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This beautiful magnitude −3 Quadrantid in Taurus was photographed by a team of the *Dutch Meteor Society* from Biddinghuizen, the Netherlands, on January 4, 1995, at $1^h33^m26^s$ UT. The exposure was made from $1^h30^m00^s$ UT till $1^h45^m00^s$ UT.

In this issue:

- The databases of the IMO
- Practical information for all observers
- Satellite observations of fireballs
- More on the 1994 Leonids
- The 1995 Quadrantids and other observational results
- Abstracts from the professional literature

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

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Useful Information

The April Issue *(WGN 23:2)*

The *April issue* will be mailed during the first week of April. Contributions are due *March 17* at the latest. They should be sent to *Marc Gyssens*.

WGN Subscription/IMO Membership 1995

The subscription rate for Volume 23 (1995) of the *Bimonthly Journal* is 35 DEM for six issues which are anticipated to contain over 220 pages in total. A combined subscription with the *Report Series* and *FIDAC News* costs 70 DEM. You can also become a Supporting Member by paying at least 15 DEM extra.

Administrative Correspondence

Ordering *IMO* publications is done in the same way as paying subscription/membership fees. Complaints about not receiving *WGN* or changes of address should be sent to *Paul Roggemans*.

All addresses can be found on the inside of the back cover.

From the President

Jürgen Rendtel

A year ago in WGN, *we speculated about possible meteor shower displays in 1994. Two candidates fulfilled our expectations: we saw another Perseid peak and a significant increase in Leonid activity. Obviously, there is need for improvement in our observational and analysis methods for rates exceeding a hundred or so meteors per hour. Besides the visual and photographic methods, video techniques are becoming increasingly important. Talks and a workshop at the* 1994 IMC *indicated that there are more projects in this field going than one might expect based purely on the material reaching* WGN. *This is also true for radio meteor work. I foresee that the effort to obtain useful data from forward scatter observations will become more obvious in our Journal as well.* WGN *reflects the variety of activities going on in the* IMO *and more generally in the global "meteor scene." Thus it is encouraging to see that meteor-related areas such as comets and noctilucent clouds are also included. Furthermore, I think that sections such as the FAQ are helpful for both beginners and experienced observers.*

In 1994, we experienced an IMC *in Bulgaria worth all the travel and preparation. It continued the series of meetings noted for their entire atmosphere—good contributions as well as chats about all things related to meteors, to astronomy, or to the lifestyles of the participants. It is one of the rather few events where we can exchange experience not only on theories, but also on everyday problems directly. Therefore, do not miss future events!*

What to expect in 1995? A further increase of the Leonids, another IMC, *new* IMO *publications, meeting other meteor enthusiasts... Do not forget to let others know what is happening in your group, and in your country, through* WGN.

I wish all IMO *members and friends of the* IMO *a successful and healthy New Year. Good luck with all your private plans and with meteor-related projects.*

From the Editor-in-Chief

Marc Gyssens

Allow me to join our President in wishing you the very best for 1995 and add my thoughts to his about what 1995 is going to bring.

With regard to WGN *the New Year did not start as well as expected, or at least hoped for. We received very few contributions for the present issue. Admittedly, a few articles are postponed to the April issue because length considerations made them more suitable for a thick issue, but such measures have been taken before without giving rise to problems. For the last two years, we had a steady flow of articles to the extent that delays in publishing them were sometimes unavoidable. Measures such as publishing part of the journal in smaller print were necessary to deal with the situation that had arisen. It is a little bit paradoxical that precisely at a time where so much excitement is going on in meteoroid astronomy and related branches we experience a shortage of articles. Perhaps—and most likely—this is only a statistical fluke, but I do not want to take any chances and therefore encourage all potential authors to finally write down those articles that may have been wandering around in your heads for several months and send them immediately to your favorite journal!*

Having mentioned this, I want to re-iterate what I have said so often before: the renewed interest in meteoroid-related phenomena and the recent successes of the IMO *concerning the events that lead to this increased interest are no cause whatsoever for euphoria.*

Both in our strongest field—visual observations—as in the fields of radio and video astronomy which are rapidly gaining importance as our President pointed out, still too few people are prepared to take up organizational responsibilities within the IMO. *As a consequence, many* IMO *officers are overloaded with work leaving not much margin to take new initiatives. Nevertheless, success in amateur radio and video meteor astronomy directly depends on whether or not we will succeed in properly organizing these fields. It is my wish that 1995 may see progress on this issue. Therefore, members who think they could contribute in this sense should contact the appropriate Commission Director or the President.*

However, it was not my purpose to sound negative or pessimistic in the previous paragraphs. I merely wanted to point out that within our Organization no achievement may be taken for granted: it must be fought for every day again. Hoping you feel the same, I wish you pleasant reading!

Letters to WGN

compiled by Marc Gyssens

We received two notes from our regular correspondent, George Zay. They are published below. At the same time, we encourage other meteor observers to follow George's example and to communicate their experiences to their colleagues. We also welcome all comments on material published in this journal, critical and other.

Life is not always easy...

I have a good meteor observing site outside my observatory, located in the mountainous region of Descanso, California, 60 km east of San Diego. San Diego is plagued by the dreaded "June Gloom"..., a weather phenomenon of nightly fog and low clouds. The low inland mountain slopes are its barrier. Thus, the fog stops about 3 km short of my observing site. This year's "June Gloom" started sometime in April. On the night of May 16-17, a rather deep low pressure trough centered itself over San Diego. This pushed the fog beyond my observatory. A little after mid-night, Robert Lunsford and I loaded up my truck with our observing gear and headed for higher ground..., to which Mt. Laguna is the highest local point at about 1750 m.

As we searched for a clear spot, the fog teased us all the way up. The stars popped in and out of view. The only clear area was at the very top of Mt. Laguna. However, the wind there was howling at about 300 000 km/s... well, maybe not that fast, but fast enough to be concerned about my pick-up truck being blown over. We were now desperate to search for a good observing site that did not have strong winds or fog. We drove along the Sunrise Highway towards Cuyamaca State Park, all the while trying to balance the fog depths with our wind tolerance. As time ticked off the clock towards sunrise, like desperate vampires, we tried to stall the night for an hour or two of prime time meteor recording. We pulled onto a desolate road in Cuyamaca Park for another fruitless effort. As we hung our heads out the window, trying to determine if this spot was a yea or a nay, our hair whipped about our heads by a cold driving wind. Low clouds could be seen in all directions except above us. Deciding that this was a no-go and wanting to try one more place before declaring the night a total lost, I hurriedly backed my truck off a small overhang and was high centered. I was cold and the wind blew through one ear and out the other. I was in a hurry to salvage the night and frustrated by the fact that I was in a real pickle. On top of that, I was faced with the possibility that I may have to tell my wife what I did. I had no desire to see her roll her eyeballs around. I had a car jack but needed some rocks to stuff under my tire as I jacked the truck up. As the lack of luck would have it, the area seemed to be missing rocks almost entirely. Mind you that I am doing this in the dark with a quickly dimming hand light. I am working feverishly. The back window to my truck shell was open. As I hurriedly got up from the jack to find more rocks, I smashed my head on this window. Stumbling around and cursing to myself as I explored the possibility of having to stop some bleeding, I was finally able to find just one more rock. As it turned out, this was all I needed along with Robert's help pushing, as I gently stepped on the gas. I was out... exhausted, in pain, and it was 4 a.m. The sky will be too bright to observe meteors in about 40 minutes. As far as I am concerned, the night was over. Chalk this one up as another "I was there and my heart was there, but it just was not to be" night. Meteor observing is not always an easy undertaking. However, most nights are not like this. This was an exception.

George J. Zay, December 19, 1994

Fireball reporting from the public

I have recently completed a little project, that was aimed at retrieving fireball data from the general public. The plan was based on the concept that whenever an exceptional meteoric event occurs, the public frequently contacts their local police or fire departments, but these guys are usually looking for a "plane crash." When these places are called, they not only do not know what data to ask for, they have no clue what to do with it.

Often, it goes no further than the local news media. So... I took it upon myself to send a copy of a "modified for the public" Fireball Report Form with instructions, to over 300 colleges, planetariums, observatories, and science centers throughout the United States. In my cover letter, I asked these places to keep the forms on file in the event the public reports to them. A few wrote back to acknowledge they will do this. They also stated that until now, they had no idea as to what to do with this information. So, I feel I am on the right track.

Now, I would like to suggest a worldwide expansion to this plan. Postage for my mailings to within my country is relatively cheap compared to mailings abroad. I suspect this is the same for others in their country. I am hoping people will pick up the initiative and do the same for their country. Perhaps some people have already done something similar? If anybody is interested, please write me and I shall send you a copy of what I sent, so that it can be used as a guide to re-write for your purposes. With the public's help, perhaps we can make fireball reporting more of a routine that will lead to more accurate fireball studies?

George J. Zay, December 19, 1994

Frequently Asked Questions on Observing Methods

compiled by Rainer Arlt

Which items are of particular importance to record when plotting meteors?

Interest in plotting meteors and meteors from minor showers has grown lately. Therefore, I would like to give some details on meteor plotting. Naturally, the apparent path of the meteor is the most important information for the shower association or radiant investigation. Meteors can only be drawn on gnomonic charts, any other projection method results in paths which are curved instead of straight lines. An ideal set of charts is the *Atlas Brno 2000.0* created by Vladimír Znojil [1].

When you noticed a meteor you should remember the surrounding stars though they may often be rather faint. The more stars you know on your map, the closer are the stars you can use for plotting the meteor path. Otherwise, it may take sometime to identify magnitude +5 stars on the map. Most observers do not have extremely good knowledge of the sky; they will use more distant and brighter stars to plot the meteor. These stars should not be further away from the meteor path than about 15°. Otherwise, the accuracy suffers from the same disadvantages as the counting method; namely the necessity of prolonging the path over large distances on a sphere (i.e., beyond the actual visible trajectory of the meteor as it appears in the sky.)

Since the *direction of the path* is essential for the association with a radiant, we should concentrate on this information when plotting a meteor rather than the length. It is helpful to remember two stars near the prolongation of a meteor, such as "a bit left of this star, but a bit more right of that star" with both stars being located at different distances from the meteor but near the prolongation. If you make such a relative positional estimate for four stars on both the forward and backward prolongation, the plot will have sufficient accuracy, although you did not use the magnitude +5 and +6 stars in the very vicinity of the meteor path. Alternatively, if the meteor appeared very close to a star which you easily find on the chart you can also use this star as a reference and define the direction by two further stars on the prolongation.

When you have drawn the meteor path on your map, you can note the other characteristics of the meteor, starting with the *time* in hours and minutes and an estimate of the *brightness* of the meteor in half-magnitude steps. The Atlas Brno provides the observer with magnitude values of several stars on each of its charts. But do not note a magnitude of +2.2 when the meteor was as bright as γ Cygni; just write "+2."

The *angular velocity* should not be neglected when plotting meteors. It provides very helpful information when discriminating sporadic meteors from shower meteors. Although it seems difficult to estimate the speed in degrees per second I can only recommend this measure as described in the FAQ in last year's February *WGN* [2].

Finally, an estimate of the *accuracy* of the plot should be given. It is recommended that you use a three-step scale from "1" (accurate plot) to "3" (uncertain path), or, alternatively, to note "+," "0," and "−." Generally, good accuracy is associated with meteors near the center of the field of view whereas lower accuracy will indicate meteors which were noticed near the edge of the observed field.

When you got accustomed to plotting, and it takes you only half a minute or so to plot a meteor you should also give additional information such as the *color and persistent train* when you detect these details. The following items are sorted by their importance for plotting meteors:

1. apparent path, magnitude and (at least) time stamps about every 15 minutes;
2. angular velocity;
3. an estimate of the accuracy of the plot (e.g., 1, 2, or 3); and
4. color, persistent train, and other peculiarities.

How do I get the Atlas Brno 2000.0?

The atlas can be ordered from the treasurer of *IMO*, Ina Rendtel. You will then receive the atlas directly from the author, Vladimír Znojil. The price is 5 DEM. American observers can send 4 USD to Peter Brown instead who will then inform Ina about the request by e-mail.

References

[1] V. Znojil, "Gnomonický Atlas Brno 2000.0", *WGN* 16:4, August 1988, pp. 137–140.

[2] R. Arlt, "Frequently Asked Questions on Observing Methods", *WGN* 22:1, February 1993, p. 6.

The Present Visual Meteor Database

Rainer Arlt

1. Introduction

It has been a long time since the last report on the status of the *Visual Meteor Data Base* (*VMDB*) in 1992 [1] where the statistics up to 1990 are reported. The database was created by Paul Roggemans in 1988, and the best proof of its quality is that it has been the main tool for meteor shower analyses for more than 6 years.

Table 1 gives the totals over the years. The numbers for the earlier years may have slightly increased compared to [1] due to later input. As the last column shows, magnitudes were estimated for only 80% of the meteors seen. ZHR calculations are the based on the actual population index r derived from the meteors involved rather than on assumed r-values derived from previous years. Therefore, the magnitude of the meteor is as essential as the shower association.

Figure 1 shows the distribution of observing sites of 1993 and 1994. There is a very heavy contrast between northern and southern latitudes. A lot of new results were possible if a larger number of high-quality observations from southern latitudes were available.

Table 1 – *VMDB* totals for 1988–1993. The column "Meteors (R)" gives the number of meteors in the rate file; "Meteors (M)" gives the number of meteors in the magnitude file. The last column gives the percentage of meteors for which magnitude data are stored.

Year	T_{eff}	Meteors (R)	Meteors (M)	M/R
1988	5 684$^{\text{h}}$	115 298	6 5751	57%
1989	5 322$^{\text{h}}$	89 493	49 416	55%
1990	4 488$^{\text{h}}$	79 053	64 585	82%
1991	5 360$^{\text{h}}$	139 308	109 191	78%
1992	4 529$^{\text{h}}$	76 811	62 049	81%
1993	7 532$^{\text{h}}$	178 566	140 406	79%

2. Limiting magnitudes

Although the amount of data in the *VMDB* looks impressive, the quality of the observations is very inconsistent. Table 2 shows the distribution of observations versus the limiting magnitude.

Table 2 – Distribution of observations of 1993 and 1992 versus limiting magnitude bins.

Year	$\overline{\text{Lm}}$	4.25–4.75	4.75–5.25	5.25–5.75	5.75–6.25	6.25–6.75	6.75–7.25
1992	5.74	5.3%	13.5%	22.1%	32.5%	21.7%	3.2%
1993	5.80	3.6%	13.4%	24.4%	36.7%	18.5%	2.9%

The limiting magnitude of the majority of observations is less than 6.5. In an analysis these observations will be corrected to 6.5 according to the population index r. The correction factor is 5.2 for a limiting magnitude of 5.0 at $r = 3.0$. Uncertainties in the r-value cause erroneous corrections. Any of the applied correction factors (limiting magnitude, clouds, zenith correction) adds to these systematic errors. In order to keep the corrections reasonable, we put the maximum total correction for an observation to 5.0 in shower analyses. Hence, observations with limiting magnitudes less than 5.0 are of little help for reliable analyses. Therefore, only very little data with such poor conditions in 1994 and in future years will be entered into the *VMDB*. Only in peculiar situations, like the outburst of a meteor shower which was covered by very few observations, will these lower quality data be stored in the database.

3. The solar longitude

The original procedure for the computation of the solar longitude in the *VMDB* referred to equinox 1950.0. Although it was later changed to 2000.0, it turned out to not be sufficiently accurate for very short observing periods during the Perseid peak. The procedure was replaced by the algorithm given by Steyaert [3] which provides an accuracy of some $0\overset{\circ}{.}001$ representing about 1.5 minutes.

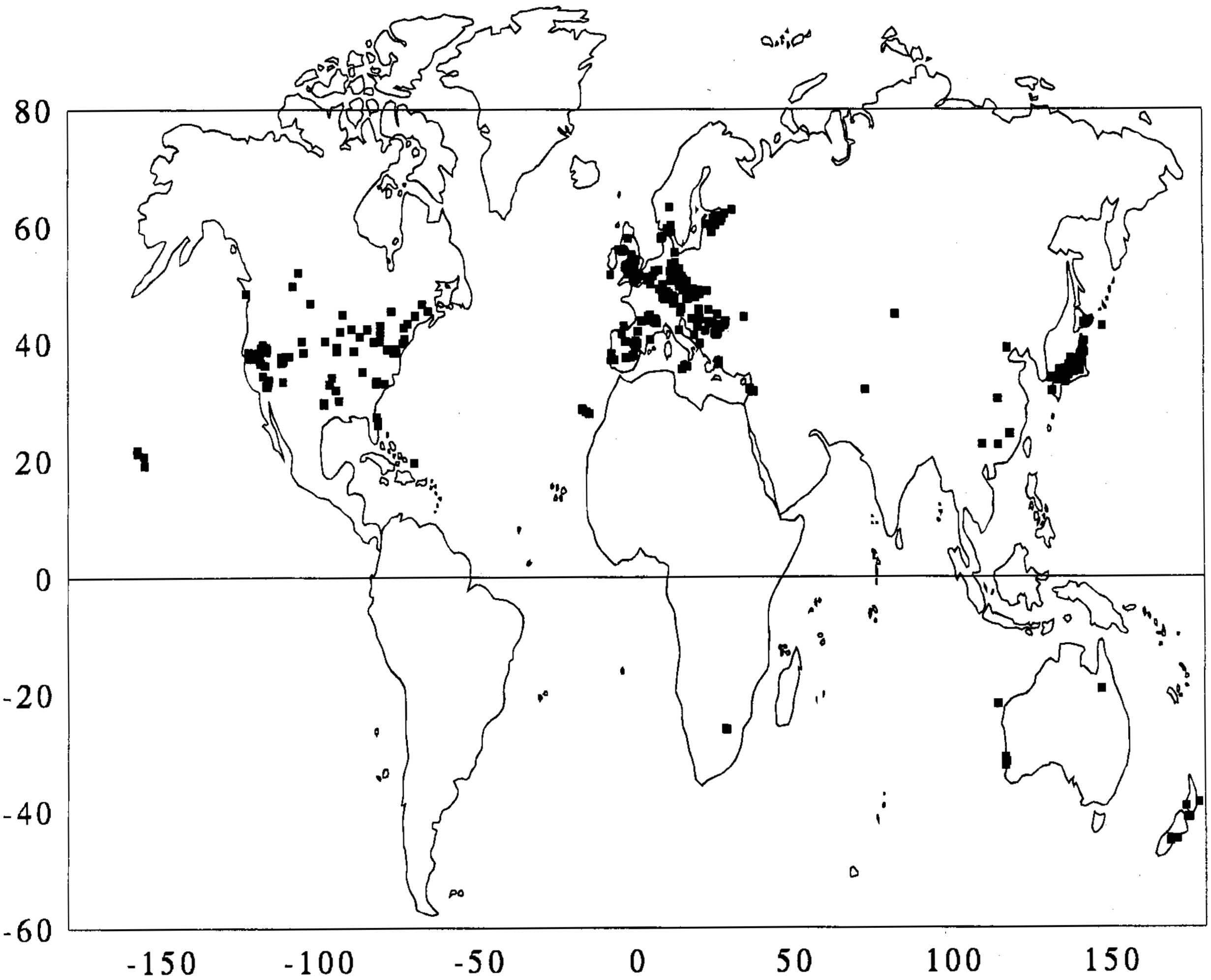

Figure 1 – Distribution of observing sites of 1993 and 1994.

4. The deadline for 1994 observations

In order to prepare Volume 7 of the *Observational Report Series*, containing 1994 observational data which will be done during the summer, we would like to receive your data *before May 31*. This is not to say that there is plenty of time until May 31. Please try to send in your observations as soon as possible. It has always been very hard to enter large amounts of data for people who "woke up" just before the *Report* was created.

The forthcoming issue of the *Report Series* will have a reduced thickness. The majority of interested amateurs have access to computers; and generally, investigations are carried out by means of computers as well. Hence, the next *Report* will contain fewer tables, but a diskette with the complete data of the *VMDB* instead.

References

[1] P. Roggemans, "Visual Meteor Data Base Statistics for 1989 and 1990", *WGN* 20:1, February 1992, pp. 6–10.

[2] P. Roggemans, "The Visual Meteor Database (VMDB)", *WGN* 16:6, December 1988, pp. 179–186.

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

Meteor Photographs Received for the PMDB in 1994

Jürgen Rendtel

In 1994, we started to publish notes for photographic meteor observers on a regular basis. In the second half of last year, the first results were sent in by several observers. Most efforts were done during the Perseids, which produced high rates and included many photographic meteors.

I know of several photographic double station experiments, which have been at least partly successful. However, most images are still single-station photographs. We very much acknowledge meteor photographs for the *Photographic Meteor DataBase* (*PMDB*). In 1994, the following observers contributed to the *PMDB* archive:

> David Holman (USA), André Knöfel (Germany), Vasile Micu (Rumania), Jürgen Rendtel (Germany), Nikolai Wünsche (Germany), and George Zay (USA).

Perhaps you have meteor photographs in your personal archive as well and might consider sending these for inclusion into the *PMDB*.

As already mentioned, most of the photographed meteors are Perseids. However, there are also Geminids, December-Monocerotids, and sporadic meteors. The number of meteors from ecliptical sources is very low. For example, in 1994, the Taurids seem to have produced less fireballs than in some previous years. In some years, a few clear Taurid nights yielded a substantial number of photographed meteors. As pointed out in the hints for photographic observers, we need quite a large sample of meteors of probably ecliptical origin before we may try a radiant investigation comparable with the analysis of meteor plots (cf. the Aquarid Project [1,2]). Therefore we ask you to continue photographic work and to send in all meteor trails.

Almost all images we received were sent as black and white prints. We know that only few observers do the processing themselves. However, if you are able to influence the copying process or you do the laboratory work yourself, please avoid using too high a contrast. In this case, nearly all information is in one blackening level and this is quite difficult to handle, e.g., with a scanner or other measuring devices.

Another disproportion concerns the lack of photographic records from the southern hemisphere. Except the sources close to the ecliptic (including the η-Aquarids, the Orionids, and the Geminids as major showers) there are no other regular major showers in the southern sky. One rather complex radiant area is the Puppid-Velids, which should be subject of photographic investigation. According to the experience obtained from the Aquarid Project, visual observations are not sufficient to distinguish different sources which are as close together in their radiants and their atmospheric entry velocity as the different Aquarid radiants [2]. Hence the components of the Puppid-Velid complex must be regarded as unresolvable by visual techniques as well. This is also important for establishing a reliable working list of visual meteor showers.

We may assume that the amount of photographs available for several investigations increases quite soon. If possible, every observer should try to organize double station photography with another observer. However, a discussion during a photography workshop at the 1994 *IMC* indicated, that a substantial portion of meteor photographs will be single station images, which are very useful as described in the series. We intend to continue hints for both fields of photographic work throughout the next issues.

References

[1] R. Koschack, J. Rendtel, "Aquarid Project 1989", *WGN* 17:3, June 1989, pp. 90–92.

[2] R. Arlt, R. Koschack, J. Rendtel, "Results of the IMO Aquarid Project", *WGN* 20:3, June 1992, pp. 114–135.

Visual Observers' Notes: March–April 1995

Jeff Wood

1. Introduction

In March and April, only the δ-Pavonids and the April Lyrids are active among the major showers. However, these months are characterized by a whole host of minor streams that makes observing, especially after midnight, most interesting when rates in dark skies can reach over 20 meteors per hour on occasions. As well, there is the unusual number of brilliant fireballs that emanate out of the Scorpius, Libra, Centaurus and Virgo regions. Two of these, seen on March 18, 1983, and April 6, 1975 were recorded as -19 and -15 respectively!

Table 1 lists some of the meteor showers to be seen in March and April 1995. Table 2 shows moonlight and observing conditions. 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.

The Visual Commission of the *IMO* although requiring data on all streams realizes practical considerations like work, study, family, Moon and weather prevent people from observing regularly on a day by day basis throughout most of the year.

With this in mind, it has been decided to encourage everyone who has time to observe to concentrate on a couple of showers per month rather than the whole lot. This means we should be able to get a good set of data on these few rather than sparse data on many showers. The showers chosen for special investigation for the months of March and April are the Virginids, δ-Leonids, γ-Normids, δ-Pavonids, α-Scorpids, π-Puppids, and the theoretical radiants of 1863 Antinous and 1981 Midas.

Table 1 – A list of some of the meteor showers to be seen in March–April 1995.

Shower	Activity	Max	Radiant			Drift		V_∞	r	ZHR
			α	δ	Diam.	$\Delta\alpha$	$\Delta\delta$			
Virginids	Feb 01–May 30	several	195°	−04°	15°/10°			30	3.0	5
θ-Centaurids	Jan 23–Mar 12	Feb 01	210°	−40°	6°	+1°1	−0°2	60	2.6	
δ-Leonids	Feb 05–Mar 19	Feb 16	159°	+19°	8°	+0°9	−0°3	23	3.0	3
γ-Normids	Feb 25–Mar 22	Mar 14	249°	−51°	5°	+1°1	+0°1	56	2.4	8
δ-Pavonids	Mar 11–Apr 16	Apr 07	308°	−63°	10°/15°	+1°2	+0°1	59	2.6	13
Scorpid/Sagittarids	Apr 15–Jul 25	several	260°	−30°	15°/10°			30	2.3	10
Lyrids	Apr 16–Apr 25	Apr 22	271°	+34°	5°	+1°1	0°0	49	2.9	var
π-Puppids	Apr 15–Apr 28	Apr 23	110°	−45°	5°	+0°6	−0°2	18	2.0	var
α-Bootids	Apr 14–May 12	Apr 26	218°	+19°	8°	+0°9	−0°1	20	3.0	3
η-Aquarids	Apr 19–May 28	May 03	336°	−02°	4°	+0°9	+0°4	66	2.7	50

Table 2 – Moonlight and observing conditions in March–April 1995.

Date	k	Date	k
Friday February 24	0.34−	Friday March 31	0.00−
Friday March 03	0.03+	Friday April 08	0.48+
Friday March 10	0.56+	Friday April 14	0.97+
Friday March 17	1.00+	Friday April 21	0.63−
Friday March 24	0.48−	Friday April 28	0.03−

New Moon:	March 1, March 31, April 29
First Quarter:	March 9, April 8, May 7
Full Moon:	March 17, April 15, May 14
Last Quarter:	February 22, March 23, April 22

2. Virginids

This shower is very complex and is active from February 1 through to May 30. There are many subradiants and submaxima. Observers are encouraged to continue the project outlined in the Visual Observers' Notes for January and February 1995 [1].

3. γ-Normids

This shower is often misnamed the Corona Australids due to a transcription error by the great New Zealand meteor worker R. McIntosh in 1935. The γ-Normids are active from February 25 through to March 22. A variable maximum of 3 to 15 meteors per hour occurs on March 14. They are fast meteors and are best seen from the southern hemisphere in the pre-dawn hours.

Observers should locate their field center no more than 40° away from the radiant and plot all possible γ-Normids seen. If observers wish to monitor both the δ-Pavonids and the γ-Normids, the field center must be located around $\alpha = 270°$ and $\delta = -55°$. The Full Moon on March 17 means this shower is best observed pre-maximum in 1995.

Table 3 – Radiant positions of the γ-Normids.

Date	α	δ	Date	α	δ
Feb 25	234°	−53°	Mar 14	249°	−51°
Mar 03	237°	−52°	Mar 19	254°	−50°
Mar 08	242°	−52°	Mar 22	258°	−50°

4. δ-Pavonids

The δ-Pavonids are thought to have been formed from the debris of Comet P/Grigg-Mellish (1907 II). Observations to date indicate that the shower produces variable activity with rates at maximum varying in the range of 5 to 15 meteors per hour. With the radiant reaching its greatest altitude in the southern hemisphere skies in the pre-dawn hours, the δ-Pavonids should provide moon-free viewing for most of their period of activity except from March 13 to 25. The δ-Pavonids appear to have several sub-maxima during the period March 30 to April 10, apart from the major maxima that occurs on the morning of April 7. With this in mind, southern-hemisphere observers are encouraged to give the δ-Pavonids particular attention in 1995. They should locate their field center no more than 40° away from the radiant and ensure that all meteors seen are plotted.

Table 4 – Radiant positions of the δ-Pavonids.

Date	α	δ	Date	α	δ
Mar 11	296°	−65°	Apr 05	307°	−63°
Mar 21	301°	−64°	Apr 10	309°	−63°
Mar 31	305°	−63°	Apr 15	311°	−62°

5. April Lyrids

The Lyrids are active from April 16 to 25 reaching a maximum of between 10 and 15 meteors per hour on April 22. On a few occasions, the most recent being in 1982, rates have been much higher almost reaching 100 meteors per hour. The Lyrids' parent body is comet P/Thatcher (1861 I). In 1995, the start of the activity period is heavily affected by the Moon. From April 21 onwards, observers in the northern hemisphere can start observing the shower around 22^h local time when the radiant reaches sufficient elevation and should continue until the Moon reduces the limiting magnitude below 5.5. In the southern hemisphere, the radiant altitude and the Moon make the viewing conditions very difficult. Observations should only be made if the limiting magnitude exceeds 5.5.

With a V_∞ of 49 km/s care needs to be taken when identifying meteors as Lyrids. To help new observers who joined the *IMO* this year in correctly identifying shower membership, we reprinted the information in Table 7. Observers should ensure that the center of their field of view is no more than 40° from the radiant. Also they should plot all meteors seen unless the ZHR exceeds 10 when countings are permitted. Only at maximum is this likely to be the case.

Table 5 – Radiant positions of the Lyrids.

Date	α	δ	Date	α	δ
Apr 16	265°	+34°	Apr 22	271°	+34°
Apr 19	268°	+34°	Apr 25	274°	+34°

6. α-Scorpids

The α-Scorpids are one of the major components of what Hoffmeister called the Scorpio-Sagittarius complex of showers. This ecliptic stream is active from March 26 to June 4 with a broad maximum of between 4 and 8 meteors being reached during early May. The α-Scorpids are well known for the many brilliant yellow, orange and green fireballs they produce. Few, however, leave a persistent train.

With a velocity V_∞ of 35 km/s, and several other Scorpio-Sagittarid radiants active in the same region of the sky, especially in May and early June, special care needs to be taken when recording and classifying these meteors. Observers should plot all possible α-Scorpids seen. They should center their field of view no more than 30° from the radiant.

Table 6 – Radiant positions of the α-Scorpids.

Date	α	δ	Date	α	δ
Mar 26	236°	−21°	May 05	246°	−24°
Apr 05	238°	−21°	May 15	249°	−25°
Apr 15	241°	−22°	May 25	252°	−25°
Apr 25	244°	−23°	Jun 04	254°	−26°

Table 7 – Angular velocity (°/s) as a function of the altitude of the meteor's beginning point h_b and the distance D between the end point and the radiant for various values of a stream's geocentric velocity V_∞. H_b is the altitude of the meteor's beginning point above the Earth's surface.

	$V_\infty = 20$ km/s, $H_b = 100$ km					$V_\infty = 25$ km/s, $H_b = 100$ km				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	0.2	0.3	0.6	0.9	1.0	0.2	0.4	0.8	1.1	1.3
10°	0.3	0.7	1.3	1.7	2.0	0.4	0.9	1.6	2.2	2.5
20°	0.7	1.3	2.5	3.4	3.9	0.9	1.7	3.2	4.3	4.9
40°	1.3	2.5	4.7	6.3	7.3	1.6	3.2	5.9	8.0	9.3
60°	1.7	3.4	6.3	8.5	9.8	2.2	4.3	8.0	11	13
90°	2.0	3.9	7.3	9.8	11	2.5	4.9	9.3	13	14

	$V_\infty = 30$ km/s, $H_b = 100$ km					$V_\infty = 35$ km/s, $H_b = 100$ km				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	0.3	0.5	1.0	1.4	1.6	0.3	0.6	1.1	1.5	1.7
10°	0.5	1.1	2.0	2.7	3.1	0.6	1.2	2.2	3.0	3.4
20°	1.1	2.1	4.0	5.3	6.2	1.2	2.3	4.3	5.8	6.7
40°	2.0	4.0	7.4	10	12	2.2	4.3	8.2	11	13
60°	2.7	5.3	10	14	16	3.0	5.8	11	15	17
90°	3.1	6.2	12	16	18	3.4	6.7	13	17	20

	$V_\infty = 40$ km/s, $H_b = 100$ km					$V_\infty = 50$ km/s, $H_b = 110$ km				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	0.3	0.7	1.3	1.7	2.0	0.4	0.8	1.5	2.0	2.3
10°	0.7	1.4	2.6	3.5	4.0	0.8	1.6	2.9	3.9	4.6
20°	1.4	2.7	5.0	6.8	7.9	1.6	3.1	5.8	7.8	9.0
40°	2.6	5.0	9.5	13	15	2.9	5.8	11	15	17
60°	3.5	6.8	13	17	20	3.9	7.8	15	20	23
90°	4.0	7.9	15	20	23	4.6	9.0	17	23	26

	$V_\infty = 60$ km/s, $H_b = 115$ km					$V_\infty = 66$ km/s, $H_b = 115$ km				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	0.5	0.9	1.7	2.3	2.6	0.5	1.0	1.9	2.5	2.9
10°	0.9	1.8	3.4	4.5	5.2	1.0	2.0	3.7	5.0	5.8
20°	1.8	3.5	6.7	9.0	10	2.0	3.9	7.3	10	11
40°	3.7	6.7	13	17	20	3.7	7.3	14	18	21
60°	4.6	9.0	17	23	26	5.0	10	18	25	29
90°	5.3	10	20	26	30	5.8	11	21	29	33

	$V_\infty = 70$ km/s, $H_b = 126$ km				
	$h_b = 10°$	20°	40°	60°	90°
$D = 5°$	0.5	0.9	1.8	2.4	2.8
10°	1.0	1.9	3.6	4.8	5.5
20°	1.9	3.7	7.0	9.4	11
40°	3.6	7.0	13	18	21
60°	4.8	9.4	18	24	28
90°	5.5	11	21	28	32

7. π-Puppids

The π-Puppids are a young meteor shower having been recorded only over the last 20 years. Their parent body is comet P/Grigg-Skjellerup. The π-Puppids are a periodic shower occurring in great numbers every five years. Rates therefore range from almost zero up to 40 per hour. The last strong activity was in 1987.

The π-Puppids are a southern hemisphere shower and are best seen during the early evening hours. They are very slow meteors and often have a yellow-orange hue. Many fireballs are produced.

With the Full Moon occurring on April 15, the shower's viewing conditions, observers should be able to get a few hours of dark sky They should center their field no more than 40° from the radiant and plot all possible π-Puppids seen unless the rate exceeds 10 per hour when counts are permitted.

Table 8 – Radiant positions of the π-Puppids.

Date	α	δ	Date	α	δ
Apr 17	106°	−44°	Apr 23	110°	−45°
Apr 20	108°	−45°	Apr 26	112°	−46°

8. Theoretical radiants of 1863 Antinous and 1981 Midas

The Earth has a closest approach to the orbit of the minor planet *1981 Midas* on March 19 and with *1863 Antinous* on April 3. Numerical data can be found elsewhere in this issue, in Dirk Artoos's contribution.

The orbits of both asteroids come close to that of the Earth's and the values of V_∞ make it possible to observe showers related to one or both objects. Due to the close approach and the high V_∞, 1981 Midas is the more favored candidate. The theoretical radiant positions provide northern hemisphere observers with the better viewing conditions though they can be observed in both hemispheres in the evening skies.

It should be noted that the theoretical radiant positions may differ somewhat from the actual observed ones by some degrees. This means that it is impossible to carry out shower associations and obtain ZHRs using standard observing procedures. What needs to be done is to investigate whether or not there is a significant radiant in the vicinity of the predicted one. In order to do this, observers should center their field of view at a distance of less than 20° from the predicted radiant position and plot all meteors seen that radiate from an area of about 25° around the predicted radiant position onto the Atlas Brno gnomonic charts. The x, y-coordinates of the plots should be measured (see [2]) and reported in the table format described in the Aquarid Project (see [3]). Please, of course mention the chart number.

In 1995, the *IMO* requests that observers watch the 1863 Antinous radiant from March 27 (radiant position $\alpha = 195°$, $\delta = +33°$) to April 11 ($\alpha = 210°$, $\delta = +31°$). The 1981 Midas radiant on March 19 is badly affected by the Moon. However, northern-hemisphere observers can start to watch this radiant around 21^h local time and should continue until the Moon reduces the limiting magnitude too greatly. The radiant should be monitored from March 22 ($\alpha = 214°$, $\delta = +34°$) to March 30 ($\alpha = 220°$, $\delta = +33°$).

Table 9 – Radiant positions of possible 1863 Antinous shower.

Date	α	δ	Date	α	δ
Mar 27	195°	+33°	Apr 11	208°	+32°
Apr 01	199°	+33°	Apr 16	212°	+31°
Apr 06	204°	+32°	Apr 21	216°	+31°

Table 10 – Radiant positions of possible 1981 Midas shower.

Date	α	δ	Date	α	δ
Mar 05	201°	+36°	Mar 20	213°	+34°
Mar 10	205°	+35°	Mar 25	217°	+34°
Mar 15	209°	+35°	Mar 30	220°	+33°

References

[1] J. Wood, "Visual Observers' Notes: January–February 1995", *WGN* 22:6, December 1994, pp. 184–186.

[2] R. Koschack, "Comments for Visual Observers", *WGN* 18:6, December 1990, pp. 197–198.

[3] R. Koschack, J. Rendtel, "Aquarid Project 1989", *WGN* 17:3, June 1989, pp. 90–92.

Photographic Observers' Notes: March–April 1995

Jürgen Rendtel

The Lyrids are the only significant non-ecliptical meteor shower active in this period of the year. Noticeable activity is restricted to a few days, and we may expect only few photographic meteors from this shower. There have been reports of events with high rates (up to 90 for about half an hour) in the past. If this happens, a photographic record could be of great interest.

In 1995, the activity period (April 16–25) coincides with the waning Moon. This means that the time after local midnight with the radiant being sufficiently high in the sky is disturbed by the Moon. However, if the amount of straylight is not too high and we restrict the exposure times to about 10–15 minutes, we may obtain acceptable images because of the high ecliptic latitude of the radiant. We should choose a field northwest or north of the radiant before local midnight, and east or northeast of the radiant after local midnight. Observers at mid-northern latitudes should point their cameras with standard lenses to field centers near $\alpha = 230°$, $\delta = +55°$ and $\alpha = 310°$, $\delta = +45°$, respectively. Photographers at more southern latitudes are restricted to the morning hours and may have to choose fields which are closer to the moon, e.g., near $\alpha = 300°$ and $\delta = +20°$.

The radiant of the ecliptical meteor complex has moved into Virgo by March. As in the previous months, only little is known about the radiant structure and the activity level during this period of the year. The Virginids are a complex of radiants rather than one individual source. If we obtain a sufficient number of single-station photographs we may try a radiant search as described for the Sagittarid complex in the June 1994 issue of *WGN*. The most suitable suitable field centers for standard lenses are at $\alpha \leq 150°$, $\delta \approx +5°$ and $\alpha \geq 250°$, $\delta \approx +5°$. The use of a rotating shutter with known interruption frequency is recommended.

Telescopic Observers' Notes, March–April 1995

Malcolm J. Currie

Abnormal clear weather blessed many parts of Europe around the turn of the year. Already, the Telescopic Commission has reports of 327 meteors from December 29 to January 6 by Javier Méndez Álvarez, Chris Hall and myself. These should yield information about the Coma Berencids and the Quadrantids, though few of these data were obtained on January 3-4, the Quadrantid visual maximum. The best telescopic activity from the Quadrantids was in the two pre-dawn hours on January 2 ($\lambda_\odot \approx 282\overset{\circ}{.}7$). The actual maximum cannot be determined as we still do not have observers in North America and Asia.

The Geminids were not similarly favored. From the United Kingdom, December 8-9 was clear and the Geminid activity was greater than expected. A net 5.9 hours yielded 73 meteors of which 15 are probably Geminids. Chris Hall was fortunate on December 13-14 to see 20 meteors in 1.55 hours in a pre-dawn session after moonset, though hampered by poor skies. Chris Hall and myself were also able to gather some data between December 3 and 5. These data have only had a superficial inspection at best. No doubt many results will come once fully analyzed.

Forthcoming events

This is the time of year most observers rest on their laurels. This is understandable; the weather is usually poor and unpleasant, activity reaches its annual nadir, and there are not many showers, and those that are present only give one a respectable display. Perhaps the notes should end here... but the very fact that so few people look out could easily conceal new showers, especially those comprising faint meteors. The meteor flux is dynamic—showers come and showers go—so the only way to follow it is by regular observation. Given the paucity of data during this season, it may offer the best chance of finding a new or previously unknown radiant. One prominent example during this period is the π-Puppid shower first seen in 1972.

The observing strategy is to use a series of field centers at approximately the same declination (but not within 30° of the pole) separated by about 20°–30° and that will attain an altitude of 40°–70° during the observing session. Start with the westernmost field center. Then alternate between it and its adjacent field, perhaps twice if the duration of each watch is under 30 minutes. As the sky revolves switch to a new pair to the east, and so on. For example, if you had four fields labeled A–D, the order could proceed ABABCDCD, or my favorite ABACBDCD, for a 4-hour session. Shorter sessions can sometimes suggest the presence of a "new" radiant, but we are often thwarted by small-number statistics, and the result is inconclusive. Results from earlier years can sometimes be combined to confirm the shower, however, best results come from extended sessions, and after midnight. Also for a potential new radiant to be believed there must be independent corroboration.

So, the bottom line is that we need more telescopic observers doing more watching during the first half of the year. During March and April, the fields used for the Virginids can double up to look for any other minor showers in that region of the sky. The lower sporadic rate will make any weak shower more prominent above the noise. Those at high northern latitudes, say at least 55° N, might try charts 80, 82, 83, and 84 instead.

The best-known minor shower of this period is the *Virginids*, and the main target for the *IMO* Telescopic Commission during this period. Planetary perturbations have divided it into numerous low number density and overlapping streams clustered around the ecliptic giving weak showers rich in faint meteors that last from February to May, though best rates are during March and April. Several maxima have been claimed to exist, presumably due to the separate radiants. There is great uncertainty as to the durations and locations of these components, and indeed whether some really exist or not. Although meticulous observations by Hoffmeister mapped out nine showers and many radiants, visual watches tend to show these as "clouds" rather than distinct radiants.

We believe that telescopic plots can pinpoint the individual components. During the 1994 campaign, Javier Méndez Álvarez and Chris Hall amassed 135 telescopic meteors in 20.77 hours. This excellent series of observations was made during ten nights from March 14-15 to April 14-15, including seven of the nine nights from April 6-7. Their plots indicate that these clouds *are* resolvable into individual radiants. There must be the usual caveat that the numbers of Virginids seen was small, and the results can only be regarded as preliminary. We shall need many more patient observers contributing accurate visual and telescopic plots over a few more years before we can be confident of our conclusions.

In 1995, we can fill in some of the gap in late March and the first week of both March and April. Use charts 124–126 and 147 during early March; replace 147 with 128 in late March and early April; and select 125, 126, 128, and 129 in late April. The changing fields are to keep pace with the eastward motion of the Virginid complex. Try to use at least three fields per night. An apparent radiant seen from several field centers is far less likely to have arisen by chance alignments. Because of the density of radiants it is vitally important for watchers to concentrate on plotting the meteor trail as carefully as possible. The critical parameter is the orientation of the meteor. The long paths and slow angular speeds of the Virginids should help to achieve high accuracy.

The *Lyrids* are not rich in faint meteors and so can be regarded as a minor shower for the telescopic watcher. On occasion this shower can give strong returns, some five times or more the normal visual peak. As far as I know, such an outburst has not been studied telescopically. Points of interest would be the radiant properties and the population index, so that they could be compared with normal maxima. These outbursts are not common, but no clear periodicity has been established, so it is always worth observing the Lyrids just in case. In a typical year the aim of telescopic observation is to determine the radiant location and size. This year there is a last-quarter Moon near the shower's maximum, though it rises only around 1^h local time at mid-northern latitudes. The radiant is low in the north east until about 23^h local time, thus watches need to continue well after midnight to see many of the fast-moving Lyrids. Suggested chart pairs are 67 and 69, and 109 and 111, located about 15° from the radiant.

Theoretical Radiants of Minor Planets and Comets

Dirk Artoos

Below is a list of theoretical radiants of minor planets and comets, some of which may cause meteor activity during March and April.

Table 1 – Theoretical radiants of asteroids and comets in March–April 1995.

Name	$\lambda_\odot$	Date	α	δ	V_∞	Distance
P/1845 III	341°.29	Mar 02	285°	− 3°	61 km/s	0.03158 AU
1994 XM1	342°.32	Mar 03	18°	−11°	16 km/s	0.09759 AU
P/1907 IV	346°.40	Mar 07	352°	−13°	32 km/s	0.06019 AU
P/1993 V	346°.84	Mar 07	79°	−70°	37 km/s	0.12926 AU
P/1830 II	350°.30	Mar 11	304°	− 9°	58 km/s	0.17648 AU

Table 2 – (continued).

Name	$\lambda_\odot$	Date	α	δ	V_∞	Distance
1993 VA	351°38	Mar 12	17°	−18°	16 km/s	0.08415 AU
1993 UC	352°21	Mar 13	36°	−43°	23 km/s	0.08942 AU
Geographos (1620)	353°57	Mar 14	194°	+34°	16 km/s	0.08114 AU
P/1097	355°02	Mar 16	202°	+14°	42 km/s	0.04961 AU
P/1983 IV	357°04	Mar 16	271°	−54°	70 km/s	0.17648 AU
Midas (1981)	357°16	Mar 18	214°	+33°	30 km/s	0.00054 AU
P/1683	357°57	Mar 18	211°	−50°	54 km/s	0.05549 AU
P/1804	358°40	Mar 19	32°	−74°	36 km/s	0.12367 AU
P/1763	359°56	Mar 20	314°	+22°	47 km/s	0.01485 AU
Seneca (2608)	359°17	Mar 20	124°	−35°	16 km/s	0.08940 AU
P/1877 I	1°33	Mar 22	280°	−39°	74 km/s	0.17510 AU
1994 GL	3°96	Mar 25	306°	−27°	15 km/s	0.01528 AU
P/1686	6°01	Mar 27	343°	+17°	40 km/s	0.09983 AU
P/1931 III	8°05	Mar 29	40°	−57°	30 km/s	0.16130 AU
P/1556	8°17	Mar 29	186°	−32°	36 km/s	0.08278 AU
P/1969 VII	8°56	Mar 29	31°	− 4°	24 km/s	0.01095 AU
P/1907 II	10°39	Mar 31	310°	−60°	60 km/s	0.00375 AU
Aristaeus (2135)	10°47	Mar 31	30°	−37°	21 km/s	0.01039 AU
P/1834	11°07	Apr 01	187°	−10°	32 km/s	0.06443 AU
Bacchus (2063)	11°16	Apr 01	351°	+22°	16 km/s	0.06746 AU
P/1941 IV	12°54	Apr 02	265°	−17°	69 km/s	0.11101 AU
P/1917 II	12°64	Apr 02	300°	− 9°	69 km/s	0.01458 AU
1994 GK	13°67	Apr 03	19°	+21°	19 km/s	0.00305 AU
Antinous (1863)	13°83	Apr 03	205°	+31°	20 km/s	0.17877 AU
1991 GO	14°92	Apr 05	10°	+21°	22 km/s	0.02869 AU
1986 PA (4034)	18°04	Apr 08	20°	−15°	19 km/s	0.13145 AU
1994 GV	19°13	Apr 09	66°	+24°	14 km/s	0.00010 AU
P/1580	22°22	Apr 12	333°	+33°	43 km/s	0.14180 AU
Seneca (2608)	22°55	Apr 12	104°	−38°	16 km/s	0.15663 AU
P/1885 III	24°44	Apr 14	180°	−72°	42 km/s	0.12509 AU
P/1830 I	26°62	Apr 17	119°	−35°	22 km/s	0.07527 AU
P/1882 I	26°70	Apr 17	358°	−13°	51 km/s	0.00762 AU
P/1894 II	27°81	Apr 18	355°	−61°	50 km/s	0.08086 AU
P/1737 I	27°84	Apr 18	218°	−25°	41 km/s	0.12616 AU
P/1957 IX	28°47	Apr 18	331°	−24°	67 km/s	0.01973 AU
1994 GL	28°91	Apr 19	271°	−31°	15 km/s	0.01343 AU
1993 VW	28°97	Apr 19	49°	− 7°	16 km/s	0.06335 AU
1994 XG	30°22	Apr 20	186°	−32°	20 km/s	0.09409 AU
P/1861 I	31°87	Apr 22	273°	+34°	48 km/s	0.00294 AU
P/1864 III	32°43	Apr 22	279°	+14°	57 km/s	0.13829 AU
P/1848 I	32°91	Apr 23	4°	−30°	56 km/s	0.16195 AU
P/1972 II	33°33	Apr 23	107°	−45°	19 km/s	0.00135 AU
P/1987 X	33°34	Apr 23	107°	−44°	19 km/s	0.00667 AU
1987 KF (5511)	33°95	Apr 24	36°	− 5°	24 km/s	0.19837 AU
P/1849 III	34°16	Apr 24	260°	+31°	42 km/s	0.13128 AU
P/1830 I	34°17	Apr 24	113°	−34°	22 km/s	0.08608 AU
P/1844 II	35°19	Apr 25	290°	+ 6°	67 km/s	0.07275 AU
P/1748 II	35°26	Apr 25	253°	+26°	46 km/s	0.09439 AU
P/1702	35°57	Apr 26	44°	+11°	28 km/s	0.02909 AU
P/1911 VI	36°67	Apr 27	321°	+24°	58 km/s	0.02501 AU
P/1790 III	36°96	Apr 27	321°	+20°	60 km/s	0.05810 AU
P/1698	39°76	Apr 30	328°	− 7°	71 km/s	0.10126 AU

Fireballs and Meteorites

Fireballs Spotted by US Defense Satellites

communicated by SrA. Amy Webb, AFTAC Public Affairs

Three fireball events recorded by United States Department of Defense satellites are described.

Visible light sensors aboard two Department of Defense satellites recorded the bright flash of a meteoroid impact into the atmosphere at $3^h43^m15^s$ UT on December 7, 1994. Times of these recordings coincided with eyewitness reports of a bright fireball in the Fort McMurray/Fort Chipewyan region of northern Alberta ($\varphi = 58\overset{\circ}{.}5$ N, $\lambda = 110°$ W). Using a 6000 K black-body model for the flash, the radiant intensity measured by the satellites was 8.5×10^9 Watts/steradian, corresponding to a visual magnitude of -18.4. Radiant energy of the event, using the same model, was 8×10^9 Joules.

A second bolide event was detected by visible light sensors on three Department of Defense satellites on December 16, 1994, at $9^h41^m02^s$ UT. The event occurred at $\varphi = 42\overset{\circ}{.}33$ S and $\lambda = 28\overset{\circ}{.}2$ E at an approximate altitude of 30 km. Radiant intensity (6000 K black-body model) was 3×10^{10} Watts/steradian, corresponding to a visual magnitude of -19.97. Radiant energy, same model, was 5×10^{10} Joules.

Optical light sensors aboard three Department of Defense satellites recorded the bright flash of a fireball in the atmosphere at $10^h17^m25^s$ UT on January 18, 1995. The location of the event was estimated to be $51\overset{\circ}{.}5$ N by $115\overset{\circ}{.}4$ E at an altitude of 25km. The peak radiant intensity, measured by a 6000 K black-body model, was 3.25×10^{10} Watts/steradian, corresponding to a visual magnitude of -19.7. Radiant energy of the event, determined using a 6000 K black-body model, was 9×10^{10} Joules.

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Impact Craters in North America

summarized by Graham W. Wolf

Increasingly, geologists in North America are finding a number of impact craters of up to nearly 200 kilometers in diameter, with a high concentration existing, for example, in both Western Canada and Oklahoma, USA. These craters are detected by gravity "wells" and magnetic anomalies at their surface. Furthermore, at the outer edge of these impact craters are found large oil deposits and kimberlite pipes with associated diamond formations, both of which have considerable commercial possibilities. Increasing evidence for a rain of small asteroids on the Earth's surface some 65 million years ago, gives extra support to the KT (Cretaceous-Tertiary) extinction theory of Luis and Walter Alvarez of Berkeley in California, which was first postulated in the late 1960s.

This is an edited summary of some of the meteoritics-related information in a lecture given in April 1993 by Professor Don Lawton, a born New Zealander working in Canada, to the Royal Society of New Zealand's Wellington Branch Geology Section in Thorndon, Wellington.

1. Impact craters and the KT boundary

There are believed to be some 130 documented impact craters on the Earth, perhaps the most famous being the Barringer Crater in the USA, which by world standards is rather small, being some 1.2 kilometers in diameter and only a few hundreds of meters deep. There are many much larger examples, for instance the Houghton crater in Canada, which is 30 km in diameter. This particular crater has been found to have an 800 nanoTesla magnetic anomaly at its center, and a tell-tale gravity "well."

Chicxulub is perhaps the best known large impact crater, being some 180 km in diameter (the largest discovered so far), and believed to have been formed by a 10 to 12 km diameter object. The crater is located on the edge of the Yucatan peninsula in Southeast Mexico.

Chicxulub is widely regarded as the best suggested site for a massive impact crater that may have killed off the dinosaurs, during a period in time geographically marked by the KT boundary: a region in rock structure that dates back some 65 million years in time, and is often characterized by high levels of the rare substances iridium and rubidium. Luis Alvarez of Berkeley suggested that the levels of these two substances, which are rare on Earth, could have only been contributed from outer space in the form of a massive meteorite impact, either by a comet or small asteroid. This "smoking gun" theory, dating back to 1965, appears to be gaining credence in scientific circles. Iridium samples in the KT boundary have now been found in about 100 world-wide sites.

Pilkington and Green found what appears to be meteorite ejecta from Chicxulub at Haiti, Cuba, and several regions ringing the Gulf of Mexico. Distinct tsunami deposits were also found in these areas. Specialized argon-argon dating has established these deposits as being 65 ± 0.2 million years old. The 40 km Manson impact crater in Iowa has been similarly dated by the same isotope methods.

Small but distinct lamellae, similar to that in meteorite Widmanstätten patterns, have been found in quartz crystals from meteor impact sites. Metamorphism of rocks generally requires 100 GigaPascals pressure. At pressures above 500 GPa, even the toughest rocks generally start to melt.

2. Simple and complex impact craters and commercial considerations

Impact craters that are up to 4 km in diameter, are called "simple craters" such as the famous Barringer Crater. Larger ones are called "complex craters," such as the Manicoagan Crater (some 70 km diameter) in Canada. Most of these larger "complex craters" have a central upwelling or "island" that may be several hundred meters in elevation above the outer crater floor, in some cases as great as one kilometer. These impact craters generally take the shape of a giant annulus.

Geographical modeling of impact craters suggests that at speeds greater than 15 km/s, the propagation of shock waves is at a greater velocity than the elasticity of the underlying rocks themselves. The impact shock waves rebound off the lower rock strata, causing an outer expulsion of crater ejecta, and the characteristic raising of the crater rim.

Kimberlite pipes—chimney-shaped structures which contain concentrations of diamonds—are found near impact craters, although a direct correlation is difficult to understand, since these structures are believed to be the result of eruptive volcanism.

Impact craters seem to be more common than first thought, and are geographically as well as commercially significant. It appears that the impacts crush underlying rock down to a depth of up to a few kilometers, creating a porous breccia, which can act as an oil "sponge," to accumulated any deposits lying underneath in the Precambrian layers of rock. Also, rocks are fissured down to a depth of some 8 km or more, well into the Precambrian layers, and this creates a capillary action, which "sucks" up the oil-bearing material into the porous breccia, where it can be commercially extracted. The Oklahoma region in the USA is a notable case, where a large concentration of oil deposits have been found around the edges of an equally large number of impact craters.

Speculation abounds as to the cause of the KT extinction some 65 million years ago. Was it solely due to a comet or small asteroid impacting on the earth simultaneously over a small period of several years, giving rise to an asteroid bombardment theory? Research into these and other questions regarding the KT boundary continues.

A Summary of Recent Falls and Finds

compiled by Graham W. Wolf

At 1^h26^m a.m. local time, some 72 km above Puerto Rico, on April 8, 1989, a −10 fireball appeared and was recorded by 5 instruments from 3 separate sites on the island. It exploded at 28 km altitude about halfway between Arecibo (where the giant radio telescope is located) and Ponce, to the south. This was the first observation of the Arecibo Initiative on Dynamics of the Atmosphere (AIDA). Debbie L. Knutson of Whitworth College recalls that at 1^h26^m a.m. local time, she heard a whistling noise (apparently an electrophonic sound), and looked up to see the fireball, dubbed "bolide Aida," throwing off sparks, and eventually breaking up into two pieces before disappearing behind local hills.

John D. Mathews of Pennsylvania State University suggests the fireball was probably a member of the χ-Virginid stream, and had entered the Earth's atmosphere at a height of 72 km and a velocity of 20 km/s. It then slowed to about 3 km/s before exploding into 4 pieces about 28 km up. The estimated mass of the fireball was some 25 kilograms [1].

At 7^h00^m p.m. local time on August 31, 1991 (0^h UT on September 1), Broadie Spaulding (13 years) and Brian Kinzie (9 years) had an extremely close call with a fist sized meteorite in Noblesville, Indiana, some 30 km north of Indianapolis, USA. Standing in Spaulding's front yard talking to each other, they heard a low pitched whistle followed by a thud nearby. Walking just 3.5 m from where they had been standing, they found a crater 9 cm wide and 4 cm deep. The rock was analyzed by scientists from Purdue University and found to be an unusual type of chondrite [2].

In the 1850s in the Atacama Desert in Chile (not very far from the European Southern Observatory), local miners discovered metal rich rocks lying about the plains, which they melted down for their iron ore. Little did they know then, that the strange "rocks" were meteorites from the Vaca Muerta (Dead Cow) fields. By the turn of the twentieth century, only about 45 kg out of an estimated 3 tons were known to exist in collections.

Forgotten for a century or so, a curious geology student, Edmundo Martinez, found a 300 kg chunk in 1985. Information about this long forgotten meteorite field, stretching several kilometers, reached Harri Lindgren of the La Palma Observatory, who with two colleagues spent the next four years investigating and establishing the extent of the field, and collecting specimens. About 4 tons from an estimated original mass of 6 tons has now been recovered. The Vaca Muerta meteorites are of a rare type called mesosiderites, that is, part stone and part iron. The Vaca Muerta find nearly triples the existing mass of this type, and probably fell in the last 3500 years [3].

[1] *Sky and Telescope*, November 1990, pp. 468–469.

[2] *Sky and Telescope*, April 1992, p. 372.

[3] *Sky and Telescope*, December 1992, p. 61.

Sinuous meteor photographed? (*communicated by Cis Verbeeck*)

Curved meteor trails have at regular intervals been a hot topic of debate in this journal. In the Letters' Section of the February 1992 issue (*WGN* 20:1, pp. 56–57), Martin Beech discusses a sinuous meteor trail observed in 1852 in the Belgian province of Namur. Via the internet, John Walker (`kelvin@fourmilab.ch`, `http://www.fourmilab.ch/`) communicated a photograph taken after midnight UT on the morning of August 13, 1994, about 15 km northeast of Neuchatel, Switzerland, showing a sinuous meteor trail. According to Dr. Hawkes, most sinuous meteor trails are artifacts, but the present one looks as it could be genuine. This image is in the public domain.

Observational Results

The 1994 η-Aquarids in Southern Brazil

Gilberto Klar Renner

An overview of 1994 η-Aquarid observations from Southern Brazil is given. Rates were somewhat higher than expected.

Four people who observed the η-Aquarids almost every year since 1983 once more watched that shower on May 6 an 7 in 1994. The hourly rates were higher than our expectations on May 6, because the sky was not very good: there was some fog and moonlight, and the radiant had an elevation of only 37°. On that night, several bright meteors were seen.

The author calculated the ZHR values for these dates assuming a population index r of 2.5. A very bright meteor appeared near the radiant on May 7. It had a magnitude of −5 at least and it presented a double flash of blue and green light, according to different observers.

The following observers participated in the η-Aquarid observations:

Darlan Moraes, Gilberto Klar Renner, Luís Antônio da Silva Machado, and Luís Antônio Reck de Araújo.

Tables 1 and 2 present an overview of our observational results.

Table 1 – An overview of the activity of the η-Aquarids in 1994 as observed in Southern Brazil. The solar longitude $\lambda_\odot$ is given relative to the equinoctium 2000.0

$\lambda_\odot$	Date	T_{eff}	Obs	$\overline{Lm}$	η-Aqr	$\overline{m}_{\eta-\text{Aqr}}$	ZHR	Spor	$\overline{m}_{\text{Spor}}$
46°05	May 6	1.23	4	+5.4	91	+1.84	114 ± 23	40	+3.02
47°04	May 7	2.33	3	+5.7	157	+2.66	84 ± 19	66	+2.57

Table 2 – Magnitude distribution of the η-Aquarids and sporadics on May 6 and 7, 1994.

Shower	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	Tot	$\overline{m}$
η-Aquarids	3	1	2	4	3	7	38	50	78	60	2	248	+2.36
Sporadics	0	0	0	0	0	6	9	25	32	34	0	106	+2.74

Radio Observations of the 1994 Leonids in Japan

Kazuhiro Suzuki[1] *and Takuji Nakamura*[2]

Japanese radar observations of the 1994 Leonids are described. Enhanced activity was registered for about 6 hours around $\lambda_\odot = 235.^\circ4$ (eq. 2000.0).

Leonid activity was detected by monitoring forward-scattered meteor echoes of the MU radar wave of Kyoto University (46.5 MHz, 1 MW) at the Damine Meteor Observatory (DMO), Aichi, Japan. The observation was carried out from 10^{h} UT on November 17 to 7^{h} UT on November 18, 1994 for 21 hours, at DMO ($\varphi = 35.^\circ07$ N, $\lambda = 137.^\circ53$ E), located about 150 km east north-east from the radar site ($\varphi = 34.^\circ85$ N, $\lambda = 136.^\circ10$ E).

[1] Kozakai Senior High School, Aichi, Japan
[2] Radio Atmospheric Science Center, Kyoto University, Japan

The variation of hourly rates of meteor echoes (with minimum amplitude of at least 106 dBm) was plotted in Figure 1 in which the non-shower period (November 4–6, 1994) and the shower period November 17–18, 1994) are compared.

The hourly echo rate clearly increased from November 17, 20^h UT, to November 18, 2^h UT, compared to the average of November 4–6, and reached 80–135 (about 60–110 on November 4-6). This increase of the echo rate is considered to be due to the activity of Leonid meteors, and the corresponding solar longitude was $\lambda_\odot = 235\overset{\circ}{.}4$ (eq. 2000.0). The hourly rate of long-duration echoes (more than 20 seconds) (numbers indicated between brackets in the plot) increased remarkably to 3–5 times the usual value.

Thus, it seems evident that the activity of the Leonids meteor shower has already started increasing towards 1998–99.

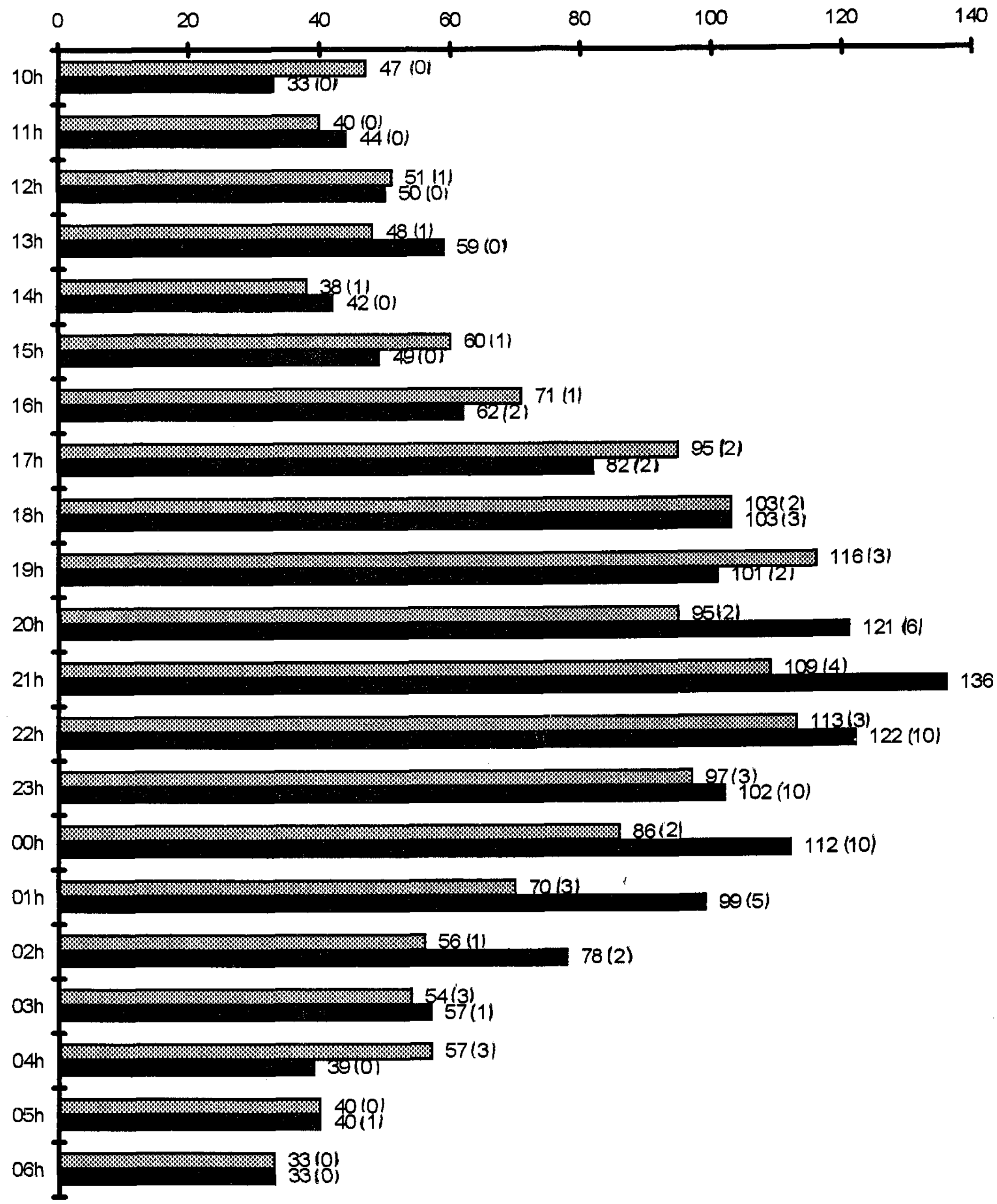

Figure 1 – Radar meteor echo rate on November 17 and 18 UT, 1994, at DMO by using the MU radar (46.5 MHz M-Mode) wave.

High Leonid Activity in Rumania

Valentin Grigore

A high Leonid activity was observed by the author on November 17-18, 1994, from Targoviste, Rumania, $\lambda = 25°29'00''$ E, $\varphi = 44°57'18''$ N, $h = 350$ m.

Two persons observed the Leonids in Rumania. Vasile Micu in Hunedoava enjoyed a clear sky only a short time after the radiant's rise. After that, the sky became clouded. Fortunately, I had a clear sky 400 km southeast from this place, in Targoviste.

I started my watch at 0^h22^m UT, and immediately saw a −3 bluish Leonid. After 0.2 hours of effective observing time in which 5 Leonids were seen, I realized that the activity was higher than normal. The periods with good activity alternated with low activity periods (see Table 1). The largest activity occurred between 3^h26^m and 3^h36^m UT: 13 meteors in 8 minutes of effective observing time. The period with the brightest meteors started at 3^h34^m and ended at 3^h45^m UT: 5 meteors among which one of magnitude −3, −5, and −6.

Eight Leonid fireballs were observed. The brightest was −6 and yellow with a persistent train lasting 3 seconds, appearing at $3^h44^m42^s$ UT in Ursa Minor. The most spectacular one was a −5 yellow fireball with a white −2 persistent train lasting 3 seconds, which lit up at $3^h36^m08^s$ UT at a height of 10°–15° above the northeast horizon. Some meteors (not fireballs) had greenish or yellow-orange persisting trains lasting 3 or 4 seconds.

Tables 2 and 3 show that the enhanced activity coincided with an increase of brighter meteors.

Although the Moon was Full, 44% of the Leonids featured a persistent train (compared to none of the sporadics).

During the observation, I also took photographs with a 50 mm/1.8 camera and Azopan 400 ASA film. Two possible Leonids were captured.

Table 1 – High activity periods alternate with low activity periods of Leonids observed by the authors on November 17–18, 1994.

Period (UT)	T_{eff}	Lm	Leo	Spor	Comments
00^h22^m–00^h32^m	0.10	4.5	4	1	fireball, −3
00^h32^m–00^h50^m	0.25	4.5	1	2	
00^h50^m–00^h55^m	0.07	4.5	2	0	
00^h55^m–01^h06^m	0.18	4.5	0	0	
01^h06^m–01^h17^m	0.16	4.5	4	0	
01^h17^m–01^h25^m	0.13	4.5	0	0	
01^h25^m–01^h28^m	0.05	4.5	3	1	
01^h28^m–02^h12^m	0.65	5.0	7	2	fireball, −3 1 meteor every 5–7 minutes
02^h12^m–02^h26^m	0.20	5.0	8	1	fireballs, −3, −4
02^h26^m–03^h24^m	0.88	5.0	10	2	
03^h26^m–04^h03^m	0.48	5.0	27	1	fireballs, −3, −3, −5, −6 sometimes 3 meteors per minute

Table 2 – Rate data of the author's observations on November 17–18, 1994.

Period (UT)	T_{eff}	Lm	Leo	Spor
00^h22^m–01^h37^m	1.11	4.5	14	4
01^h37^m–02^h48^m	1.06	5.0	17	4
02^h48^m–04^h03^m	1.02	5.0	35	2

Table 3 – Magnitude distribution of the Leonids observed by the author on November 17–18, 1994. The three first lines give the magnitude data for the Leonids, whereas the last line concerns the sporadics.

Period (UT)	-4^-	-3	-2	-1	0	+1	+2	+3	+4	Tot	$\overline{m}$
00^h22^m–01^h37^m		1	0.5	4.5	1.5	2.5	2.5	1.5		14	+0.25
01^h37^m–02^h48^m	1	2	1	1	6	4	0.5	1	0.5	17	−0.18
02^h48^m–04^h03^m	2	2	3	3.5	9	9	4.5	2		35	−0.07
00^h22^m–04^h03^m					3	3	2	2		10	+1.30

The 1995 Quadrantid Maximum in the Netherlands

Impression and First Preliminary Results

Marco Langbroek

An impression of and a preliminary activity curve resulting from observations of the 1995 Quadrantid maximum by members of the *Dutch Meteor Society* are given. A maximum near $2^h15^m \pm 45^m$ UT and peak ZHR near 150 are found, agreeing closely with data in [1].

Early January is notorious for its often extremely bad weather conditions in the Netherlands. As a consequence, recent history has seen very few opportunities to observe the maximum of the Quadrantid meteor stream on January 3-4. But finally, in 1995 Dutch observers got what they had been longing for so many years. Though weather conditions caused some "suspense" among observers until noon of January 3 (by then it had finally cleared in the whole of the country), the maximum night would prove to be clear, allowing a view on the Quadrantid maximum which is as good and unprecedented in recent Dutch observational history.

Some 25 observers in the *Dutch Meteor Society*, spread across the country, challenged temperatures of −8° to −9° C, often for a period of 13 hours. At four sites (Rha, Biddinghuizen, Bosschenhoofd, and Oostkapelle) photographic activities with multi-camera stations were employed.

The night started with low numbers of Quadrantid meteors, about 15 an hour on average. As time passed, and both maximum approached and the radiant climbed higher in the sky, meteors became more numerous. At the end of the night, most observers counted 90 to 110 Quadrantids per hour and things by time became quite hectic at the observational sites. Several observers commented that at times the situation to them was a bit reminiscent of the "good old days" of the 1993 Perseids in the Provence. When dawn ended the observational night around 6^h15^m UT, each observer had gathered respectable numbers of meteors (between 500 and 700 for those who had been active for the whole night).

A few Quadrantid fireballs, up to magnitude −5 (twice), were seen during observations. Before observations started, the author noticed a very brilliant fireball (sporadic) of at least magnitude −5 to −6 in very early twilight (16^h16^m UT, virtually no stars to be seen) while setting up the equipment at Biddinghuizen. Another one, probably a Quadrantid, was seen in a bright orange and blue morning dawn sky, absent of stars, through the windscreen of the car around 7^h15^m UT by Casper ter Kuile and the author while driving home, and by members of the team at Rha.

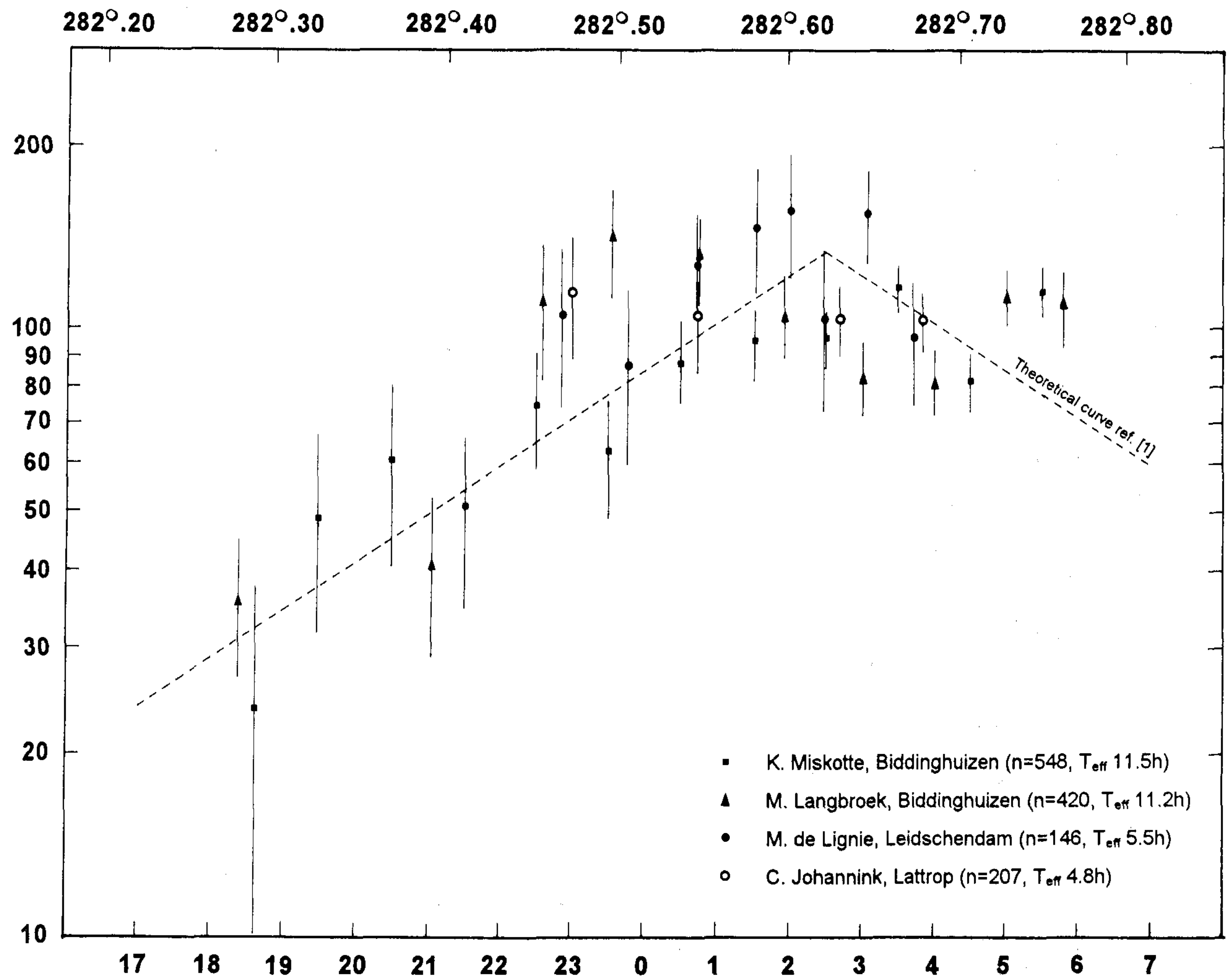

Figure 1 – ZHR plot from observations of the 1995 Quadrantids by members of the *Dutch Meteor Society* on January 3-4, 1995. Times refer to UT and solar longitudes to eq. 1950.0. For more details, see the text.

Both photographically and visually, the campaign was very successful. Each station photographed between 80 and 150 meteors this night. We expect some 50–100 of them to be simultaneously photographed between two or more stations. As this article is written (January 9, 1995), we are still in the process of sorting them out. Visually, the total number of observed meteors will most probably amount to some 10 000, I estimate (as the campaign ended only a few days ago, not all observers have sent in their observations yet).

Figure 1 gives some preliminary results based on observations by four experienced observers of whom observational results were quickly available (Koen Miskotte, Marc de Lignie, Carl Johannink, and the author). ZHRs have been calculated following the procedure outlined in [1]. A recent study by Peter Jenniskens [1] into the activity behavior of some 50 meteor streams has shown that meteor stream behavior is well represented by a set of exponential curves, resulting in straight lines when activity is plotted on a single logarithmic scale against solar longitude. Common annual meteor stream behavior can be expressed by the following equation:

$$\mathrm{ZHR}_{\lambda_\odot} = \mathrm{ZHR}_{\max} \times 10^{-B|\lambda_\odot - \lambda_{\odot,\max}|},$$

or in a few selected cases (streams with a steep main peak superimposed on a shallow more extended background) by a combination of two such curves [1]. It is found that the exponential slope B, $\mathrm{ZHR}_{\max}$, and of course $\lambda_{\odot,\max}$, are typical for each stream and do not vary much from year to year.

For the Quadrantids, Jenniskens gives a $\mathrm{ZHR}_{\max}$ of 133 ± 16, a B-value of 1.8 ± 0.4 and a maximum at $\lambda_\odot = 282\overset{\circ}{.}62 \pm 0\overset{\circ}{.}03$, equinox 1950.0 [1]. Using these parameters in the equation mentioned above, this results in the activity behavior which is shown as a dashed line in Figure 1. The theoretical maximum for the 1995 Quadrantids should be expected at $2^h30^m \pm 40^m$ UT. From a symmetrical fit to the preliminary observational results depicted in Figure 1, I find a maximum near $2^h15^m \pm 45^m$ UT ($\lambda_\odot = 282\overset{\circ}{.}61 \pm 0\overset{\circ}{.}03$, equinox 1950.0), a maximum ZHR of about 150 and a B-value of about 2.1. Within uncertainties, the theoretical behavior according to [1] and the preliminary results on observed behavior depicted in Figure 1 are identical.

From the magnitude estimates by the mentioned four observers, I find a mean population index r of 2.4 (but again note that this is a very preliminary result, perhaps—or, rather, probably—subject to change when more data are added and more strictly reduced). This agrees quite well with the r-value of 2.5 which [1] gives for the Quadrantid maximum.

Acknowledgments

I thank Koen Miskotte, Marc de Lignie, and Carl Johannink for quickly providing their observational data, and Hans Betlem for some practical advice. The author wishes to express his gratitude to Lizzie and Koen Miskotte and Casper ter Kuile for housing him during the campaign and its aftermath.

Reference

[1] P. Jenniskens, "Meteor Stream Activity I. The Annual Streams", *Astronomy and Astrophysics* 287, 1994, pp. 990–1013.

The 1995 Quadrantid Maximum in Hungary

István Tepliczky

An account is given of Hungarian Quadrantid observations during the night of maximum. In the first part of the night, low activity was recorded, while in the last part of the night, very high activity was registered.

The *Hungarian Astronomical Association*'s Meteor Section organized an expedition to observe the Quadrantid's maximum on January 3-4, 1995. At Matra Hills, our observing site, observing conditions were ideal: the temperature was around −10° C without snow; only weak winds disturbed us. The limiting magnitude was +6.3. We started our observing run at 17^h20^m UT on January 3, when activity was low. Five observers (Ferenc Fodor (FODFE), Ákos Kereszturi (KERAK), Gabor Kutrovatz (KUTGA), Krisztián Sárneczky (SARKR), and Krisztián Wieszt (WIEKR)) counted 99 meteors, among which 53 were Quadrantids and 46 others until 20^h50^m UT. The coordinator of the observations was István Tepliczky (TEPIS).

Table 1 – Rate data for the Hungarian observations of the 1995 Quadrantid maximum.

Period (UT)	Obs	T_{eff}	Lm	Quad	Spor
17^h20^m–20^h50^m	FODFE	3.49	5.9	13	11
17^h20^m–20^h50^m	KERAK	3.49	6.0	19	14
17^h20^m–20^h50^m	KUTGA	3.49	6.1	27	10
17^h20^m–20^h50^m	SARKR	3.49	6.3	22	21
17^h20^m–20^h50^m	WIEKR	3.49	6.1	24	20
01^h30^m–03^h30^m	KERAK	2.00	5.9	139	12
01^h30^m–03^h30^m	SARKR	2.00	5.9	153	26

Between 21^h and 0^hh UT, we encountered some snow and fog, and the sky was covered as a result of a weak cold storm. After 0^h UT, the sky cleared. Between 1^h30^m and 3^h45^m UT, two observers (KERAK and SARKR) recorded exactly 300 Quadrantids and 40 other meteors, while the limiting magnitude was around 5.9. According to our results, maximum activity occurred around 3^h UT on January 4, 1995.

Table 1 contains a summary of the rate data.

Radio observations of the 1995 Quadrantid Maximum in Japan

Chikara Shimoda and Kazuhiro Suzuki

An overview is given of radio observations by members of the *Nippon Meteor Society* of the 1995 Quadrantid maximum in Japan. Maximum activity levels were somewhat higher that usual.

The 1995 Quadrantid meteor activity was detected by monitoring forward-scattered meteor echoes of the FEN Okinawa broadcasting wave (89.1 MHz, 6 kW, Okinawa, Japan) during January 3–6 UT, 1995 at the Shimoda Observatory ($\lambda = 137^\circ\!.9$ E, $\varphi = 36^\circ\!.1$ N), Nagano, Japan, located about 1500 km north-east of the broadcasting station ($\lambda = 127^\circ\!.7$ E, $\varphi = 26^\circ\!.2$ N).

Table 1 – Distribution of hourly forward-scattered meteor echo rates monitored during January 3–6 UT, 1995.

UT	Jan 3	Jan 4	Jan 5	Jan 6	h_{rad}
00^h		114	27	23	75
01^h		109	24	21	68
02^h		111	15	14	58
03^h		87	17	13	49
04^h		86	7	12	39
05^h		79	6	9	30
06^h		43	5	6	22
07^h		31	6	6	14
08^h	9	20	6	8	7
09^h	3	8	4	4	2
10^h	7	6	7	5	–
11^h	9	4	9	10	–
12^h	17	9	13		–
13^h	11	8	11		–
14^h	19	16	8		3
15^h	33	15	12		8
16^h	26	15	11		15
17^h	31	14	16		23
18^h	35	9	17		32
19^h	57	22	20		42
20^h	52	21	27		51
21^h	52	16	23		61
22^h	42	21	25		70
23^h	50	18	17		75

The distribution of hourly rates of meteor echoes observed during January 3-6 UT, 1995, is shown in Table 1. The highest Quadrantid activity level persisted for about 6 hours (0^h–6^h UT on January 4), and the maximum seemed to be centered at $\lambda_\odot = 283^\circ\!.3$ (eq. 2000.0). The maximum hourly rate of echoes reached 100–115 (compared to 15–25 when no shower was active[1] and about 80–90 during an average Quadrantid maximum[2])

The increase of the echo rates amounts to 5–7 (110/20 = 5.5) times more than usual non-shower activity, and 1.2–1.4 (110/85 = 1.3) times more than average Quadrantid activity.

1995 Meteor Summer School Announcement

Oleg Belkovich, Engelhardt Observatory

Last July, we organized the first Meteor Summer School at our Engelhardt Astronomical Observatory near Kazan, Russia. It was our first such experience.

Now we are going to organize for the *IMO* the 1995 Meteor Summer School. We can admit up to 20–30 people. The cost would be about 20 USD per day including meals and lodging, and will not depend on the number of participants. We can organize lectures on meteor astronomy, meteor physics, the theory of radar and forward scatter observations of meteors, our method of processing of meteor visual observations (in English); as well, there will also be room for a culture program. The event will be held in June–August 1995 over a period of 10–15 days. It is possible to organize several groups. We can admit also individuals at any time afterwards if a personal arrangement is made. All participants have to come to Moscow where our representatives will meet them and distribute train tickets to Kazan (return tickets costs about 35 USD). It is also possible to stay a couple of days in Moscow: meals, lodging, and excursions will cost 70 USD per day.

The Kazan University is the center of meteor research in Russia. There are about 30 people working in meteor astronomy and in meteor communications system design. The meteor radar works continuously. I would ask all the people interested taking part in the 1995 Meteor Summer School 1995 to contact me and answer the following two questions:

1. Which period(s) is (are) most convenient for you?
2. What subject in meteor astronomy would you like to have as a lecture?

Please communicate your answers via electronic mail only. My address is `oleg@astro.kazan.su`.

From the Meteor Library

compiled by Paul Roggemans

- *M. Beech, P. Brown, "Impact probabilities on artificial satellites for the 1993 Perseid meteoroid stream," Mon. Not. R. Astron. Soc. 262, 1993, L35-L36.*

It is argued that the new but short-lived maximum in the activity profile of the Perseid meteor shower may yield an enhanced meteoroid flux in 1993 August. An estimate of the impact probability of Perseid meteoroid stream particles with Earth-orbiting satellites is presented. The impact probability for objects comparable in size to the Hubble Space Telescope and the Space Shuttle is found to be small nut non-negligible. The probability of meteoroid impacts on the proposed Space Station is also discussed.

- *J. Jones, P. Brown, "Sporadic meteor radiant distributions: orbital survey results," Mon. Not. R. Astron. Soc. 265, 1993, pp. 524-532.*

The structure of the sporadic meteor complex is determined from the data in 10 orbital surveys. In addition to the previously known apex, helion, antihelion and northern toroidal sources, we find a southern toroidal source and a splitting of the apex source. The size of the sources and possible origin of meteoroids from each region are discussed.

[1] At 0^h–3^h UT on January 6.

[2] According to the results of radio observations in 1991 and 1987.

- *J. Jones, P. Brown, A.R. Webster, K. Ellis, "A forward-scatter determination of the radiant distribution of sporadic meteors," Planet. Space Sci. 42:2, 1994, pp. 127–134.*

This paper describes a method for using echo rates to determine the relative geocentric strengths of each of the diffuse sporadic radio-meteor sources found previously by Jones and Brown (*Planet. Space Sci.* 42, 1994, pp. 123–126) in the orbital surveys catalogued at the IAU Meteor Data Center. We have demonstrated the method by applying it to some data collected continuously between 1991 and 1992 with a "short-hop" forward-scatter system between London (Ontario) and Ottawa and find encouraging agreement for the relative source strengths found by other workers. Although our method needs some refinement, the results so far indicate that the strengths of the various sources are substantially constant throughout the year.

- *J. Jones, P. Brown, "The radiant distribution of sporadic meteors," Planet. Space Sci. 42:2, 1994, pp. 123–126.*

The radiant distribution of sporadic radio-meteors has been studied using six surveys catalogued by the IAU Meteor Data Center. In addition to the previously known Apex, Helion, Antihelion and Northern Toroidal sources, we have discovered a Southern Toroidal source and have confirmed that the Apex source may be split into Northern and Southern components.

- *M. Beech, P. Brown, "Space-platform impact probabilities—the threat of the Leonids," ESA Journal 18, 1994, pp. 63–72.*

Comet P/Tempel-Tuttle passes perihelion on February 28, 1998 and it is highly likely that in the interval from 1997 to 2000 the Earth will witness at least one meteor storm from the associated Leonid meteoroid stream. The very high meteoroid flux, and the contominant rise in the space-platform-meteoroid impact probability that could result from a Leonid meteor storm, poses a tangible threat to all Earth-orbiting space platforms.

- *P. Brown, Z. Ceplecha, R.L. Hawkes, G. Wetherill, M. Beech, K. Mossman, "The orbit and atmospheric trajectory of the Peekskill meteorite from video records," Nature 367, 1994, pp. 624–626.*

On October 9, 1992, a bright fireball appeared over West Virginia, traveled some 700 km in a northeasterly direction, and culminated in at least one impact: a 12.4 kg ordinary chondrite was recovered in Peekskill, New York. Fortuitously, the event was captured on several video recordings, which provide a detailed a detailed record of both the fragmentation of the object and related atmospheric effects. These are the first motion pictures of a fireball from which a meteorite has been recovered. We report here the preliminary analysis of 14 video recordings of the event, from which we determine the ground path and the original orbit of the object.

- *A.M. Stepanov, "The meteor streams detection by a correlation method," Astronomicheskij Vestnik 28:1, 1994, pp. 76–80.*

The method of meteor stream identification with the aid of meteor radar with arrival angle measurements is proposed. Some algorithms of image processing are used. Sensitivity of the method allows to increase time interval in which the stream is observed usually. Application to the Geminid radar observations in 1988 at Kazan allows to determine equatorial coordinates of radiant: $\alpha = 111°19' + 58' \times (\lambda_\odot - 260°)$ and $\delta = 32°09' - 12' \times (\lambda_\odot - 260°)$ (eq. 1950.0).

- *V.V. Sidorov, Rasim Amir Ali, "Determination of meteor velocity distribution over the celestial sphere from the observations by radar with arrival angle measurements," Astronomicheskij Vestnik 28:1, 1994, pp. 81–92.*

An algorithm for the determination of the meteor velocity disttibution over the celestial sphere is given. The discrete solution of the problem is based on observation by a radar with arrival angle measurements. Results obtained for observations in Kazan in 1986–1988, December 19–23, is given (velocity, flux, coordinates of the radiant and orbital elements). It was obtained that besides known showers (Geminids, Tuttle 1926) some unknown annual showers are active: with radiants ($\alpha = 233°$, $\delta = +45°$), ($\alpha = 111.°9$, $\delta = +46°$), ($\alpha = 106.°9$, $\delta = 27.°1$), ($\alpha = 105.°3, \delta = +08.°1$), and others.

- *J. Svorěn, L. Neslušan, V. Porubčan, "Applicability of meteor radiant determination methods depending on orbit type. II. Low-eccentric orbits," Contrib. Astron. Obs. Skalnaté Pleso 24, 1994, pp. 5–18.*

All known parent bodies of meteor showers belong to bodies moving in high-eccentricity orbits ($e \geq 0.5$). Recently, asteroids in low-eccentricity orbits ($e < 0.5$) approaching the Earth's orbit, were suggested as another population of possible parent bodies of meteor streams. This paper deals with the problem of calculation of meteor radiants connected with the bodies in low-eccentricity orbits from the point of view of optimal results depending on the method applied. The paper is a continuation of our previous analysis of high-eccentricity orbits. Some additional methods resulting from mathematical modeling are presented and discussed together with Porter's, Steel-Baggaley's, and Hasegawa's methods.

In order to be able to compare how suitable the application of the individual radiant determination method is, it is necessary to determine the accuracy with which they approximate real meteor orbits. To verify the accuracy with which the orbit of a meteoroid with at least one node at 1 AU fits the original orbit of the parent body, the Southworth-Hawkings D-criterion was applied. Then $D \leq 0.1$ indicates a very good fit of orbits, $0.1 < D \leq 0.2$ is considered for a good fit, and $D > 0.2$ means that the fit is rather poor and the change of orbit unrealistic. The optimal method, i.e., the one which results in the smallest D-values for the population of low-eccentricity orbits, is that of adjusting the orbit by varying both the eccentricity and perihelion distance. A comparison of theoretical radiants obtained by various methods was made for typical representatives from each group of the NEA (near-Earth asteroids) objects.

- *M. Gavajdová, "On the population of very bright meteors in meteor streams," Contrib. Astron. Obs. Skalnaté Pleso 24, 1994, pp. 101–110.*

The present paper summarizes the analysis of a set of 1028 photographic orbits of meteors with magnitudes brighter than −3. The analysis was made separately for subsets of the meteors brighter than magnitude −3, −5 −7, and −9. Fireball streams were sought using the method of Southworth-Hawkins' D-discriminant considering radiants, their daily motions, and sizes and shapes of the radiant areas. Most of the detected fireball streams belong to known meteor streams; a few of them were classified as new meteor streams. The mean orbits, radiants, periods of activity and velocities of the streams are presented in tables.

- *M. Šimek, "Fine structure of the 1985 Giacobinids," Astron. Astrophys. 284, 1994, pp. 276–280.*

Fine structure profiles of the 1985 Giacobinid meteor shower derived from the Ottawa Megawatt meteor radar are presented. The recorded meteor echoes were divided for the analysis into two groups: underdense, represented by meteor echoes having durations $T < 0.4$ s; and overdense, with $T \geq 0.4$ s. Maximum activity for underdense echoes occurred at 9^h25^m UT, October 8, when the ten-minute zenithal rate reached about 1200, and for overdense echoes the rate peaked at 10^h25^m UT with about 700 echoes. Mass distribution factor for underdense echoes $s = 2.06$ and that one for overdense $s = 2.11$ was found.

- *P. Jenniskens, "Meteor stream activity. I. The annual streams," Astron. Astrophys. 287, 1994, pp. 990–1013.*

Between 1981 and 1991, a small group of amateur meteor observers in Australia and the Netherlands counted meteors during 4482 hours of effective observing time. These counts have been reduced and are to be presented here as a first homogeneous set of some 50 meteor stream activity curves for all major and many minor streams on both hemispheres. Together with the sporadic background, these give an accurate picture of annual meteor activity. Empirical corrections are given that relate the observed meteor rates to well-defined ZHRs. It is found that all major streams are well represented by a set of exponential curves: $\mathrm{ZHR} = \mathrm{ZHR}_{\max} 10^{-B|\lambda_\odot - \lambda_{\odot,\max}|}$. Values of $\mathrm{ZHR}_{\max}$ and B are given. There is no evidence for stable sub-maxima in the activity profiles. In four, and possibly six, cases, there is evidence for a background component in the activity curve. In all cases, the background is more extended to small solar longitude $\lambda_\odot$. From a fit of the above dependence to the rates of minor streams, it is found that the slopes of the most high inclination ($i > 15°$) streams have a characteristic value of $B = 0.19 \pm 0.08$ per degree of solar longitude increase in $\log_{10}(\mathrm{ZHR})$. The ZHR is transformed into mass influx rates, from which the total mass in the meteoroid stream is estimated by making an assumption about the distribution of matter perpendicular to the path of the Earth. Total masses of the observed streams are of order 10^{14} to 10^{16} g.

- *D.O. ReVelle, Z. Ceplecha, "Analysis of identified iron meteoroids: possible relation with M-type Earth-crossing asteroids?," Astron. Astrophys. 292, 1994, pp. 330–336.*

We have used two different techniques to analyze the US Prairie Network fireballs in order to search for possible nickel-iron meteoroids. The first approach used is that of ReVelle and Rajan which is similar to the analysis carried out earlier by Wetherill and ReVelle in a series of papers relating first to the chondrites and later to fireballs of cometary origin. The second approach is a new technique developed by Ceplecha and co-workers that can simultaneously determine the presence and location of gross fragmentation events and also determine an effective ablation parameter during the fireball entry. Using this combined approach we have determined that seven fireballs among the 287 that were analyzed are likely to be iron in composition. Using the method of Ceplecha we have determined that none of these objects experienced any gross fragmentation events during their entry into the atmosphere and most of the meteoroids also exhibited rather large ablation coefficients during entry as well, a feature that is also characteristic of the ReVelle and Rajan approach. Six of these objects have orbits with their aphelia in the main part of the asteroid belt similar to those of the three photographed and recovered meteorites. One of these iron meteoroids has an orbit of the Aten type as does one of the detected Earth-crossing asteroids, 3554 Amun. Two additional meteoroids of the Aten type also passed two of the three possible tests of ReVelle and Rajan. For all these objects for which we currently have available data, we have determined that gross fragmentation events did not occur during the entry. Further studies are needed to locate more of these objects so that the association between M-type Earth-crossing asteroids and iron meteoroids observed in the atmosphere can be strengthened.

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