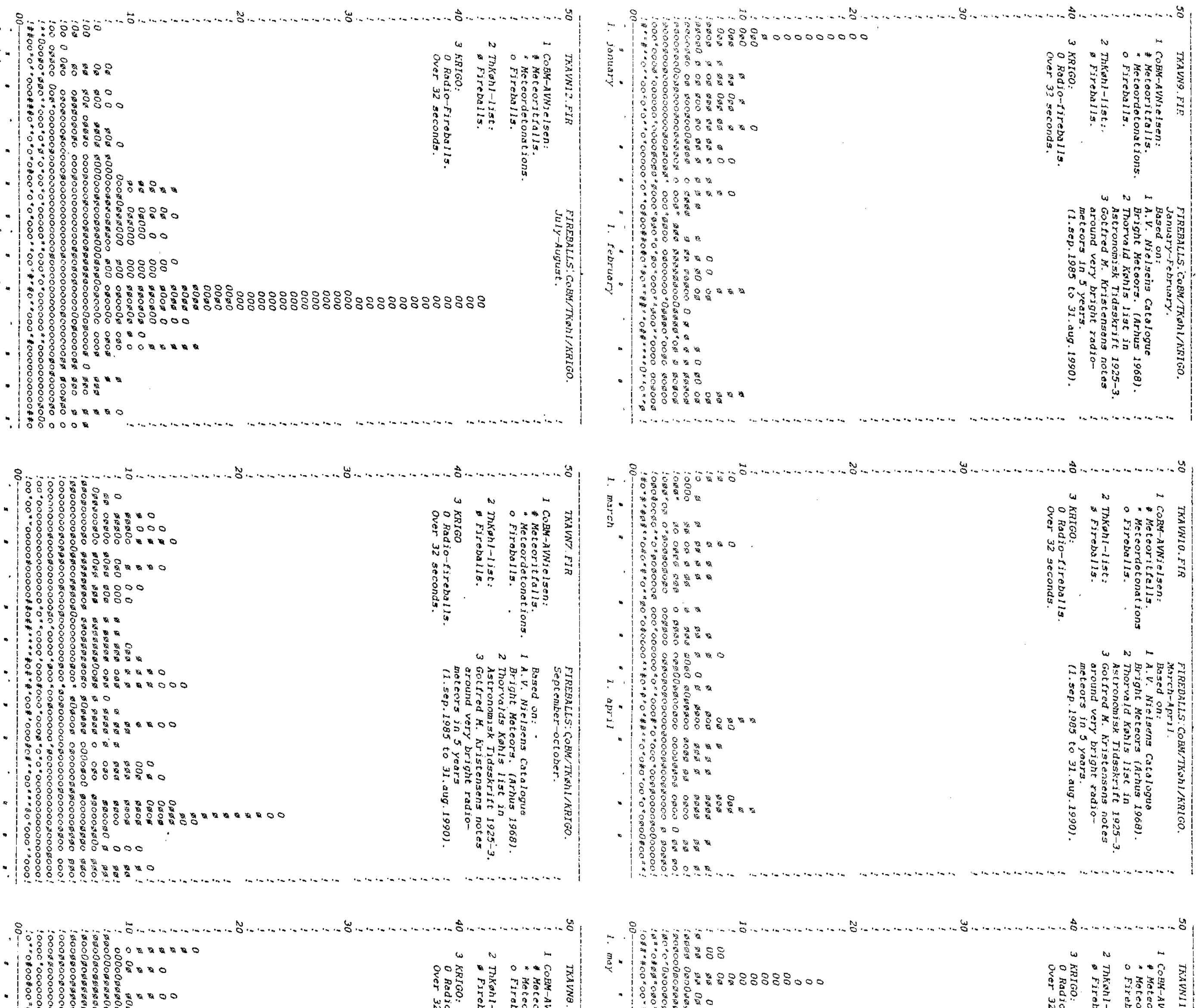

Figure 3 – Fireball data.

Visual Double Station Observations of Taurids and Leonids in 1990

Luis Ramón Bellot and Francisco Reyes Andrés

A report is given on the trajectory calculations for two visual double-station meteors observed in Spain in the fall of 1990, the first being a Southern Taurid and the second a Leonid.

In 1990, we started systematic double station observations, in order to catch simultaneous meteors photographically as well as visually. Although visual work is much less accurate, the quality of the plots obtained and the estimates of the error when plotting allow us to get interesting data on the two meteors caught.

This is the first time we make trajectory computations in Spain, although we have many double station meteors.

Observations were carried out from the places listed in Table 1.

Table 1 – Observing sites.

Location	λ	φ
Murcia	01°08′19″ W	37°59′23″ N
Granada	03°36′42″ W	37°10′42″ N

The distance between both places is 236 km. Such a distance allows less accuracy when plotting without increasing a lot the final error.

The first meteor seen was a Southern Taurid of magnitude +3 from Granada and +3.5 from Marcia. It appeared on the 10th of November at $23^h24^m45^s$ UT. It was seen in Cetus by Francisco Reyes and in Granada, Luis R. Bellot saw it in Orion.

The coordinates of the beginning and the end points are as shown in Table 2.

Table 2 – Meteor track data for the Southern Taurid.

Location	α_{begin}	δ_{begin}	α_{end}	δ_{end}
Murcia	$00^h.24$	$-09^\circ.7$	$23^h.76$	$-14^\circ.6$
Granada	$04^h.95$	$+11^\circ.2$	$05^h.52$	$+08^\circ.4$

From these data, we obtained the following atmospheric trajectory, which is shown in Table 3 and Figure 1.

Table 3 – Trajectory data for the Southern Taurid.

	λ	φ	h
Begin	2°36′40″ W	36°44′37″ N	113 ± 4 km
End	2°39′15″ W	36°51′00″ N	78 ± 4 km

The second meteor was registered the 16th of November, 1990, at $05^h05^m58^s$ UT by Francisco Reyes from Murcia and by Antonio Román Reche from Granada. It was a Leonid of magnitude +2.5 from Granada and +3.0 from Marcia.

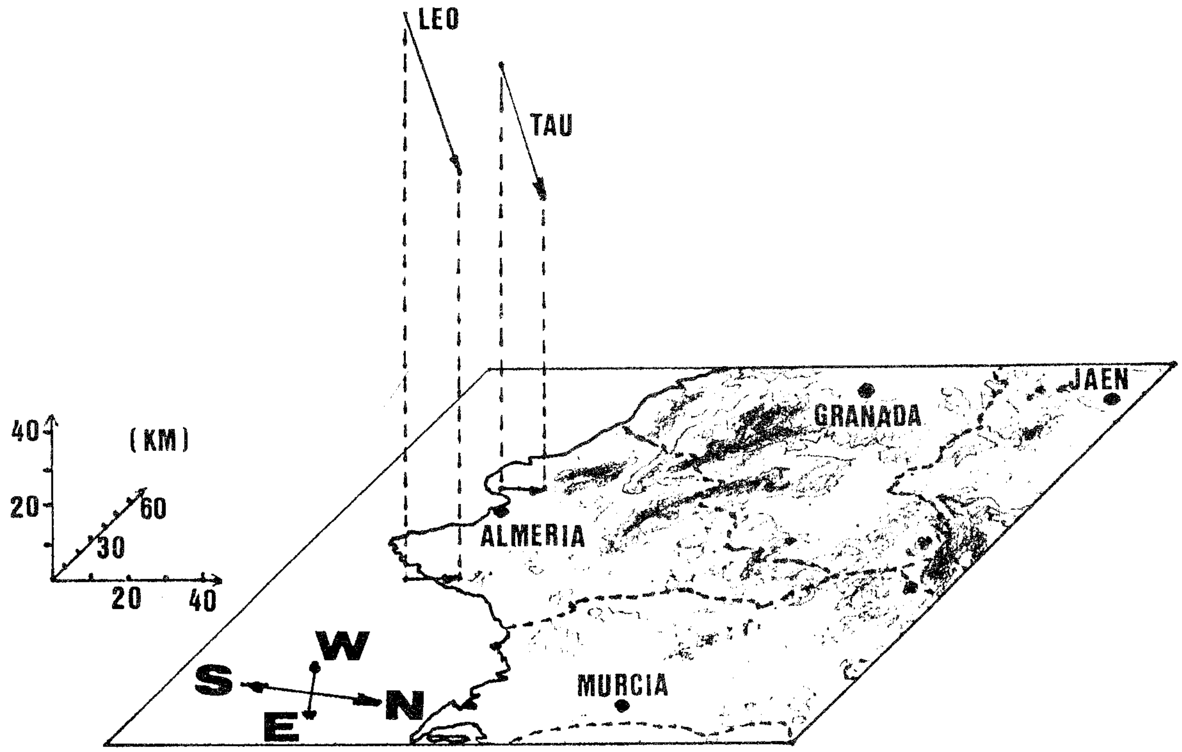

Figure 1 – Atmospheric trajectory of the Southern Taurid and the Leonid meteor over the Southeast of Spain and the Mediterranean Sea.

The coordinates of begin and end points are shown in Table 4.

Table 4 – Meteor track data for the Leonid.

Location	α_{begin}	δ_{begin}	α_{end}	δ_{end}
Murcia	$11^{h}70$	$+19.^{\circ}6$	$12^{h}42$	$+16.^{\circ}8$
Granada	$07^{h}44$	$-00.^{\circ}5$	$07^{h}09$	$-04.^{\circ}9$

From these data, we obtained the following atmospheric trajectory, which is shown in Table 5.

Table 5 – Trajectory data for the Leonid.

	λ	φ	h
Begin	1°51′55″ W	36°56′36″ N	152 ± 8 km
End	1°54′10″ W	37°03′22″ N	109 ± 4 km

This Leonid, which is also drawn in Figure 1, is less accurate, as the plotting error was a little bit larger. This fact could explain the high beginning height.

Now we are computing the meteor orbits, as well as other double station meteors.

Please do not forget to renew your membership/subscription early! Last year, many people paid very late as a consequence of which it was difficult to make a good planning for the present volume of *WGN*. This had as a consequence that certain urgent documents, such as the *1991 IMO Meteor Calendar*, had to wait for the April issue to be sent out! Please help us in avoiding similar problems this year by not postponing your renewal!

The 1991 Perseids

The 1991 Perseid Campaign in Spain

José M. Trigo Rodriguez

An account is given of 1991 Perseid observations in Spain. During the night of maximum, an increase in the percentage of persistent trains was noticed.

Members and collaborators of the *SOMYCE* (Spanish Meteors and Comets Society) participated in a Perseid campaign. Although the observing site was very good, we were troubled by clouds from the night of August 8–9 onwards. Luckily, this trend changed on the night of the maximum.

During that night, the visual characteristics of the Perseids were very different. In particular, an increase in the percentage of meteors with a persistent train and in the number of meteor explosions was noticeable. Several twins and "bundles" of meteors were observed that night.

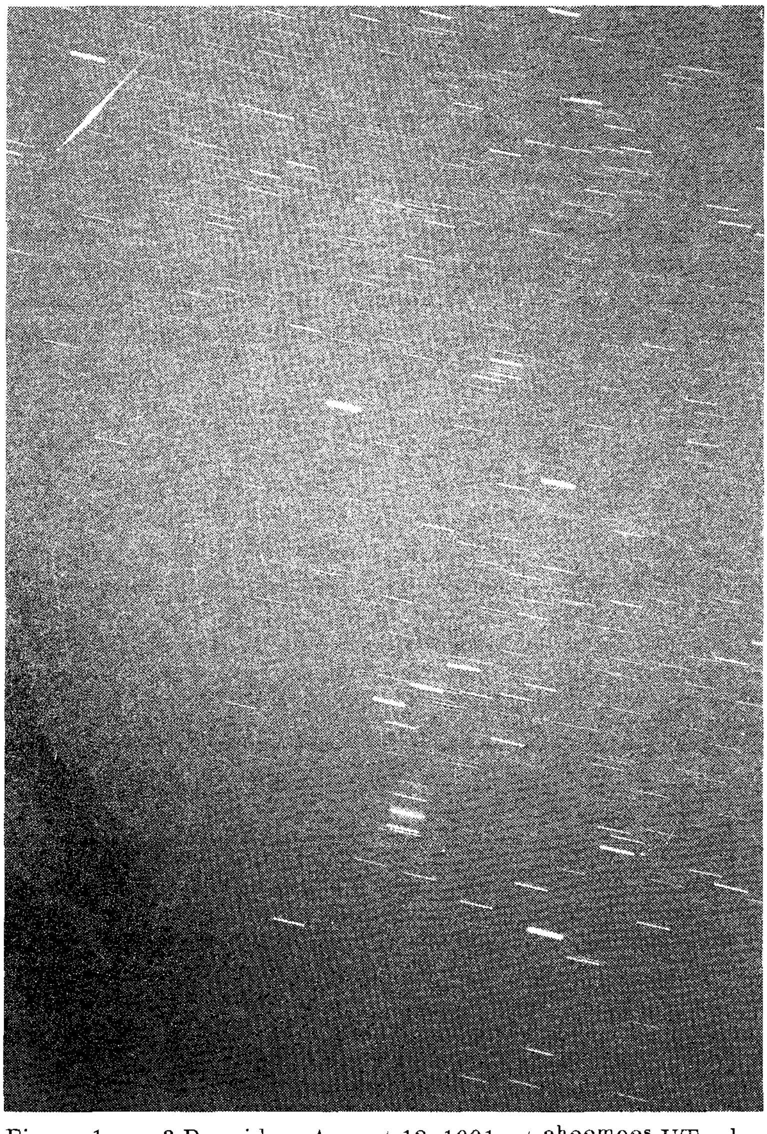

Figure 1 – −3 Perseid on August 12, 1991, at $3^h22^m02^s$ UT, photographed by the author at Pico Peñarroya, Tervel. Orion is clearly visible; the bright star in the upper left corner is γ Gem. The photograph was exposed from $3^h17^m34^s$ till $3^h22^m06^s$.

There was a long period of high activity. On the night of August 11-12, the activity was mainly caused by fainter meteors. On the night of the maximum, a change in characteristics is evident, and more brighter meteors with persistent trains appear. During the night of August 13-14, the activity was still high with a ZHR around 60.

The Valencia and Barcelona groups organized a four-station watch for meteor photography. Fourteen observers participated from the Tervel site. The results: very good!

The 1991 Aquarids and Perseids from Spain

Luis Ramón Bellot

An account is given of 1991 Aquarid and Perseid observations in Spain. Attention is asked for a suspected minor shower, called the π-Cetids.

During 15 nights in July and August 1991, the author saw 544 Perseids, 46 South δ-Aquarids, 44 North δ-Aquarids, 15 South ι-Aquarids, 25 α-Capricornids, 15 κ-Cygnids, 14 π-Cetids and 229 sporadics.

The main purpose of this campaign was to obtain plots of Aquarid meteors for the *IMO Aquarid Project*, as well as monitoring the Perseid activity near the maximum. Therefore, the first part of the nights was used to observe the Aquarid region, while the second part was used to follow the Perseid activity, when the radiant was high in the sky.

Table 1 – Magnitude distributions.

Shower	$\overline{\text{lm}}$	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	Tot	$\overline{m}$	$\overline{m}_{6.5}$
Perseids	6.35	0	0	0.5	4.5	14	54.5	182	177	93.5	18	544	2.59	2.66
δ-Aquarids S	6.07	0	0	0	0	0	7	15	13.5	9	2.5	47	2.68	3.11
δ-Aquarids N	6.35	0	0	0	0	1	2.5	8.5	13	15	4	44	3.15	3.30
α-Capricornids	6.14	0	0	0	0	1	3	4	10	5.5	1.5	25	2.82	3.18
π-Cetids	6.39	0	0	0	0	2	0.5	5.5	4	2	0	14	2.25	2.36
Sporadics	6.36	1.5	0.5	0	0	2	19	39	78.5	65.5	23	229	3.07	3.21

Table 1 shows magnitude distributions for these streams. I saw 250 Perseids leaving a train, which is almost 46% of the total number of Perseids. Among the minor showers, the activity of the π-Cetids (a stream which is not listed in the *IMO* catalogue) is weak, but detectable. They were seen from August 5 to August 18. They are quite bright (+2.36), with medium-low speed and approximately 36% of them leave train. The radiant seems to be nearly stationary, and it lies at $\alpha = 42°$ and $\delta = -16°$, with a possible maximum on August 11-12. I think *IMO* should pay more attention to this stream to find out whether it exists or not in years to come. It is listed as a minor shower in [1]. In 1987, Rosario Moyano (*SMS* member) observed from Cochabamba (Bolivia) and she saw a high activity of π-Cetids during the first week of August. This year, also Mario Gaitano reports some π-Cetids, so it seems worthwhile studying this minor stream.

Reference

[1] "SMS List of radiants", *Meteors* 16, July-August 1991, p. 15.

I have to warn for extreme caution when trying to "discover" new minor showers. Single station visual observations are mostly inaccurate for this purpose. On the other hand, several established major and minor showers can hardly be covered, so should we not concentrate on them in the first place? (Ed.)

The 1991 Perseids from Bulgaria

Paul Roggemans

An account is given of the 1991 Perseid observations of the *Arbeitskreis Meteore* on Mt. Rozhen in Bulgaria.

The Perseids of 1991 appeared under very favorable circumstances moonwise and maximum effort was made to observe this year at the best place we knew about. After many years of observing in Southern France, I finally tried another location: Mount Rozhen in Bulgaria. In October 1990 I had proposed some observers of the *Arbeitskreis Meteore (AKM)* to join me in Lardiers, Southern France. It was very cloudy and rainy and the *AKM* observers left Lardiers with a very poor impression about the observing conditions in the area. Since I had been many times in that area of Europe, I was very disappointed that the *AKM* observers got such bad impression of the region, especially since I obtained splendid observing series there so often in the past. By the way, with only five observers in Lardiers we recorded as many meteors in October 1990 as the rest of the world together, despite the bad weather. Anyhow, strong stories were told about Mt. Rozhen, a place that must be a paradise for observing. Indeed, I was very eager to observe at such a place and arrangements were made to enable my participation in Perseid observations at Mt. Rozhen.

On July 26, I went to Potsdam in order to leave from there with a rented van on July 30. We first drove to Dresden, then through Czechoslovakia and Hungary. After a short sleep at a camping place in Hungary near the Yugoslavian border, we crossed Yugoslavia and entered Bulgaria without any problem. Traveling for about 2000 km with six people in a van is taking quite a bit of energy. It took me several days to recover from the travel. Once in Bulgaria I was surprised by the resemblance to Northwestern Europe. Everything looked very humid and the vegetation indicated that it is certainly not a dry area.

Mt. Rozhen is a professional observatory at 2000 m altitude in the southern part of the Rodope Mountains, just north of Greece. The roads are very good and the observatory is quite new, just ten years old. It houses a 2-meter optical telescope used for galaxy research and a few smaller telescopes. A separate building includes the working rooms of the astronomers, administration offices and private residences for astronomers, technicians and their families. We got an apartment which included everything one can expect in a comfortable modern house. We had a lot of living space. The building was well isolated against the heat; it was often rather too cold. Since the observatory is at over 2000 m, the air is thinner which could be felt during physical efforts (running up four floors on a staircase ...).

The nature with its typical mountain vegetation is very beautiful and several excursions were made. We visited an impressive canyon, some giant stone bridges and caves. It is an area that will once attract many tourists; at the moment there are almost none.

Observing was our main target. My *AKM* friends had put my expectations very high. I should expect near to 100 hours of effective observing time and a sky I had not often seen before. Some of it came true; it was a long time ago that I had seen such bad weather during my summer observations! Bulgaria experienced one of the most rainy summers in many years, just when we were there. Waiting for every clear opening in the cloud cover we managed to observe most nights, losing a limited number of nights without any observations. In fact we were very lucky that the night of August 12-13 was very good, just well-timed for the maximum. The horizon never got perfect, but from about 10° elevation the sky was very transparent. I got a record faint limiting magnitude of +6.8, while I normally get no further than +6.5 in perfect sky. Getting older I see my limiting magnitude improve while the opposite is to be expected! On August 12-13, the Perseids started very strong with the radiant very low on the horizon. The activity did not increase, giving the impression of being constant or even less in the middle of the night. While many faint Perseids were recorded, some bright appearances occurred leaving very long persistent trains. The deep-dark transparency of the sky showed many details and we saw the *Gegenschein*, the ecliptical light and the zodiacal light in the morning.

Ralf Koschack decided to obtain plotting data for the *IMO Aquarid Project* and to have some high accuracy plottings for Perseids well seen near the radiant to verify rumors about a double radiant structure. The Aquarids are very faint meteors, and many were plotted. In total the six observers, being Rainer Arlt, Ragnar Bödefeld, Ralf Koschack, Ina and Jürgen Rendtel and the author counted or plotted over 14 000 meteors, which is very good, especially when the big losses due to bad weather are taken into account.

Bulgaria is a small country but has a long tradition in meteor observing. Several groups of students observe there every year. We had the pleasure to meet the four main meteor observing groups from Bulgaria. They use the *IMO* methods now and in the future their results will be included in our analyses. They can provide very valuable data from their more southern latitude in Eastern Europe. The many talks and discussions we had with these very friendly people were most interesting and we are grateful to our Bulgarian friends who visited us. On our way back we also visited Mr. Vladimir Znojil and his wife in Brno (Czechoslovakia), where we picked up 200 copies of the famous *Atlas Brno 2000.0*. This visit left us a with a very fine memory of Brno, and we enjoyed a very friendly hospitality.

Despite the results we felt disappointed because of the unexpected bad weather that reduced our observing possibilities quite a lot. However, I think it is a bad attitude to go observing, expecting 80% perfect skies all the time. We should go to some places, take the weather for what it is and see what we can do for observing. The remaining time should be spend as holidays, like at Mt. Rozhen where we could visit beautiful sites in the area; also the trip itself was very interesting. If one always expects the very best circumstances for observing, there will mostly be big disappointment at whatever place on Earth.

Expeditions like this one are of very high importance. We should go on with it, but we must be a bit philosophical when weather turns out to be far below the expectations.

The 1991 Perseids from Maryland

Richard Taibi

An impression is given of the author's observations of the 1991 Perseids from Maryland. A rather high number of fireballs was seen in the night of August 12-13.

It has been many months since the weather cooperated enough to permit monitoring a shower during its peak. An uncharacteristically well-timed high pressure air mass slipped over Washington D.C. on August 10.

Amazingly, it stayed in place for observations on August 11 and 12. Clouds seemed to be reasserting themselves on the 12th but, as the evening twilight deepened, the clouds disappeared! So, I was able to observe on August 13 too. Consecutive days of observation—quality skies are more likely in Tucson or San Diego, but for Washington D.C. it is nothing short of a miracle.

As a spectacle, 1991's Perseids were impressive. A magnitude −5 fireball on August 12 was surpassed by two −6 fireballs on the 13th, as well as another −5. Incredibly, the two −6 fireballs occurred within five minutes of each other! Although three hours' observation is not equal to much solar longitude, the brilliance of the 13th's meteors suggest to me that something unusual, like the second Perseid peak was happening. I look forward to the *IMO* analysis to see where my data correspond in the activity rates.

Radio and Telescopic Observations in Hungary

The 1991 Quadrantids from Hungary

István Tepliczky and Péter Spányi

The maximum of the Quadrantids was observed by eight Hungarian amateurs during a 27-hour long continuous radio meteor counting.

We began our observing session at 8^h00^mUT on January 3, 1991. Our equipment consisted of a Hungarian synthesizer tuner (with a sensitivity of 2 μV) and a simple dipole antenna which we preferred because of its uniform characteristics. The observation was made at the frequency of 94.7 MHz. Detecting the meteor echoes was done by listening to the audio output of the receiver. The observers worked in shifts of half an hour. The exact time, duration and relative intensity of the reflections were recorded.

At the location of the observation (downtown Budapest) the high level of the electromagnetic interferences—especially during daytime—increased the amount of work for the observers. In Figure 1, the numbers of meteor echoes in 30-minute intervals are shown. The dashed line indicates an uncertainty during the afternoon. Before and after the Quadrantids' appearance, the sporadic background was about 30 meteors per 30 minutes. The number of detected echoes continuously decreased during the evening, consistent with the lower culmination of the radiant. After 21^h UT the activity started to rise slightly, and around midnight (in UT) a sudden change took place: not only the number but also the duration of the echoes increased dramatically. We could, for instance, enjoy a part of Pink Floyd's "Wall" for several seconds!

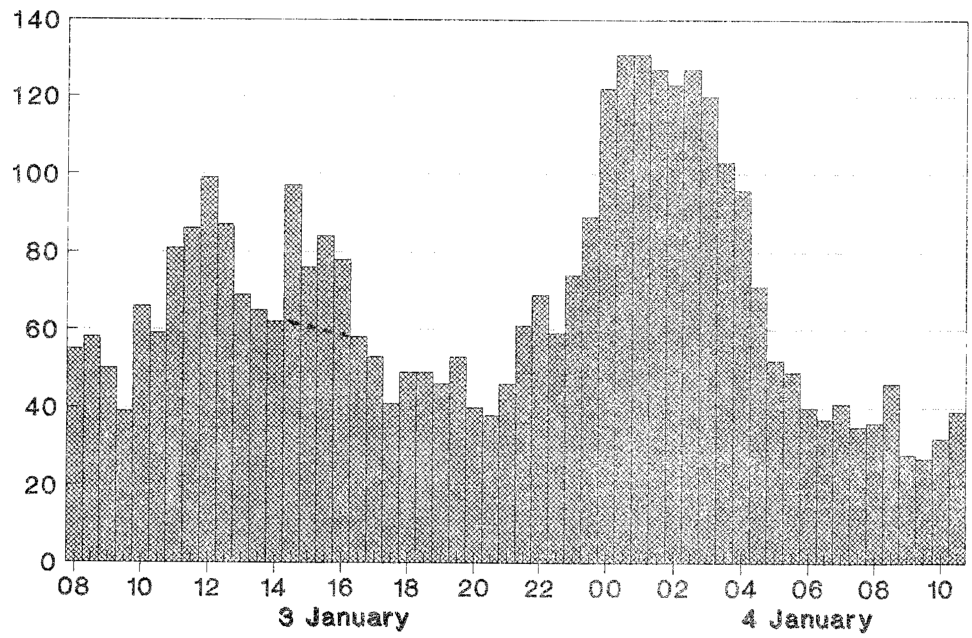

Figure 1 – Number of meteor echoes per half hour recorded in Budapest by eight observers listening at 94.7 MHz on January 3 and 4.

The period of high intensity ended after 4^h UT, despite the fact that this is the time when the sporadic activity reaches its daily peak. In addition, the radiant of the Quadrantids approached its culmination! Our experiences confirmed that the maximum of the Quadrantids only lasts for a few hours. According to our observation it took place between 1^h and 2^h UT, on January 4, 1991. Unfortunately the Full Moon prevented us from doing visual observations. The following persons participated: István Tepliczky, Attila Vetési, Csaba Bálint, János Fekete, Krisztián Sárneczky, Zoltán Antal Nagy, Ákos Keresztúri and Huba Bálint.

The 1991 April Lyrids from Hungary

István Tepliczky and Péter Spányi

Based on Hungarian telescopic observations, the determination of the radiant's position was possible. The result of a series of radio observations suggest the existence of a possible double maximum.

The appearance of the April Lyrids was observed only in one location in Hungary, near the town of Tata (47°38′ N, 18°24′ E). On April 21-22, 1991, during the period 0^h45^m–02^h25^m UT, Krisztián Sárneczky observed 8 Lyrids and 9 sporadics (limiting magnitude of 5.8); István Tepliczky saw 3 Lyrids and 5 sporadics (limiting magnitude of 5.5). The brightest stream members were of magnitude −1 and −2. Most of the meteors were faint and fast.

Zoltán Antal Nagy achieved a much more spectacular result while carrying out telescopic observations from downtown Budapest on the previous day, between 22^h15^m and 23^h45^m UT. With his 7 × 50 binocular he was watching two areas around α and β Lyr and κ Cyg. Six of the eight observed meteors were Lyrids and their paths are shown in Figure 1. The position of the intersection of the lines is: $\alpha = 18^h23^m$, $\delta = +32\overset{\circ}{.}6$.

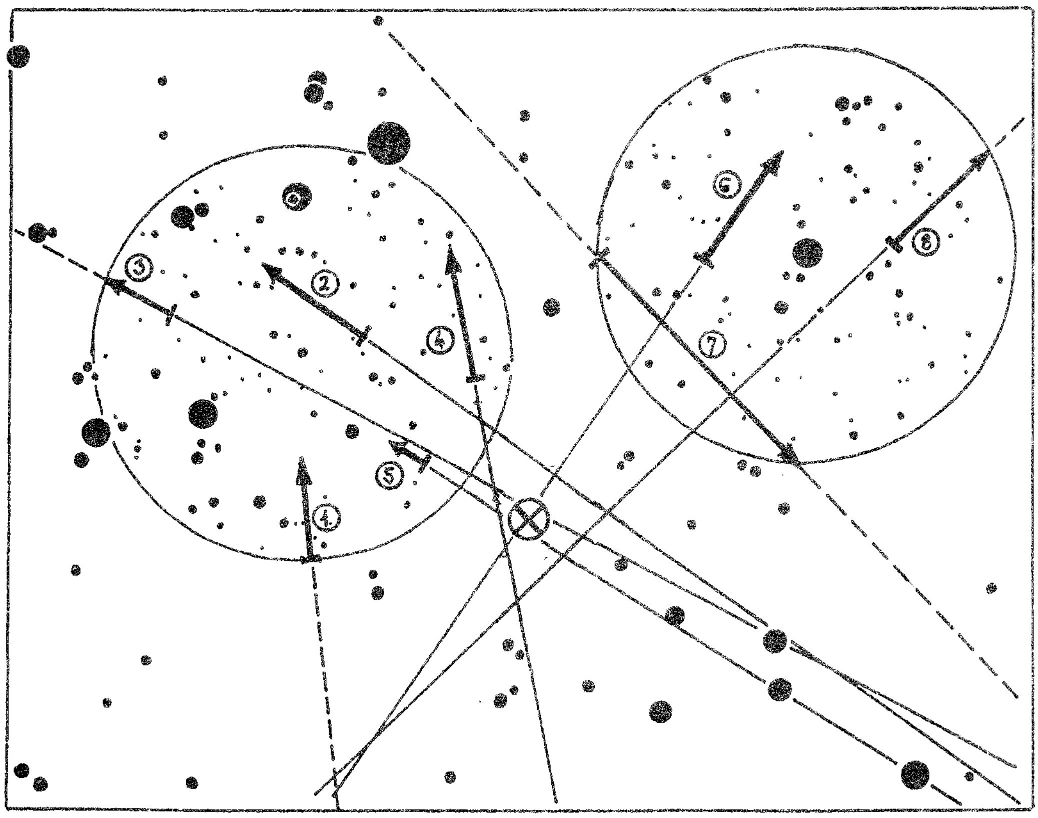

Figure 1 – Telescopic Lyrid observations with a 7 × 50 binocular by Zoltán Antal Nagy on April 20 between 22^h15^m and 23^h45^m UT.

János Szücs in Makó (46°12′ N, 20°30′ E) made a series of radio observations within the period of April 18–26 at 88.3 MHz. (He has a Hungarian-made receiver with a sensitivity of 2 μV, and a 9-element Yagi antenna directed to an azimuth of 270°.) The numbers of meteor echoes detected between 3^h30^m and 4^h00^m UT are shown for each morning in Figure 2.

It is interesting to see that before the expected maximum on April 21-22, another higher peak is seen on April 18-19. Visual observations would have been very useful to check this event. We expect data from other observers about this period of the year.

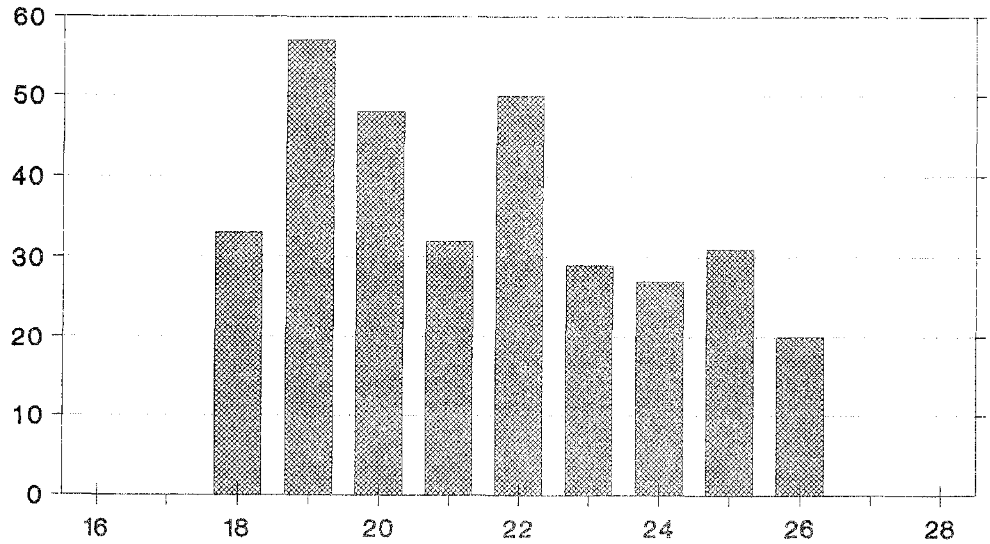

Figure 2 – Radio observations of the April Lyrids between April 18 and 26 in the interval 3^h30^m–4^h00^m UT, obtained by János Szücs at 88.3 MHz.

From the Meteor Library

compiled by Paul Roggemans

- *Martin Beech, "William Frederick Denning: In Quest of Meteors", J. Roy. Astron. Soc. Can. 84:6, 1990, p. 383.*

W.F. Denning (1848–1931) was one of those rare amateur astronomers who achieved world-wide respect and fame in several areas of astronomy during his life time. He is probably best remembered today, however, for his work in the field of meteor astronomy. Denning was one of the first Corresponding Fellows of the Astronomical and Physical Society of Toronto. In the thirty years between his election and eventual death, Denning published a whole host of articles in the Society's journal. It is these contributions that are reviewed here.

Special emphasis has been directed towards his comments on the popularization of meteoric astronomy, and his occasional lapse into poetic imagery, this latter feature being examined with the hope of discovering a deeper understanding of Denning's personal life and beliefs.

- *Jack D. Drummond, "Earth-Approaching Asteroid Streams", Icarus 89, 1991, pp. 14–25.*

The osculating orbital elements of 139 Earth-approaching asteroids (through 1990 KA) are compared with the *D*-discriminants to identify the asteroids traveling in the most similar orbits. No Apollo associations are noted, but three Amor groups are identified whose members, if they were meteors, would be classified as comprising a shower or stream. Two of the streams have five members each, and are shown to be inconsistent with random groupings. One involves two V-type asteroids, and the other five-member group has a secondary minimum in mutual orbital separation in the main belt, perhaps pointing to the location of a collision. The three meteorites with known orbits are also examined. Innisfree is most closely related to 1989 DA, Pribam is questionably associated with 4486 (1987 SB), and Lost City mau be another outlier of a four-member asteroid association. Independent corroboration of these asteroid streams is provided by Halliday et al. in *Meteoritics* 25, 1990, pp. 93–99, who find four streams among 89 meteorite-producing fireballs, three of which are evidently the meteor components of the asteroid streams.

It is remarkable that in the face of disturbing perturbations, asteroid streams could survive for any length of time, but if they are true non-random associations then the opportunity exists for studying an "exploded" asteroid in the near-Earth environment and through examination of pieces dropped by stream fireballs. The prediction is made that near-Earth asteroid search projects should find more members if they search the mean orbits of the streams.

The International Meteor Organization

Council

Commission Directors

WGN — The Journal of the International Meteor Organization and Observational Report Series

Editor-in-chief: Marc Gyssens, tel. 32 (3) 455 68 18, e-mail: gyssens@ccu.uia.ac.be
fax: 32 (3) 820 22 44 (mention Marc Gyssens, Dept. WISINF)
Editorial board: Peter Brown, Masahiro Koseki, Jürgen Rendtel, Jeff Wood, and
Trond Erik Hillestad, Stengelsrud, N-3600 Kongsberg, *Norway*
Typesetting: Urania, the Public Observatory of Antwerp
Printing: André Gabriël

Other author's addresses

C. Verbeeck, Kontichstraat 3, B-2650 Edegem, *Belgium*
D. Artoos, Nattenhofstraat 74, B-2800 Mechelen, *Belgium*
R. Taibi, 7002 Coolridge Drive, Temple Hills, *MD 20748, USA*
G.M. Kristensen, Vænget 13 st. th., DK-4622 Havdrup, *Denmark*
L.R. Bellot et al., C/ Ronda 105 4 E, E-18003 Granada, *Spain*
J.M. Trigo, Avda Antic Regne de Valencia 35, 9 aptda, E-46005 Valencia, *Spain*
I. Tepliczky et al., Baji ut 42, H-2890 Tata, *Hungary*

Please renew promptly your

Subscription/Membership for 1992

and save us a lot of difficulties!!!

Last year, many *WGN* subscribers renewed late. As a consequence, we had serious trouble in planning the new volume. Please save us this trouble by renewing early. All subscription/membership information can be found on pp. 169–170!

The stock of IMO

The following publications are available from IMO. To save on banking costs, we suggest you to order them together with your subscription/membership renewal. All prices include surface mail delivery. For details, please refer to p. 169–170 of this issue!

Publications in English:

	DEM	USD	BEF	GBP	JPY
Bibliographic Catalogue of Meteors 1794–1987	20	15	400	8	1700
Photographic Meteor Data Base (1986)	8	5	160	3	700
Proceedings International Meteor Weekend 1986	6	4	125	2.50	550
Proceedings International Meteor Weekend 1989	12	8	250	5	1000
Proceedings International Meteor Weekend 1990	10	7	200	4	900
Gnomonic Atlas Brno 2000.0	5	3	100	2	500
Photographic Astrometry	10	7	200	4	900
Photographic Astrometry + diskette	13	8	260	5	1100
Bull. Astron. Inst. Czechosl., vol. 1990	40	27	800	15	3400
Bull. Astron. Inst. Czechosl., vol. 1991	40	27	800	15	3400

WGN Observational Report Series:

	DEM	USD	BEF	GBP	JPY
1988 Visual and Fireball Observations	15	10	300	6	1300
1989 Visual and Fireball Observations	15	10	300	6	1300
1990 Visual and Fireball Observations	15	10	300	6	1300

Backissues of the WGN Journal:

Please note that single issues of volumes 9 to 12 can only be ordered with a minimum quantitity of five copies!

	DEM	USD	BEF	GBP	JPY
Volume 9 (1981): nrs. 3, 4, 5 and 6, per copy:	2	1.50	40	1	170
Volume 10 (1982): nrs. 1, 2, 3, 4 and 5, per copy:	2	1.50	40	1	170
Volume 11 (1983): nrs. 2, 3, 4, 5 and 6, per copy:	2	1.50	40	1	170
Volume 12 (1984): nrs. 2, 3, 5 and 6, per copy:	2	1.50	40	1	170
Volumes 13–15 (1985–87): complete, per volume:	10	7	200	4	900
Volumes 16–19 (1988–91): complete, per volume:	20	15	400	8	1700