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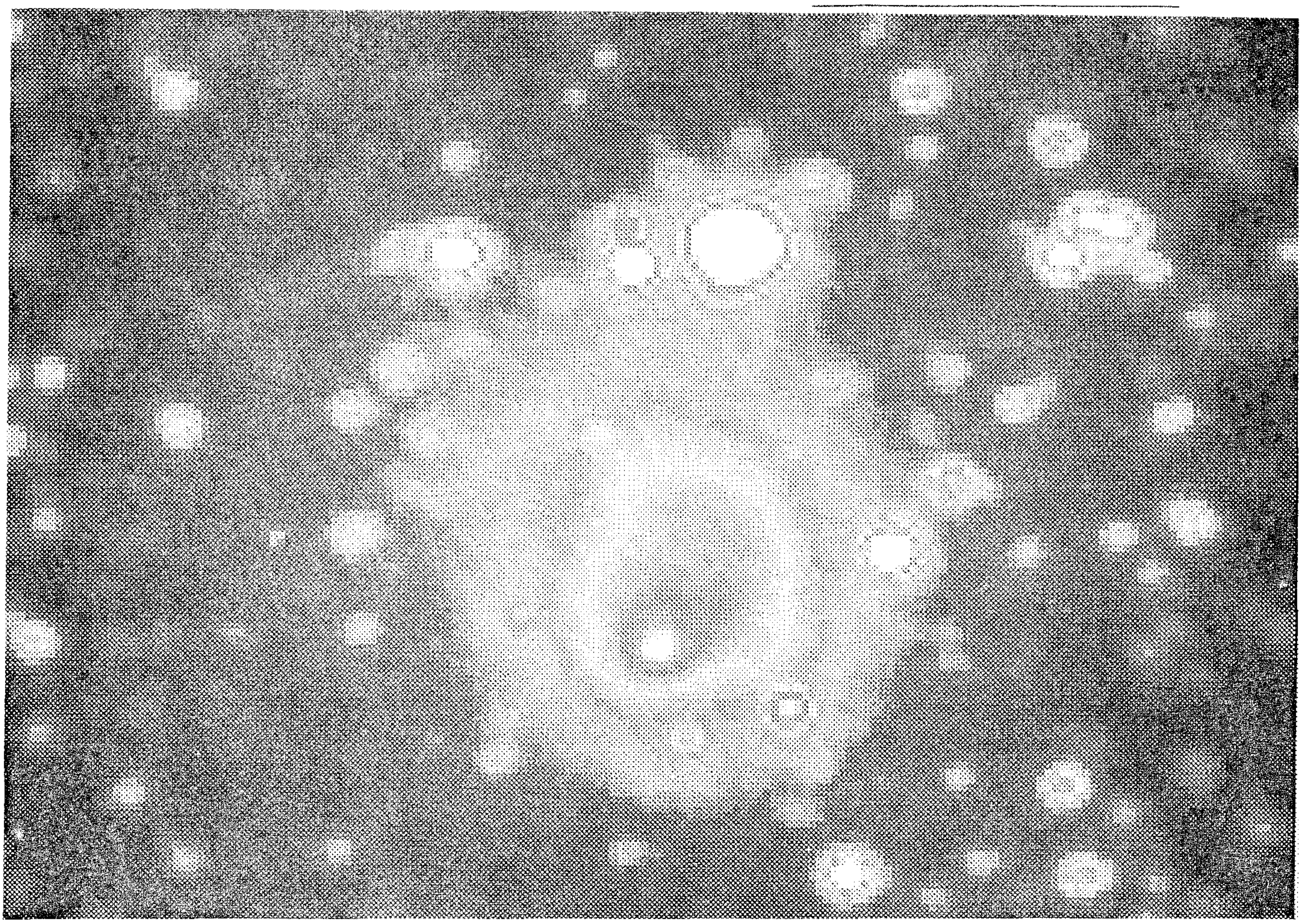

This 2-minute exposure of Comet 1995 O1 Hale-Bopp was taken through a red filtre, just before 0^h UT on September 1, 1995 by Dahlgren (Uppsala Astronomical Observatory, Sweden) and Lahulla (Observatorio Astronomico Nacional, Madrid, Spain) observing with the Dutch 0.90-m telescope at the ESO La Silla Observatory.

In this issue:

- A report on the Brandenburg IMC
- Practical information for all observers
- No link between Hale-Bopp and the Quadrantids
- New International Leonid Watch Bulletin
- Observational results

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

WGN, Vol. 23, No. 5, October 1995, pp. 161–184

Contents

Useful Information

The December Issue *(WGN 23:6)*

The *December issue* is anticipated to be a thick issue and will be mailed towards the beginning of December. Contributions are due on *November 10* at the latest. They should be sent to *Marc Gyssens*.

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 Editor-in-Chief

Marc Gyssens

Despite a steady input flow of articles, organizational circumstances forced me to restrict this issue to a regular one. A probably extra-thick issue is planned for December. Even though this issue is "only" a regular one, it contains a lot of important information, however.

Last year, the first—though still modest—Leonid outburst in a long time was seen, probably the first "announcement" by the stream of the anticipated events towards the end of the century. Information on last year's observations and hints for this year's observations are contained in a new ILW *Bulletin. Also in this issue, Dr. Steel puts to rest the recent speculations on a relationship between the Quadrantids and Comet Hale-Bopp. We also learn more about the 1995 Perseid maximum, which Japanese observers monitored by radio.*

Last but not least, there was also the IMC *in Brandenburg, Germany, which was one of the most successful ever. You can read and see more of this furtheron in this issue. Next year's* IMC *will be in the Netherlands. If you were not in Brandenburg, do not miss this unique opportunity to meet your fellow meteor observers this time!*

Christmas and Other Greeting Cards through the IMO!

Godfrey Baldacchino

The Meteor Group of the *Malta Astronomical Society* is printing a set of four original full color cards which should appeal to meteor watchers and *WGN* readers.

The first two are Christmas cards, displaying two scientific explanations of the mysterious "Star of Betlehem:" a Jupiter-Saturn triple conjunction in Pisces in 7 BC (order name `XMAS 1`) and a Jupiter-Venus triple conjunction in Leo in 2 BC (order name `XMAS 2`). The second two are versatile, open cards—suitable for any occasion. They depict an amateur observation of the Perseid Meteor Shower (`PERS`) and (keeping in mind imminent 1999) a display of the Leonid Meteor Storm (`LEON`).

All four illustrations represent the skies faithfully. There is no artist impression of the stellar background, but an exact representation, thanks to computer software which allows the recreation of the star background at any location and date.

Say Merry Christmas, Happy Birthday, Thank You, or Happy Anniversary to your relatives and friends, in your country and abroad, while at the same time passing on some astronomical knowledge, at quite competitive prices.

All four cards are standard size (148 mm×105 mm), are accompanied by envelopes, and contain a brief explanation (in English) of the depicted event on the inside left side. The Christmas cards contain *Season Greetings* printed in all major European languages on the inside right side.

The *IMO* has kindly accepted to serve as an agent. *WGN* readers and their friends may order cards through *IMO* Treasurer Ina Rendtel, with whom payment is to be lodged. The Malta Meteor Group will be responsible for satisfying orders by air mail.

Do not send cheques to Ina Rendtel. Use international postal money orders, credit her (postal) giro account, or simply send bank notes as cash (ensure these are not visible through the envelope!). It is a good idea to combine the payment for your order with your subscription renewal for 1996 to reduce the costs inherent to international payments. Information on subscription renewal follows in the next article.

Cards cost 1.60 DEM or 1.10 USD each. For orders of 10 cards or more, cards cost only 1.40 DEM or 1.00 USD each. In any case, add 1.00 DEM or 0.70 USD to cover air mail postage, irrespective of the size of your order. These prices are guaranteed until the end of 1995.

In your order, indicate clearly which card(s) you are ordering, and the number of copies desired of each. Use the codes `XMAS 1`, `XMAS 2`, `PERS`, and `LEON` as explained above.

Any income from card sales will go to cover part of the expenses projected by the Malta Meteor Group in preparing a meteor publication for the general public in the local language. Funds will also be used to finance the subscription of Maltese meteor observers to the *IMO*.

Renew Your IMO Membership/WGN Subscription Now!

Ina Rendtel

General information

Last year, we had to run on and off to the post office to send out copies of *WGN* to late renewers. Please save the already overloaded *IMO* officers this extra work by renewing right now. All information is concisely summarized below.

International payments invariantly involve costs. Therefore, if you also wish to buy greeting cards (previous article) or other *IMO* publications (outside back cover), it is a good idea to combine this with your renewal in one order and one payment. *New* IMO *publications* are the long-awaited and completely rewritten Visual Handbook, Report 7 containing the 1994 visual observations, and the Proceedings of the 1995 *IMC*. You can also pay your subscription for *two* years.

Now take a few moments to carefully check the instructions below.

Price list

Type of subscription	1996	1996 + 1997
Regular subscription (*WGN*)	35 DEM or 25 USD	70 DEM or 50 USD
Combined subscription (*WGN*, *FIDAC* News, Report)	70 DEM or 50 USD	140 DEM or 100 USD
Also possible outside Europe:		
Regular subscription with airmail delivery	50 DEM or 35 USD	100 DEM or 70 USD
Combined subscription with airmail delivery for *WGN* only	90 DEM or 65 USD	180 DEM or 130 USD

You can **become a supporting member** by adding at least 15 DEM or 10 USD per year to your membership.

Payment instructions

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

- **in Europe:** pay in *German Marks* to *Ina Rendtel* by transfering to the postal giro account number 547234107 at Postgiroamt Berlin, bank code 10010010. (Please send **no bank checks**!—If you must pay by check, pay to Peter Brown as indicated below.)
- **in the United Kingdom:** proceed as above, or pay to *Alastair McBeath*, 12A Prior's Walk, Morpeth, Northumberland NE61 2RF, England.
- **in Japan:** pay to *Masahiro Koseki*, 4-3-5 Annaka, Annaka-shi, 379-01 Gunma-ken, Japan.
- **All others** pay in *US Dollars* to *Peter Brown*, Dept. of Physics, Univ. of Western Ontario, London, Ont., N6A 3K7, Canada.

All people insisting on paying by check should pay to Peter Brown in US Dollars, as indicated above. Make checks payable to Peter Brown, not to the IMO!

Letters to WGN

compiled by Marc Gyssens

Dark meteors

*Alastair McBeath's article on dark meteors in the June issue (*WGN 23:3*, pp. 91–96) sparked yet another reaction.*

Alastair McBeath started in one of the last issues of *WGN* an interesting discussion about a strange effect that he called a "dark meteor:" sometimes we see objects that move meteor-like in the sky but are darker than the sky background. As possible explanations both failures of the human vision system and real dark objects like flying birds are considered.

In the last few years, I saw several of such unusual objects, too. In private discussions during the last *IMC*, many observers supported the idea of dark phenomena from their own observations, hence, there really must be something causing "dark meteors." Almost everybody saw them, but nobody talked about it earlier because the thing was just too odd. I always thought that it must have been a bird, I did not believe in errors of my vision. I never saw illuminated birds against the dark sky as described by Alastair; on the other hand, I had no explanation why bats or birds should move like meteors along straight lines.

Yesterday, I browsed through our video tapes looking for some special sound effects. Eventually, I noticed by pure chance a "dark meteor" just following a real one and moving as I remembered it from my observations: a fast "something" darker than the sky background traveling straight across the screen!

I was, of course, really excited and watched the tape several times. Then I recalled the circumstances of the observations: Both DUBKA and I were watching the Lyrids on April 22-23 in a wood near the south end of Berlin. The sky conditions were normal for those circumstances, we had limiting magnitudes up to 6.0. There were no direct lights in the field of view that might have illuminated birds, nor do I remember any sounds from moving animals despite the noise from some nearby wild boars.

I digitized all frames and tried to obtain a picture of the event. Unfortunately that was much more complicated than expected: The SNR of single video frames is already bad enough, but dark objects against the sky are completely lost in the noise. I could not average the frames which would have improved the SNR but would have removed the interesting object, too. It needed some heavy image processing procedures (median filter, extreme contrast enhancement, minimum of all frames) until the trail of the object became weakly visible in the image.

Interestingly, there did not appear a straight line but a trail with distortions. Furthermore, the shape of the object changed. In some frames, it appeared longish whereas it was round or turned by 90° in others. This implies that I have recorded a flying animal at a low height over the camera system, most probably a bat. It is much too fast for having an astronomical origin, too: the estimated velocity was about 80°/s.

I want to conclude that at least some "dark meteors" (not to be confused with "fuzzy" or "worm meteors") are real objects and not errors of our human vision system. Bats or maybe birds can be seen dark against the sky and might look as if they move along straight lines. We must consider that they appear only for a fraction of a second, thus, we see only a small part of their flight path. I have put both the image of the trail and a sequence of video frames to my WWW page. You may access them via the URL `http://www.tu-chemnitz.de/meteore/dark.html`, but do not expect to find images with photographic quality and a black trail against a bright sky; I am glad that I could make the path visible at all. At the original video tape the "dark meteor" is still best visible.

Sirko Molau, October 18, 1995

The new working list of visual meteor showers

We already received a first reaction to the new working list of visual meteor showers published in the August issue.

In regards to the *IMO*'s new Working List, I applaud the changes. It gives it more realistic sense. Still, I think there is more eventual room for more changes... namely in the areas of activity periods. From my own observations, I feel that the Coma Berenicids (for example) can extend their period of activity by beginning sooner. For them, nearly a week sooner. Also, from what I saw of the 1993 Geminids, I feel that its ZHR is still a little low. Still, this new list is a positive step in the right direction and I am sure there will be more changes in the years to come as more data filters join in to support them.

George Zay, October 10, 1995

Full Moon observing

I do not normally observe within 5 days before or after a Full Moon. Sometimes though, a major shower occurs during this period and I make an exception. The 1995 Perseids was one of those exceptions. As always during a major shower, there are all kinds of sources recommending where to look etc. I have read in my local papers and that of major magazines giving apparently non-experienced advice. Some said to look East at midnight and one even recommended to look South. During a Full Moon, there is only one direction one can look with the least amount of obliterating moonlight... and that is in a northerly direction. I recommend for observers in the Northern Hemisphere that if they must observe with a Full Moon, to look in a North Westerly direction around 9 p.m. local time; around midnight, due North; and at 3 a.m. to look North Easterly. Also elevate your view at about 50° above the horizon. You may have to adjust this a little to accommodate your latitude, but this is the darkest region during a Full Moon. It makes no difference where the radiant is, because this is essentially the only region that has any observable sky. No doubt, it is in a Southerly direction for our friends in the Southern Hemisphere.

George Zay, September 8, 1995

Tying up some loose ends

I would like to briefly respond to a couple of letters in the August Journal without making much ado about the topics. First I would like to reassure Marco Langbroek and others that I am fine and well despite the bad omens (knock on wood).

Secondly, I was thrilled to see my picture along with others on the cover of *WGN*. It is not as being on the cover of the Rolling Stones, I guess, but still I was pleased. Now everybody in the world will have some idea as to what I resemble ... this could be good or bad. I have not thought that one through yet.

As to my concerns about the reliability of automated radio meteor systems, I have come to a conclusion on a few things. After reading Jean-Marc Wislez's letter in August and other literatures about the topic, I have concluded one of two things is right. (*i*) Either I am the only person in the world that detects very short aircraft radio interference on a frequent basis, or (*ii*) nobody else in the world bothered to see if they can detect short aircraft interferences by long term simultaneous visual observations/radio monitoring. There is no doubt in my mind that I get numerous short duration aircraft interference from low flying aircraft (under 10 000 feet) that mimics the short duration meteor signals that I also get.

If nobody else gets this interference, I must be getting it due to some reason unique to my set-up or location. I cannot believe nobody else has investigated this possibility by now, so it most likely has something to do with my set-up or location. I feel this is the case, and therefore I do not trust my data anymore. Thus, I have decided to cease my radio efforts. There appears to be no simple solution to continue. So ... I will channel my efforts mainly towards the visual aspects from now on and wish the automated radio boys well with their systems.

George Zay, October 10, 1995

Frequently Asked Questions on Observing Methods

compiled by Rainer Arlt

How to treat meteors which could not be associated with a meteor shower unambiguously?

Observers regularly report about meteors which they saw just at the border of their field of view. It has been unclear how to associate these meteors with the radiants active at that time as the position of the path as it is stored in the observer's mind will be very uncertain.

At first, we have to ask whether or not this meteor should be included in the reported number of meteors. The zenithal hourly rate (ZHR) is generally calculated for an unrestricted view. On the other hand, the computation of spatial number densities in meteor streams assume a diameter of the field of view of 105° (it is not 100° for statistical reasons). It turned out that the fraction of meteors seen outside this field is only about 2%. Hence, we may use the ZHR for further calculations requiring a restricted field of view. Note that a distance of 50° from the center of view is sometimes underestimated. If you watch Deneb (α Cyg) and see a meteor somewhere in Hercules, it is well within this radius. Your field extends to beyond the celestial pole, it includes all of Pegasus and Aquila. Therefore, I recommend to record every meteor seen regardless of how far from the center of view it appeared.

(Sometimes you caught a glimpse of a light source in the very corner of your field of view, and you were not sure whether this was a meteor. Although it might be confirmed by fellow observers, you should not note the meteor as you would probably not have noted it when you were alone.)

When including "long-distance" meteors, we have to deal with the problem of associating them with a shower radiant. The probability of a wrong association decreases with increasing activity of a meteor shower. Hence, during a major-shower watch you should count the meteor with unclear origin as a member of the major shower. When you are plotting meteors during a minor-shower observation, you should not apply the direction criterion too strictly. A radiant diameter of 20° is appropriate for meteors which appeared 50° off-center of the field of view. Consider the angular velocity and the path length with higher priority for shower association as these criteria will be less severely affected by the distance than the orientation of your memorized path. (Note that the physical image in your eyes is heavily distorted at the edges, and the brain cannot reconstruct true angles correctly.)

Another frequent problem is the association of meteors with *twin radiants* such as the Taurids. Meteors may match the criteria of belonging to both showers, and observers ask what to do with these meteors. There are four possibilities: (*i*) count this meteor as a sporadic, which is probably a bad solution; (*ii*) count this meteor in a separate category of undiscriminated Taurids; (*iii*) decide in favor of one of the branches in any case; or (*iv*) count "half a meteor" for either branches. Solution (*ii*) seems to be good as we apparently do not do anything wrong. However, the activity calculation of the separate branches is affected by this decision as not all meteors which belong to the Taurids will be incorporated. Hence we make a relatively large error when excluding them from both the northern and southern branch. Consequently, it seems better to include the ambiguous meteors in the separate branches anyway. A calculation of the total Taurid activity is possible with the solutions (*ii*), (*iii*), and (*iv*). It now remains to choose between (*iii*) and (*iv*). Imagine a meteor which cannot be associated with one of the branches as the assumed errors in direction and speed do not seem to allow a discrimination. However, one of the radiants *will* have another distance to the meteor and, hence, another speed expectation or the meteor *will* hit one of the radiants slightly closer than the other in most of the cases. Consequently, there is a slightly higher probability for one of the branches to be associated with the questionable meteor in next to every case; we *can* associate the meteor with one specific branch. Although this decision is based on statistical assumptions, it is the method with the smallest error we can make.

As an example, we may consider a meteor at a distance of 40° from the radiant of the Northern Taurids, at an elevation of 90°. We assume an estimate of the angular velocity of 10°/s. Imagine that the path of the meteor exactly aligns with both radiants of the Taurids. A calculation of the expected speed yields 12°/s for the northern and 14°/s for the southern branch. Although both radiants match the direction and speed criteria within the error limits, the northern branch fulfills the speed estimate closer than the southern one. Hence we do decide in favor of the Northern Taurids. Additionally, we should consider the path length. If the meteor had a short path, we should prefer the closer radiant.

If we put half a meteor into either branch's number according to (*iv*), we neglect the small differences in association probabilities. In this way, significant potential differences in the activity from both radiants can be concealed when the meteor numbers are large enough. Method (*iii*) does not suffer from this disadvantage.

The following guidelines should be considered for a meteor at the border of your field of view:

- Every meteor should be reported regardless of how far it appeared from the field of view.
- Do not report "meteors not analyzed;" decide unambiguously in favor of a radiant or the sporadics. Use the angular velocity and path length with high priority for a shower association.
- The designation *DIV* is reserved for several Aquarid radiants in July and August which cannot be resolved due to a distant field center.
- Do not report `STA`, `NTA`, and `TAU` at the same time. In case you plotted the meteors, try to discriminate both branches even if the probabilities of shower membership are only slightly different.
- Do not report half a meteor in the shower analysis.

The 1995 International Meteor Conference

Brandenburg, Brandenburg, Germany, September 14–17, 1995

Chris Trayner

1. Introduction

This year's Conference took place from Thursday, 14th to Sunday, 17th of September. It was held about 10 km north of Brandenburg, 50 km west of Berlin. This is in the old East Germany, a beautiful area of rivers and lakes where the River Havel winds slowly from Berlin across the flat North German Plain towards the sea. The venue was a hostel, the *Haus am See*, by a lake.

The meeting began on the Thursday evening with informal presentations. Sirko Molau demonstrated the video camera plus image intensifier which his group has been using for some years. He also showed a computer-edited compilation of several hours' meteors compressed into about a minute, generating a spectacular shower from genuine data.

Axel Haas gave his traditional slide show, with pictures of previous years' meetings and delegates, often to the embarrassment of the victims and the amusement of the others. His theme of *IMC* people photographing each other photographing each other certainly seemed to set delegates taking pictures over the weekend; probably Axel owns shares in Kodak.

2. The talks

The first session concerned photographic and video observations and their analysis.

Marc de Lignie talked about double-station TV imaging. This covered image intensifier characteristics, frame grabbers, and the limiting magnitudes obtainable. He warned of selection effects with these techniques and described the use of trajectory analysis software from the Ondřejov Observatory in the Czech Republic.

Then Sirko Molau described the MOVIE system demonstrated the previous evening, which involved image processing of meteor video recordings. He had obtained improved trajectories by measuring the meteor in several frames, not just the first and last. He showed interesting averaged light curves for Perseids and Lyrids, obtained by scaling the duration of each meteor to a standard amount. These were characteristic of the shower, not the individual meteor. He also had some comments on the continuing question of meteor clusters.

Whereas this was image processing in outline with results, the next talk went into more detail about the mechanism. Chris Trayner described the application of conventional astronomical CCD image processing techniques to frame-grabbed video. He also described the production of meteor light-curves from such data. This brought up the problems of magnitude estimation. These came from the noise present in any image, especially from an image intensifier, and saturation by bright objects. He said that little useful work of this sort can be done with non-cooled cameras, with 8-bit frame grabbers or with video-taped images.

Then Luis Bellot described how the fragmentation parameters of meteors could be derived from the photographic record.

On Saturday morning there was a session on visual observations and result analysis.

Peter Zimnikoval read two papers, one on the Summer 1995 observing campaign in Slovakia and the other on different projections for celestial atlases. When maps cover a large area of sky, geometric distortion in the corners can be serious when plotting a meteor path.

Manuel Solano presented an interesting technique for finding angular distances using a planisphere.

Rainer Arlt talked on the analysis of minor showers, an area where the *IMO* can make a useful contribution with its observers and its meteor database.

Ralf Koschack discussed the accuracy of visual observation plotting, an important concern if *IMO* data are to be respected as reliable. Apparently cautious behavior (such as recording a meteor as a sporadic if it is not certainly a shower) can cause artifacts in the data (an apparent increase in the sporadic rate during showers).

Detlef Koschny then gave us his measurements of the accuracy of visual observations. This showed good accuracy from experienced observers and that new observers gain most of their accuracy early on. But the real delight was his experimental apparatus, made out of Lego and a jam jar. It looked like an invention of the British cartoonist W. Heath Robinson, but it was a well-designed piece of scientific apparatus for a serious purpose.

Jürgen Rendtel said that papers are not always accurate in all details. Ideally writers should not trust references but check further, but this is not always possible.

Alastair McBeath described a spectacular fireball that flew over Northern England on July 28-29, 1995.

There was one radio observation paper, with Cis Verbeeck describing the 3-D geometry of meteor reflection and how this affected the strength of the received signal. He also described the signal rise and fall during the flight of a meteor. This paper went into a lot of detail, and showed that amateur astronomers can approach the subject in a mathematically deep way.

Sunday morning saw Alastair McBeath, the *IMO*'s specialist in Alien Monster T-shirts, talk on the reaction of the "straight" astronomical press to slightly unusual ideas. These included dark meteors, meteor clusters, and meteor ripples.

Jürgen Rendtel talked about the Perseids in recent years and about impact structures, illustrated with slides from the USA, including the Barringer Crater.

3. Workshops, posters and equipment demonstrations

Two small workshops were held, one on photography and the other on the Word-Wide Web, which was demonstrated. It was decided that the *IMO* should have a WWW home page, but that material should not be put on it until it is properly ready and looks professional.

Several posters were put up and attracted interest over the weekend. Particularly impressive was some of the Dutch photographic equipment on display. The mechanical standard of the home-made equipment was notable. They also attracted much envy with their battery of over a dozen Nikons!

4. The social life

The excellent meals were an opportunity for much social and astronomical conversation. Soft drinks and beer were available throughout the day, with a new system of paper chits bought from Ina Rendtel and used to pay for drinks.

Axel's slides on the first evening were not the only social diversion. On the Friday afternoon, an excursion had been organized by boat round the local waterways. For two hours we were taken along the Havel, through lakes with sailing boats and wildlife reserves and then back along the river through Brandenburg.

This trip allowed, for example, Alastair McBeath, the *IMO*'s Resident Alien, to demonstrate to Eva Bojurova how an Altairian spider jumps its prey. She survived.

On the Saturday evening, a campfire and barbecue went on well into the night. There was plenty of food, including delicious *Wurst*, and almost endless beer and wine. Ina's paper chit system was in operation, and even by the end of the evening it is possible that a few people were still getting their arithmetic right. Although the formal language of the Conference was English, social activity was not so limited and round the campfire this was especially true. Conversations moved at random between German, Russian, and English, with several other languages heard from some groups. Clearly the word "International" in the *IMO*'s title is not an empty claim.

5. Administrative matters and next year's conference

The *IMO* General Assembly was held during the meeting. As well as decisions about subscription prices, reported elsewhere, some explanation was given about the printing press used for *IMO* publications for several years. This is privately owned by André Gabriël, and he has charged the IMO only the costs of materials. The equipment is now near the end of its useful life, and printing will soon have to be done elsewhere. There was a general feeling of gratitude to André for all the printing he has done.

The 1996 Conference will be held in Apeldoorn in the Netherlands; the Dutch hosts have already started preparations.

There was some discussion over the proposal to hold the 1997 Conference in Yugoslavia. The questions concerned the morality of holding a meeting there if there is still any war in the Balkans. Should scientific meetings make a moral point by ignoring the divisions that politicians force on us, or make a moral point by disapproval and boycott? In practice, the decision will probably be taken in Summer 1996 when, hopefully, the war will be over. There was an interesting suggestion about the 1999 Conference made informally outside the General Assembly by Viktor Bortaş. If it is held in Rumania at the right time in August it will be under the path of the solar eclipse; only in Rumania will there be more than 100% eclipse.

All too soon the Conference came to an end. Everyone was rightly grateful to Ina and Jürgen Rendtel and Rainer Arlt for all the hard work they had put into its organization. The formal write-up will appear in the Proceedings; but for those who chose not to come, these pages may show them that their decision was a mistake.

Figure 1 – Rainer Arlt (*left*) and André Knöfel (*right*) at the 1995 *IMC* in Brandenburg.

Additional 1994 Data for the VMDB

Rainer Arlt

After the *Report Series Volume 7* had been printed, it turned out that a considerable package of observations was not entered. I received the files at the Brandenburg *IMC* from the Slovak observing group, and they can be included in the 1994 files now. A total effective observing time of $251^{h}21$ of Perseid observations had to be appended. There are now 683 Slovak observing hours in the 1994 files.

Indications for Enhanced α-Capricornid Rates in 1995?

Jürgen Rendtel

During the 1995 *International Meteor Conference* in Mötzow near Brandenburg, some indications were found for a slightly increased activity of the α-Capricornids in the night of July 29-30, 1995 (UT). Although the individual facts may be rather weak, the sum of the observations seems striking. Perhaps it is also a coincidence of good observing conditions and the weekend. In order to obtain more than a "summary of impressions," we would like the observers to check their observational data. Below we list the findings as they were put together during the *IMC*.

Several fireballs have been observed from several locations. It is not yet checked whether these were α-Capricornids. (Data reported to Alastair McBeath and André Knöfel of *FIDAC*). The current *FIDAC* archive (as of September 15) gave an average of 1 fireball per day before July 28, 3 on July 28 and 30, and 5 on July 29. However, this is a concentration to a weekend and may thus also be caused by a "sociological effect."

Visual observers gave ZHRs between 5 and 10 (Valentin Velkov's and Eva Bojurova's poster at the *IMC* showing Bulgarian results of this period; observations by George Zay, USA, reported via e-mail; and observations by Jürgen Rendtel, Germany). Observers of the British *SPA* Meteor Section reported easily detectable α-Capricornid rates, which is unusual seen the latitude of the sites.

Please, check your data and send relevant information to the author or the *IMO*'s Visual Commission Director for further analysis. Of course, also "negative reports" are of interest to find out whether this has been a true event or a coincidence of a few reports only.

Visual Observers' Notes: November–December 1995

Jeff Wood and Marc Gyssens

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. 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 October 1 through to November 25. 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 to as high as 10 or 15 meteors per hour.

Table 1 – A list of visual meteor showers to be seen during November and December. Streams marked with an asterisk are periodically or occasionally active, and therefore no ZHR is cited.

Shower	Activity	Maximum		Radiant			V_∞	r	ZHR
		Date	$\lambda_\odot$	α	δ	Diam.	(km/s)		
Orionids (ORI)	Oct 02–Nov 07	Oct 21	208°	95°	+16°	10°	66	2.9	25
Southern Taurids (STA)	Oct 01–Nov 25	Nov 03	220°	50°	+13°	10°/5°	27	2.3	5
Northern Taurids (NTA)	Oct 01–Nov 25	Nov 13	230°	58°	+22°	10°/5°	29	2.3	5
Leonids (LEO)	Nov 14–Nov 21	Nov 18	235°2	153°	+22°	5°	71	2.5	var
α-Monocerotids (AMO)	Nov 15–Nov 25	Nov 20	237°	117°	−06°	5°	60	2.7	5
χ-Orionids (XOR)	Nov 26–Dec 15	Dec 02	250°	82°	+23°	8°	28	3.0	3
Dec Phoenicids (PHO)	Nov 28–Dec 09	Dec 05	253°	18°	−53°	5°	22	2.8	var
Puppid/Velids (PUP)	Dec 01–Dec 15	Dec 06	255°	123°	−45°	10°	40	2.9	10
Dec Monocerotids (MON)	Nov 27–Dec 17	Dec 10	259°	102°	+08°	5°	42	3.0	3
σ-Hydrids (HYD)	Dec 03–Dec 15	Dec 11	260°	127°	+02°	5°	58	3.0	2
Geminids (GEM)	Dec 07–Dec 17	Dec 14	262°0	112°	+33°	5°	35	2.6	110
Coma Berenicids (COM)	Dec 12–Jan 23	Dec 19	268°	175°	+25°	5°	65	3.0	5
Ursids (URS)	Dec 17–Dec 26	Dec 22	270°7	217°	+76°	5°	33	3.0	10

Table 2 – Moonlight and observing conditions in November–December 1995.

Date	k	Date	k
Friday November 3	0.82+	Friday December 8	0.99−
Friday November 10	0.93−	Friday December 15	0.52−
Friday November 17	0.35−	Friday December 22	0.00−
Friday November 24	0.03+	Friday December 29	0.52+
Friday December 1	0.68+	Friday January 5	0.99+

New Moon:	October 24, November 22, December 22
First Quarter:	October 30, November 29, December 28
Full Moon:	November 7, December 7, January 5
Last Quarter:	November 15, December 15, January 13

Table 3 – Radiant positions for the Taurids South and North.

Date	Taurids S		Taurids N	
	α	δ	α	δ
Oct 01	29°	+10°	37°	+17°
10	36°	+10°	41°	+18°
20	41°	+11°	46°	+19°
30	48°	+13°	51°	+20°
Nov 09	55°	+14°	56°	+22°
19	62°	+16°	60°	+23°

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*.

Unfortunately, the Full Moon on November 7 heavily affects viewing around the Taurid maximum.

3. Leonids

The Leonids are fast, often blue, green or white meteors that frequently have a train. They are active from November 14 to 21 and are best seen during the last few hours before sunrise. The Leonids are a periodic shower which peaks every 33 years, the next time being 1998–99. Last year saw more intense Leonid activity for the first time in a long period. It is therefore imperative that a lot of observations are made this year as well, to see, in the context of the *International Leonid Watch*, how activity evolves.

The *International Leonid Watch (ILW)*, an *IMO* initiative coordinated by Peter Brown attempts to encourage the study of this shower in the years before and after the next expected storm. For more details, we refer to the *ILW Bulletins* published in *WGN* over the last five years. A new bulletin of the *ILW* with more information on this intriguing shower and observing conditions this year can be found elsewhere in this issue.

Please note that if the Leonid ZHR rises to above 10 per hour observers are to refrain from plotting and use the classified counts technique. When identifying Leonids, the high geocentric velocity ($V_\infty = 71$ km/s) should be taken into account.

4. α-Monocerotids

This November Monocerotid stream is active from November 15 to 25. Maximum occurs around November 20. The November α-Monocerotids are noted for their variable activity. In some years, they are virtually non-existent whereas in others the maximum ZHR has exceeded 100 meteors per hour. With the favorable moon conditions, the *IMO* has targeted the stream for a thorough investigation in 1995, the more so since Peter Jenniskens [1] pointed out that an outburst is a serious possibility this year. Although it is impossible to say during which night an outburst would occur if at all an outburst will occur, Jenniskens suggests the night of November 21-22 (UT) to be the most likely candidate. Observers in Europe and Africa are best placed to witness a possible outburst.

The *IMO* recommends that you observe both the Leonids and the November Monocerotids simultaneously whenever both radiants have an elevation of 20° or more. To do this, the observing field should be centered in the region $\alpha = 120°–150°$, $\delta = -20°–+30°$. All possible Monocerotids should be plotted as long as the ZHR is less than 10. Thereafter, use classified counts.

5. 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 Last Quarter occurring on December 15, conditions are not very favorable for viewing the Geminids in 1995, especially after midnight.

6. Coma Berenicids

The Coma Berenicids are active from December 12 through to January 23. The maximum of 5 meteors per hour occurs on December 19, under ideal conditions moon-wise. 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. From December 17 to 26, both the Coma Berenicids and the Ursids can be observed provided the observer's field is centered around $\alpha = 150°–180°$ and $\delta = +40°–+60°$. All possible Coma Berenicid meteors should be plotted.

Table 4 – 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°

7. Ursids

The Ursids are active from December 17 to 26 with a maximum on December 22. The radiant position is at $\alpha = 217°$ and $\delta = +76°$ which means it can only be observed from the northern hemisphere. The Ursids display variable activity with ZHRs of around 50 being recorded on occasions. Unless the ZHR reaches or passes 10, all Ursids seen should be plotted. 1995 is an ideal year to observe the Ursids, since the New Moon coincides with the date of maximum activity.

Reference

[1] P. Jenniskens, "Good Prospects for an α-Monocerotid Outburst in 1995", *WGN* 23:3, June 1995, pp. 84–86.

Photographic Observers' Notes: November–December 1995

Jürgen Rendtel

Most bright autumn meteors are related to the Taurid complex with the major sources being the Northern and Southern Taurids. The activity shows a broad maximum in the period between November 3 and November 13. In terms of ZHR, these maxima are not distinct. In a number of years a remarkable excess of fireballs occurred around November 1.

Taurids are part of the ecliptical meteoroid complex, and their atmospheric entry velocities (29 km/s and 27 km/s, respectively) imply meteors of relatively low angular velocities. Furthermore, the radiants are above the horizon in most parts of the night, even in medium southern latitudes. Thus the prospects for photography are quite favorable.

Single station photographs may help to associate meteors with the southern or northern branches of the Taurids if the fields are appropriately chosen, i.e., being east or west of the radiants. The most suitable field centers for standard lenses are at $\alpha \leq 30°$, $\delta \approx +15°$ (mainly before local midnight) and $\alpha \geq 60°$, $\delta \approx +15°$ (after local midnight). The use of a rotating shutter with known interruption frequency is strongly recommended.

Another promising photographic shower are the Northern χ-Orionids at the beginning of December. It also contains some remarkable fireballs [1]. Although it obviously continues the ecliptical meteor activity, the characteristics of the fireballs of the Taurids and the Northern χ Orionids are quite different. The recommended field centers are again west or east of the radiant: cameras with standard lenses should be pointed to approximately $\alpha = 50°$, $\delta = +20°$ or $\alpha = 110°$, $\delta = +20°$.

The Geminids have been the shower with the highest activity in the period November–December. This may change now since the 1994 observations indicated a reasonable increase of Leonid rates. This may further increase in the coming returns. Although the rates as well as the number of bright meteors are relatively high, the large atmospheric entry velocity causes some problems for the photography. The angular velocity of a Leonid meteor will be quite high at some distance from the radiant. Therefore the photographer should preferably choose field centers which are less than 30° from the Leonid radiant, and rather closer towards the horizon than to the zenith. The waning moon is not too far from the radiant as well, so that every observer has to change the field center during the night with the radiant and the moon moving. The high angular velocities favor somewhat higher interruption frequencies of rotating shutters, if adjustable.

The other highlight is the Geminid shower. The high activity plateau derived from visual observations offers good chances for more than only the maximum night, although the Moon will disturb some of the hours after midnight.

The possible return of an enhanced α-Monocerotid activity [3] should be also used as an opportunity to cover the respective night with photographs of the near-radiant region. Many of the short-lived outbursts (not only of this shower) are poorly documented—thus every effort is of great use to obtain a reliable sample of data on these rare events. The suggested time interval falls on November 22 between 0^h and 6^h UT [3]. However, it is possible that nothing may happen at all.

Remember, that the time of the meteor's appearance is very important, and we also need to know the start and end of the exposure with an accuracy of at least 5 seconds. Other, more general notes about the photographs can be found in [2].

References

[1] Wetherill G.W., ReVelle D.O., "Which Fireballs are Meteorites? A Study of the Prairie Network Photographic Meteor Data", *Icarus* 48, 1981, pp. 308–328.

[2] Rendtel J., "Handbook for Photographic Meteor Observers", IMO Monograph No. 3, 1993.

[3] Jenniskens P., "Good Prospects for an α-Monocerotid Outburst in 1995", *WGN* 23:3, June 1995, pp. 84–86.

Telescopic Observers'Notes: November–December 1995

Malcolm J. Currie

We have an exciting period coming up with the theme of outbursting showers. This is especially true now that the *Leonid* rates have started to climb. Conditions are not ideal but are far superior to last year. There is a waning crescent moon in the vicinity of the radiant that will hamper observations especially before the maximum on November 18. During this Leonid cycle we have the opportunity to follow for the first time the behavior of the smaller particles telescopically, and thus learn more about the dispersive processes in young meteoroid streams.

It is important not to gather data during the years where a storm might occur, but also the years leading up and following any such momentous event. Whilst studying the radiant position, size, and any structure will be of interest, the main goal is to follow the meteor flux. Thus a wide apparent field is desirable to capture as many Leonids as possible. Also take care to estimate the field limiting magnitude using the inset on the charts and the meteor brightnesses. Remember that the Leonids can only be seen after local midnight and serious watching can commence an hour later. The best time is the couple of hours prior to dawn when the radiant has attained a high elevation. Therefore you might consider sleeping or resting until 2^h and then watching until twilight terminates viewing. Fortunately, the maximum falls at a weekend so I hope more people will be able to contribute. The Leonids are as fast as meteors come. Thus the preferred field centers are located close to the radiant. I recommend 103 and 130 throughout the session and 41, 146, or 147 after 2^h. Earlier in the night, when the radiant is low, charts 81 and 123 are also suitable. Please try to observe until the end of the shower, and not just at the maximum. Clear nights are rare at this time of year so please make the most of any that come along.

Hotly following the Leonids are the *α-Monocerotids*. This appears to be another shower with periodic outbursts, though unlike the Leonids, its frequency is not tuned to the period of the parent comet. Evidence collated by Peter Jenniskens (see his article in the June *WGN*) suggests a ten-year period caused by planetary perturbations jiggling the particle orbits so that they only occasionally intersect the Earth. The last outburst was seen in 1985, so the prospects for this year look promising. The outbursts from the α-Monocerotids are much weaker than the Leonids, yet they can still attain a ZHR of 1000 for a few minutes. Such outbursts must be fun and exciting to view—an event you will treasure in your memory if you are fortunate to witness one. Besides the aesthetic, observations are of great interest because we have so few reliable data for this shower and other similar "far-comet type" outbursts. Hence our understanding of the underlying physics is poor. For these reasons I am confident that you will not want to miss any outburst this year. There is a catch, however. Predictions of the time of the possible outburst span a six-hour window, and your vigil may be for naught, as there is no guarantee of an outburst. Southern Europe is favored as this interval falls between midnight and 6^h UT on the night of November 21-22. This almost coincides with the New Moon, however the fickle weather makes it imperative that all observers attempt to watch this shower, in the hope that some sites will be blessed with clear skies.

Our goals are to determine approximate meteor fluxes through the outburst and hence derive the time of maximum. One obvious question is to see if they follow the visual activity. If an outburst begins, plotting should cease. Switch to counting in one-minute time intervals. (Thus it is important to have an accurate watch available.) Merely note whether each meteor is shower member or not, and if the rate is not too demanding, record the meteor magnitudes too. However, it is worth indicating a direction of motion for the ensemble. Combined with other fields it will yield an approximate radiant position. Do not change field centers once an outburst starts, even if you are due to switch, as you might miss most of the outburst. Again, a very wide angle field of view is desirable. Use charts 144 and 145.

In early November, the radiant structures of the slow-moving twin-radiant *Taurids* can be followed. Some earlier results by Torsten Hansen suggest different elongations along the ecliptic for the north and south Taurid components. In addition to the primary showers there are other weaker contributors to the Taurid Complex all of which lie on a diffuse cloud of particles. Although deficient in faint meteors, the familiar long paths and slow angular speeds of the Taurids compensate by increasing the probability of detection. See the previous set of these notes for chart details.

Moving into December, the Moon moves from full to last quarter during the *Geminids*. Around the time of maximum it is possible to have a few hours of darkness to follow the best telescopic shower of the year. The textbook radiant is believed to have sub-structure, and around December 14 there is evidence for a component displaced several degrees north. We need further observations to confirm these findings. A good selection of field centers is desirable to reduce the effect of artifacts in the analysis. The recommended charts are 56, 57, 80/81, 99, 123, 143; the reserves are 77, 97, 142, 144, and 145. Use as many fields as possible, watching each for about thirty minutes at a time. At the same time it is possible to observe some *Monocerotids*, *σ-Hydrids* and late *χ-Orionids*.

In the week prior to the festive season, many neglect the *Ursids*. To be fair, the weather is usually atrocious, and visual rates are normally in the 5–10 per hour range. This shower does spring the occasional surprise, however, as in 1982 and 1986, where there were enhanced rates—around 45 per hour in 1982. Rich in faint meteors, it should be amenable to our binoculars. For most observers, the radiant is circumpolar, so data can be collected throughout the night, though it is at its lowest elevation around 21^h30^m local time. There are hardly any telescopic observations of this shower, so a good set of data is bound to tell us something new about the Ursids. For instance, we should like to determine the radiant position and size, and to derive the mean meteor magnitude through the shower. During the evening charts 4 and 9, or 5 and 11 are acceptable; later there are several possible pairs including 29 and 45, and 24 and 28.

Back in 1971, I witnessed what appeared to be a short-lived visual outburst of faint, fast meteors from approximately $\alpha = 138°$, $\delta = +44°$ at $\lambda_\odot = 268.^\circ05$ (1950.0). Now this was just one young observer in one year. Without corroboration we should take the 1971 data with a pinch of salt. I would like to think that if we remain vigilant that there will be another outburst confirming the earlier one. This year the relevant night is December 20-21, when the moon is absent. If it is a "far-comet type" shower we should look from December 20, 18^h to December 21, 6^h. So please concentrate on this shower rather than the Ursids during this interval. Note that I am not making any prediction for these *38 Lyncids*, it is merely that conditions are favorable this year. Some reasonable charts to use are 59, 61, and 123. Even if there is no outburst, this shower does give a noticeable telescopic flux.

Theoretical Radiants of Minor Planets and Comets

Dirk Artoos

Table 1 – Theoretical Radiants of Asteroids and Comets in November–December 1995.

Name	$\lambda_\odot$	Date	α	δ	V_∞	Distance
P/1639	220°51	Nov 03	49°	+76°	41 km/s	0.05129 AU
P/1826 IV (Pons)	220°65	Nov 03	24°	−54°	26 km/s	0.12850 AU
Epona (3838)	221°04	Nov 03	209°	+17°	29 km/s	0.16012 AU
1987 WC (5569)	222°18	Nov 05	164°	−70°	15 km/s	0.10872 AU
1993 PC	222°62	Nov 05	45°	+25°	19 km/s	0.06580 AU
1993 VA	223°52	Nov 06	37°	− 8°	16 km/s	0.12630 AU
P/1987 XIII (Rudenko)	223°90	Nov 06	52°	+29°	32 km/s	0.19410 AU
P/1977 XI (Encke)	224°86	Nov 07	53°	+29°	32 km/s	0.19521 AU
P/1867 III (Tempel-Swift)	224°87	Nov 07	310°	+ 8°	14 km/s	0.11279 AU
P/1923 III (Dubiago-Bernard)	224°97	Nov 07	116°	+54°	58 km/s	0.18072 AU
P/1366 (Tempel-Tuttle)	224°97	Nov 07	145°	+25°	71 km/s	0.00602 AU
P/1879 II (Swift)	226°35	Nov 08	125°	−27°	61 km/s	0.11923 AU
P/1879 II (Swift)	227°53	Nov 10	125°	−27°	61 km/s	0.10243 AU
1989 VA	228°11	Nov 10	153°	+44°	20 km/s	0.16400 AU
P/1959 VI (Alcock)	228°59	Nov 11	90°	+42°	57 km/s	0.16691 AU
P/1743 I	229°27	Nov 11	22°	+ 4°	22 km/s	0.01432 AU
Apollo (1862)	229°88	Nov 12	224°	−29°	20 km/s	0.02730 AU
P/1974 XV (Bennett)	230°24	Nov 12	146°	−14°	68 km/s	0.04499 AU
1984 KB	230°38	Nov 13	53°	+13°	26 km/s	0.07365 AU
Ptah (5011)	230°42	Nov 13	43°	− 3°	17 km/s	0.08484 AU
1989 FB (5803)	230°95	Nov 13	252°	−73°	16 km/s	0.18160 AU
1994 CN2	231°44	Nov 13	241°	−25°	17 km/s	0.02310 AU
P/1869 III (Tempel-Swift)	231°50	Nov 14	304°	+ 6°	14 km/s	0.11146 AU
Xanthus (4544)	231°53	Nov 14	254°	−73°	16 km/s	0.18167 AU
1989 UP	231°91	Nov 14	2°	−20°	14 km/s	0.00214 AU
P/1873 IV (Borrelly)	232°52	Nov 15	167°	+65°	59 km/s	0.19312 AU
1993 XN2	234°33	Nov 16	194°	−75°	20 km/s	0.08876 AU
1965 IV (Tempel-Tuttle)	234°58	Nov 17	153°	+22°	71 km/s	0.01409 AU
Orpheus (3361)	235°62	Nov 19	44°	+26°	14 km/s	0.03378 AU
P/1860 IV (Tempel)	236°09	Nov 19	225°	−62°	32 km/s	0.13811 AU
1991 WA	236°57	Nov 19	189°	−45°	29 km/s	0.18949 AU
P/1707	236°89	Nov 19	115°	−34°	54 km/s	0.08841 AU
P/1961 VIII (Seki)	237°52	Nov 19	175°	+17°	70 km/s	0.09141 AU
1993 WD=1991VJ14	237°63	Nov 20	118°	−30°	32 km/s	0.13410 AU
P/1826 IV (Pons)	238°87	Nov 21	15°	−64°	25 km/s	0.17600 AU
1994 GK	239°13	Nov 21	49°	+ 6°	19 km/s	0.07006 AU
P/1944 I (van Gent-Peltier-Daimaca)	239°73	Nov 22	133°	− 8°	68 km/s	0.04470 AU
1991 JW	240°03	Nov 23	228°	−76°	13 km/s	0.03105 AU
P/1366 (Tempel-Tuttle)	240°24	Nov 23	156°	+21°	71 km/s	0.08414 AU

Table 1 – Continued.

Name	$\lambda_\odot$	Date	α	δ	V_∞	Distance
Sisyphus (1866)	240.°69	Nov 23	175°	−64°	27 km/s	0.09180 AU
P/1954 II (Pajdusakova)	241.°68	Nov 24	86°	+20°	46 km/s	0.19070 AU
Cerberus (1865)	242.°01	Nov 24	78°	+49°	20 km/s	0.15230 AU
P/1965 IV (Tempel-Tuttle)	242.°22	Nov 24	158°	+20°	71 km/s	0.04232 AU
P/1766 I (Messier)	242.°27	Nov 24	189°	+17°	66 km/s	0.09410 AU
P/1771 (Messier)	244.°01	Nov 26	42°	− 9°	22 km/s	0.11730 AU
1994 WR12	244.°34	Nov 27	190°	−24°	14 km/s	0.00294 AU
P/1801 (Pons)	244.°55	Nov 27	187°	−11°	63 km/s	0.12607 AU
P/1852 III (Biela)	244.°97	Nov 27	26°	+42°	20 km/s	0.01380 AU
1990 MU (4953)	245.°42	Nov 28	74°	− 9°	27 km/s	0.03597 AU
P/1457 II	245.°82	Nov 28	267°	−12°	24 km/s	0.10970 AU
P/1781 II (Mechain)	246.°00	Nov 28	140°	+ 0°	67 km/s	0.18610 AU
1994 XD	247.°39	Nov 30	249°	−29°	23 km/s	0.03805 AU
Heracles (5143)	249.°25	Dec 02	76°	+32°	28 km/s	0.14127 AU
1994 XL1	249.°63	Dec 02	180°	+43°	19 km/s	0.03741 AU
P/1702	249.°85	Dec 02	60°	+15°	28 km/s	0.06378 AU
1989 UP	250.°67	Dec 03	351°	−26°	13 km/s	0.02702 AU
1995 DV1	251.°39	Dec 03	15°	+20°	16 km/s	0.06328 AU
P/1978 XIX (Denning-Fujikawa)	251.°92	Dec 04	272°	−40°	22 km/s	0.07966 AU
1994 XL1	253.°08	Dec 05	176°	+45°	19 km/s	0.02129 AU
P/1969 VII (Fujikawa)	253.°32	Dec 05	57°	+ 5°	25 km/s	0.13731 AU
P/1806 I (Biela)	253.°86	Dec 06	25°	+48°	19 km/s	0.00130 AU
P/1770 I (Lexell)	254.°39	Dec 06	262°	−21°	24 km/s	0.02348 AU
1994 XM1	254.°65	Dec 07	49°	+ 0°	16 km/s	0.00458 AU
P/1812 (Pons-Brooks)	255.°03	Dec 07	202°	+71°	49 km/s	0.19830 AU
P/1941 IV (de Kock-Paraskevopoulos)	256.°25	Dec 08	181°	− 7°	70 km/s	0.11874 AU
P/1798 II (Bouvard)	256.°30	Dec 08	164°	+33°	70 km/s	0.12976 AU
1992 LC	258.°52	Dec 09	77°	− 6°	23 km/s	0.10321 AU
Nereus (4660)	258.°73	Dec 09	35°	+22°	13 km/s	0.02073 AU
P/1962 IV (Honda)	259.°80	Dec 11	111°	−24°	47 km/s	0.00105 AU
Phaethon (3200)	262.°09	Dec 14	114°	+32°	35 km/s	0.02540 AU
P/1931 IV (Ryves)	262.°75	Dec 14	131°	+20°	59 km/s	0.06310 AU
P/1917 I (Mellish)	262.°87	Dec 14	103°	+ 9°	43 km/s	0.06650 AU
Toutatis (4179)	263.°01	Dec 15	299°	−22°	16 km/s	0.00575 AU
P/1618 III	263.°71	Dec 15	282°	− 9°	25 km/s	0.08470 AU
P/1895 III (Brooks)	263.°73	Dec 15	185°	−58°	46 km/s	0.11690 AU
1989 AC (5755)	264.°08	Dec 16	298°	−22°	17 km/s	0.00556 AU
1982 XB (3757)	264.°47	Dec 16	17°	−17°	13 km/s	0.02132 AU
P/1881 V (Denning-Fujikawa)	265.°98	Dec 17	281°	−35°	23 km/s	0.03877 AU
P/1846 VII (Brorsen)	267.°54	Dec 20	205°	+ 5°	67 km/s	0.04060 AU
1994 WR12	268.°59	Dec 20	171°	−17°	14 km/s	0.07858 AU
Oljato 1947 XC (2201)	268.°95	Dec 21	86°	+20°	23 km/s	0.00920 AU
P/1935 I (Johnson)	271.°61	Dec 23	116°	−53°	45 km/s	0.16530 AU
1982 XB (3757)	271.°95	Dec 24	11°	−20°	13 km/s	0.02513 AU
P/1818 III (Pons)	272.°04	Dec 24	169°	−38°	65 km/s	0.13476 AU
P/1652	272.°43	Dec 24	192°	−60°	47 km/s	0.10953 AU
Khufu (3362)	272.°70	Dec 24	104°	+ 5°	19 km/s	0.15154 AU
P/1994 o (Machholz 2)	273.°84	Dec 25	290°	+ 2°	22 km/s	0.11384 AU
1993 VW	274.°41	Dec 26	76°	+47°	17 km/s	0.10948 AU
Tantalus (2102)	274.°59	Dec 26	135°	−45°	35 km/s	0.02810 AU
P/1952 I (Wilson-Harrington)	275.°96	Dec 27	200°	−23°	66 km/s	0.19787 AU
P/1680	276.°44	Dec 28	134°	+21°	52 km/s	0.01230 AU
Cuno (4183)	278.°31	Dec 30	89°	+36°	21 km/s	0.03676 AU
1995 CR	278.°60	Dec 30	244°	−23°	31 km/s	0.06304 AU
P/1883 I (Brooks-Swift)	279.°11	Dec 30	243°	+26°	47 km/s	0.09764 AU

Ongoing Meteor Work

No Link between Comet 1995 O1 (Hale-Bopp) and the Quadrantids

Duncan Steel, Anglo-Australian Observatory

Recently, there has been a lot of discussion on a possible link between the Quadrantids and Comet 1995 O1 (Hale-Bopp). It is argued that such a link is very unlikely. Several misconceptions that emerged during these discussion are pointed out. If, however, the author's assertion would be incorrect, and there would be a connection between the two phenomena, there is still no ground to expect a Quadrantid meteor storm during the next few years.

1. Is Comet 1995 O1 the parent of the Quadrantids?

There has been considerable discussion through the Internet between people who seem to be convinced that there is some link between the recently-discovered (giant?) Comet 1995 O1 (Hale-Bopp) and the Quadrantid Meteor Shower. The main source of puzzlement here seems to be caused by the fact that the Earth passes through the cometary orbital plane on January 3, when the Quadrantids peak, more-or-less. However, the cometary orbit does not pass very close by the Earth—in fact it is more than 0.1 AU away, at the closest point—and since meteoroids do not pick themselves up and move sideways, an Earth intercept (i.e., a meteor shower) would require some orbital evolution. Thus, some meteoroids released on previous perihelion passages (if there were any: the approximately 3000 year period [1] derived on the basis of a single detection on a UK Schmidt Telescope from April 1993 needs confirmation through continued astrometry on the comet over the next few years) *might* have followed an evolutionary path that could allow them to meet the Earth. That is most easily thought of as being a rotation of the argument of perihelion bringing the node to 1 AU, although in reality things are more complicated. In general that would lead to Earth intercept at some *other time of year* (i.e., *not* January 3) but in this case one is helped by the inclination being near 90° (for the comet; but the differing inclination for the Quadrantids means that a rather different date would be arrived at even if one could evolve an orbit like 1995 O1 into one like the Quadrantids). In view of the above one might tend to view the January 3 coincidence as being just that, with there being no genetic link between 1995 O1 and the Quadrantids.

If, however, I am wrong in the above assertion, and there *is* a link between the two phenomena, then might one expect a Quadrantid meteor storm in the next few years? The answer to that also is *no*. Meteoroids which had undergone differential perturbations (relative to the putative parent) would have different orbits to it, and thus they would not be concentrated close behind the parent, producing strong showers or storms. We see such phenomena from the Leonids and the Perseids (in recent years) only because the parent comets (55P/Tempel-Tuttle and 109P/Swift-Tuttle) happen to have orbits passing very close to that of the Earth; 1995 O1 does not. Similarly, there were no enhanced rates from the η-Aquarids and Orionids in the 1980s, the parent comet (1P/Halley) passing perihelion in 1986, because the comet does not currently pass close to the terrestrial orbit. The meteoroids we observe in those showers were released centuries to millennia ago, and so have been quite widely dispersed, producing showers of fairly constant activity from one year to the next.

2. How accurate are the tabulated orbital sizes for large meteoroid streams?

I now move on to a discussion of another point that has been brought up in some newsgroup debates. It has been claimed that various meteor showers such as the Lyrids (parent comet 1861 G1 Thatcher), the η-Aquarids and the Orionids contain meteoroids which have orbits substantially smaller than the parent, so that meteoroids from 1995 O1 could have orbits with rather shorter periods than that of the comet. Again, although I would expect streams such as the three mentioned above to have mean orbits—with a wide spread—which might be smaller than the parent comets' orbits, the discussions of the three showers (two streams) has been misguided since it has been based upon a misunderstanding of the veracity of the data involved. For example, the most-often used orbit for the η-Aquarids is based on one meteor only [2]! Although we now have over 1000 η-Aquarid orbits from a meteor orbit radar in New Zealand [3], all researchers involved in the determination of meteoroid orbits will recognize that the semi-major axes derived are rather uncertain, especially for large orbits. The reason is as follows. One actually makes a measurement of the meteor speed in the atmosphere, and then applies a correction for atmospheric deceleration prior to detection; that correction is most often just a fudge factor applied to all measurements, so that even if your measurement were perfect (zero error, which is nonsense), still you would not know the pre-atmospheric speed with precision. Next, one makes a (two times two-body) approximation in deriving the speed in space (V), and then one calculates the semi-major axis from

$$V^2 = \frac{GM}{1\ \mathrm{AU}}\left(\frac{2}{r} - \frac{1}{a}\right),$$

where r is the heliocentric distance. Anyone with a calculator will be able to see that a very small error in V will make a huge difference in the derived value of the semi-major axis (a) if it is large. This is the reason why many meteoroid orbit surveys have produced large numbers of "hyperbolic" meteors: actually large eccentricities but with $e < 1$, with measurement errors resulting in $e > 1$ being calculated.

In fact the way in which one links large meteoroid streams with the putative parent comets is through similarity in (*i*) the inclinations; (*ii*) the perihelion distances; and (*iii*) the directions of perihelion (usually, the longitude of perihelion, which varies slowly under planetary perturbations). The percipient reader will note that the derived value of the perihelion distance (q) in (*ii*) depends on the value found for the semi-major axis ($q = a(1 - e)$), and so might expect a large spread in q due to the measurement errors. However, it turns out that the errors in a and e are to some extent self-compensating (see the meteoroid orbit algorithm in, say, [4]) which leads to decent values for q. There is really no doubt about the parents of the Lyrids, η-Aquarids and Orionids. The reason that the values for the semi-major axes of the stream orbits tabulated in many reports differ somewhat from the parent comets' values is that, predominantly, measurement errors result in rather uncertain results for that parameter, although the other orbital elements may be quite well determined, allowing the genetic association to be established.

3. What shrinks the sizes of meteoroid orbits?

Another misguided comment made concerned the solar wind and light pressure, which were supposed to produce smaller orbits. That is incorrect. These provide a radial (near-radial for the solar wind) pressure which increases the orbital size, and that is the source of the idea (which may be wrong) that long-period comets make no significant contribution to the interplanetary meteoroid complex: their dust and meteoroids are blown away, as it were. Contrary, modeling has been carried out by Marco Fulle and colleagues over the past seven years or so (see several papers in *Astronomy and Astrophysics*). If a meteoroid is left on an elliptical orbit then it will have that orbit shrunken by the Poynting-Robertson effect to some extent (the rate of shrinkage varies as the reciprocal of the size of the particle). However, the greatest immediate effect is that due to the "ejection" speeds from the comet (hence Fulle's work; try putting slightly smaller values of V into the equation above and see how the semi-major axis is affected). I should note here, however, that the energy absorbed by meteoroids from impinging solar wind particles can enhance the Poynting-Robertson effect by about 20%.

4. So what is the parent of the Quadrantids?

I now turn to the real parent of the Quadrantids. A possible link between the Quadrantids and Comet 1491 I (new designation 1490 Y1) was made some years back, I believe by Ichiro

Hasegawa. That possibility cannot be ruled out [5]. However, soon after the comet now known as 96P/Machholz 1 was discovered, *that* comet was recognized as being the likely parent of the Quadrantids along with seven other showers. I discussed this in a review published in 1994 [6], from which the following is extracted:

> "Over the past decade work on one stream in particular has provided some insight into the generalities of stream orbital evolution, and this stream is that which produces the strong Quadrantid shower. Soon after the discovery of P/Machholz (1986 VIII) it was realized that this comet was very probably the parent not only of this shower, but also of seven other showers, including the Daytime Arietids, the δ-Aquarids, and the Ursids; however, association of this complex stream with Comet 1491 I cannot be ruled out (Williams and Wu, 1993), which may indicate that the complex was formed from the break-up of a single larger comet. The relationship is particularly surprising in that the orbital elements are very different for these showers and comets (e.g., the Quadrantids, Ursids, δ-Aquarids, Daytime Arietids, P/Machholz, and 1491 I have $q = 0.977$, 0.968, 0.07, 0.09, 0.127, and 0.761 AU, respectively). Recent papers on the orbital evolution of the stream include Zausaev and Pushkarev (1989), McIntosh (1990), Babadzhanov and Obrubov (1992), Jones and Jones (1992), and Wu and Williams (1992)."

Those last five papers are listed below as [7–11]; Williams and Wu (1993) is [5]. An inspection of these papers will leave the reader in little doubt that the parent of the Quadrantid shower, and seven other showers produced through the complicated orbital evolution of the stream producing them, has been identified. The coincidence of dates between the epoch of the Quadrantid shower and the time when the Earth passes through the orbital plane of Comet 1995 O1 (Hale-Bopp) is of no physical significance, and I very much doubt that there is any genetic link between them. Even if that comet *were* the parent of the shower, one should not anticipate any storm, or even enhancement in shower activity, for the Quadrantids in the next few years, at least on the basis of the appearance of 1995 O1. The two are unrelated phenomena.

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The Leonids

Bulletin 6 of the International Leonid Watch

Peter Brown

Final visual results for the Leonid return in 1994 are presented. These indicate that an increase in activity occurred in 1994 in comparison to the intervals so far studied during all previous *ILW* periods. The visual observations suggest that some level of enhanced activity was present in the interval $\lambda_\odot = 235.^\circ4$–$236.^\circ3$. The peak ZHR in 1994 was of order 100, but the very large scatter present in the observations due to interfering moonlight make a precise determination not possible. The radio forward-scatter observations also suggest a long-lived period of activity, but the raw radio counts do not agree on the precise time of maximum. The outlook for the shower in 1995 is very promising and enhanced activity might be visible from almost any longitude.

1. Introduction

As reported in Bulletin 5 of the *ILW* [1], despite poor lunar conditions, the fourth *ILW* period (November 5–25, 1994) showed the first clear indications of unusually strong Leonid activity as evidenced by a small number of visual observations. This conclusion is broadly supported by radio data gathered during November 18. The outburst in 1994 is the first from the Leonids in 25 years, the last certain outburst having taken place in 1969. The precise duration of the activity and its strength in 1994 will not be absolutely definable with the currently available data due to the very large uncertainties involved in corrections under poor lunar conditions. We may be able to gain some insight, however, into the extent of the 1994 outburst by investigating all observations finally reported to the *IMO*.

2. 1994 observational data

Visual observations

In all, 398 Leonids were observed in the interval $\lambda_\odot = 229^\circ$–$238^\circ$ (2000.0) totaling 61 hours of net observing by 25 observers in 1994. A standard value of $r = 2.5$ was used throughout, though it is quite probable that this value varied significantly through the stream. The interval $\lambda_\odot = 232^\circ$–$238^\circ$ is shown in Figure 1, where only individual ZHR's have been plotted.

Despite the relatively large number of observers and recorded Leonids, the overwhelming consideration is the bright moonlight and associated interference. The longitudes well away from the maximum show the scatter in individual ZHR values due to the tendancy to overcorrect under such conditions—indeed ZHR values as high as 30 are recorded several days before maxima, an effect clearly an artifact of the bright moonlight.

The increased activity seems to be confined to the interval $\lambda_\odot = 235.^\circ4$–$236.^\circ3$, though it is notable that a significant gap in coverage exists between $\lambda_\odot = 236.^\circ2$–$236.^\circ6$. It seems likely that a true maximum was reached somewhere in the first of these intervals. The magnitude of the maximum is not clearly defined, but might be near 100 or perhaps slightly less. By $\lambda_\odot = 236.^\circ6$ the activity has returned to normal.

Too few visual observations with magnitude estimates are available to attempt to compute the r-value for any portion of this activity profile.

Radio observations

Several radio observers monitored the Leonids in 1994. The results have been summarized in Bulletin 5 [1]. These data broadly support the final visual results and suggest that some enhanced activity took place during this interval. As reported in *ILW* 5, radio activity peaked at $\lambda_\odot = 236.^\circ0$–$236.^\circ1$ in North America while raw peak radio counts in Finland peaked near $\lambda_\odot = 235.^\circ7$ and those from Japan at $\lambda_\odot = 236.^\circ3$. All radio data in 1994, however, were elevated for many hours around these nominal (raw) peaks and support the conclusions from the visual observations that the outburst lasted for 12–24 hours.

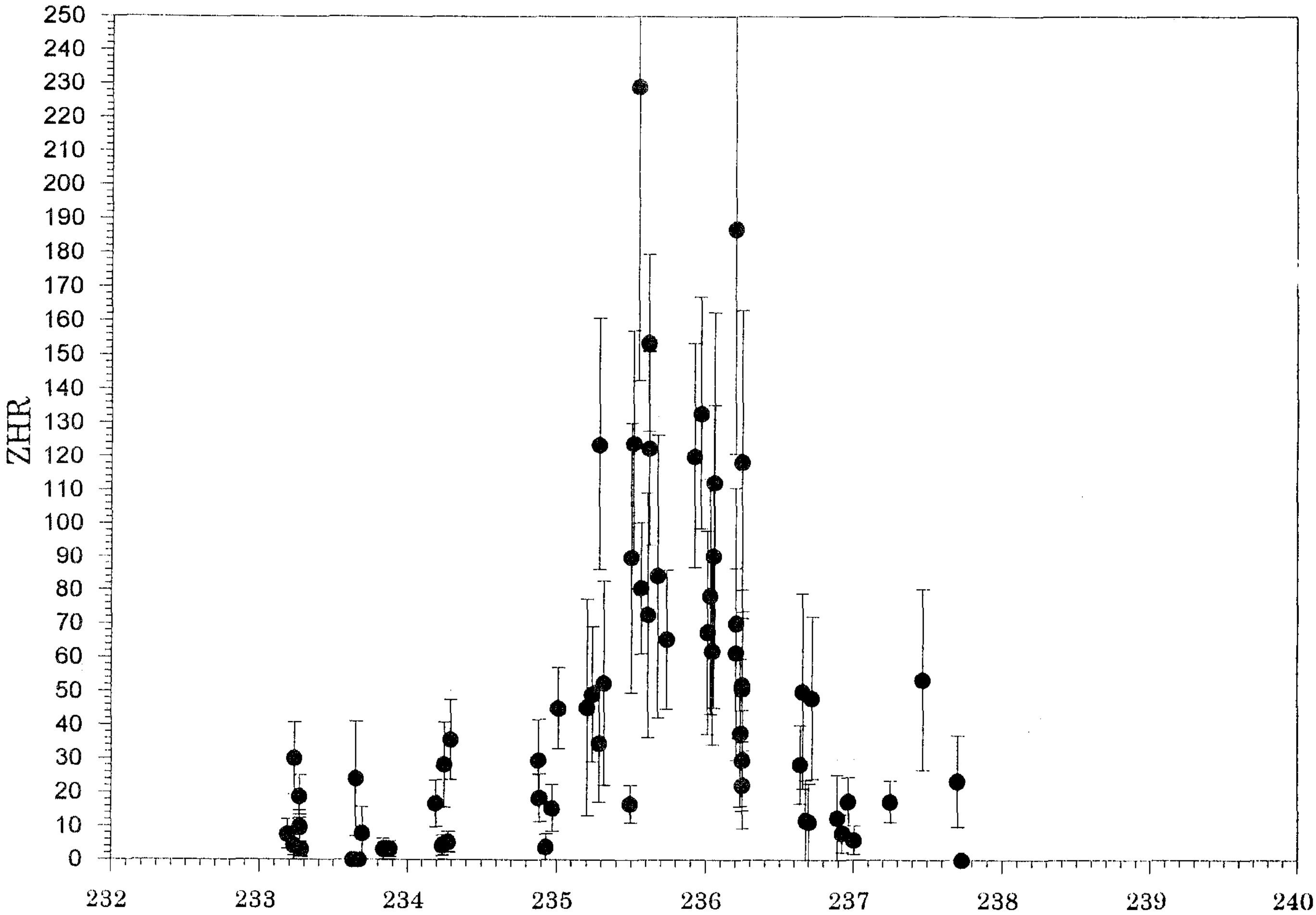

Figure 1 – ZHR profile obtained from visual observations of the 1994 Leonids. (The solar longitudes refer to eq. 2000.0)

It must be emphasized that true fluxes can only be derived from these data when all system parameters are known and the observing geometry is properly taken into account.

3. Outlook for ILW period 5: November 5–25, 1995

From the previous analysis it appears that enhanced activity from the Leonids may occur at any time from $\lambda_\odot = 235°4$–$236°3$ if the features observed in 1994 repeat in 1995. These longitudes correspond to the time interval from 4^h UT on November 18 to 1^h UT on November 19. This interval means that any enhanced activity repeating last year's pattern could be seen at virtually any longitude.

For comparison, the current node for 55P/Tempel-Tuttle is at $\lambda_\odot = 235°29$, corresponding to approximately 1^h UT on November 18. Hence observers in Eastern Europe should be particularly vigilant in 1995 should the period around this latter time prove to be the more appropriate.

The moon will be two days past last quarter on November 17-18 and just over 20% illuminated in Virgo. It should rise 1-2 hours after midnight from mid-northern latitudes, giving a few hours of complete darkness for monitoring the shower.

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The Perseids

Strong Activity of 1995 Perseids Observed in Japan

Kazuhiro Suzuki

Strong activity of the 1995 Perseids was detected by radio techniques in Japan. The maximum activity occurred at 18^h10^m UT on August 12, 1995, or $\lambda_\odot = 139\overset{\circ}{.}63$ (2000.0). The maximum hourly rates of meteor echoes reached 280–320 (100–120 during non-shower periods), and the strong activity lasted for about 50 minutes.

1. Introduction

Strong activity of the Perseids was detected by monitoring forward-scatter meteor echoes of the MU radar wave of Kyoto University (46.5 MHz, 1 MW) at Toyokawa Meteor Observatory (TMO), Aichi, Japan. The radio observation was carried out from 11^h UT on August 11 till 8^h UT on August 14, 1995 for 69 hours at TMO ($\varphi = 34\overset{\circ}{.}81$ N, $\lambda = 137\overset{\circ}{.}32$ E), located about 140 km east from the radar site ($\varphi = 34\overset{\circ}{.}85$ N, $\lambda = 136\overset{\circ}{.}10$ E).

The radar wave (by the MU radar) was transmitted not in a pencil-like beam, but in a donuts-like beam (omni-directional in azimuth) with a peak at about 30° off zenith. The transmitting antenna beam pattern is shown in the paper by Nakamura et al. [1]. The antenna used for reception is a dipole antenna with a length of 1/2 wavelength (3.3 m) located horizontally with a height of 8 m above the ground. Hence, the antenna pattern for reception is roughly isotropic.

Table 1 – The hourly rate data of the Perseid (+sporadic) meteor echoes (−106 dBm⁻) monitored during August 11–14 UT, 1995 and November 4–6 UT (during a non-shower period), 1994. Transmitting station: MU radar ($\varphi = 34\overset{\circ}{.}85$ N, $\lambda = 136\overset{\circ}{.}10$ E) of Kyoto Univ. (46.5 MHz, 1 MW), Japan. Receiver: ($\varphi = 34\overset{\circ}{.}81$ N, $\lambda = 137\overset{\circ}{.}32$ E) in Aichi, Japan.

Period (UT)	Aug 11	Aug 12	Aug 13	Aug 14	Nov 4–6
00^h–01^h		66	102	120	86
01^h–02^h		60	78	108	70
02^h–03^h		54	66	90	56
03^h–04^h		90	96	48	54
04^h–05^h		54	64	84	57
05^h–06^h		66	72	60	40
06^h–07^h		54	48	42	33
07^h–08^h		60	42	72	
08^h–09^h		66	60		
09^h–10^h		36	42		
10^h–11^h		42	42		47
11^h–12^h	60	66	48		40
12^h–13^h	66	90	84		51
13^h–14^h	78	130	66		48
14^h–15^h	120	133	78		38
15^h–16^h	102	179	126		60
16^h–17^h	150	232	126		71
17^h–18^h	172	265	180		95
18^h–19^h	154	315	168		103
19^h–20^h	144	212	168		116
20^h–21^h	132	181	186		95
21^h–22^h	156	192	138		109
22^h–23^h	120	144	162		113
23^h–24^h	108	96	138		97

2. Observational results

Table 1 shows the distribution of the hourly rates of the total number of monitored meteor echoes (−106 dBm⁻) from 11^h UT on August 11 to 8^h UT on August 14, 1995. The evolution of the hourly rates owes not only to the Perseids but also to sporadic meteors. Therefore, the activity of the Perseid meteors seems to have been added to the normal diurnal variation of sporadic meteor echoes.

The hourly echo rates clearly increased during 13^h–22^h UT on August 12, 1995, compared to the other days in August, 1995, and the average of November 4–6 (during a non-shower period), 1994 [2]. And they reached 280–320 (about 100-120 on November 4–6). This increase of the echo rates is considered to be due to the strong activity of the Perseid meteors.

Table 2 shows the detailed echo rate data in the period 13^h–22^h UT on August 12, 1995 in order to fix the accurate maximum of strong activity of the Perseids. Long persistent echoes from bright meteors are characteristic for the Perseid meteor shower. Actually around the peak of the Perseid activity, long persistent echoes increased explosively. The total dead time (in seconds per 10 minutes) due to persistent trains is shown in Table 2. Also table 2 shows the rates per 10 minutes of the total number of monitored meteor echoes (−106 dBm⁻).

Figure 1 shows the evolution of the hourly rates of the total number of echoes and the dead time (in seconds per 10 minutes) caused by long-lasting echoes around the maximum of the Perseid activity. The hourly rates were derived by a 10 minute step method.

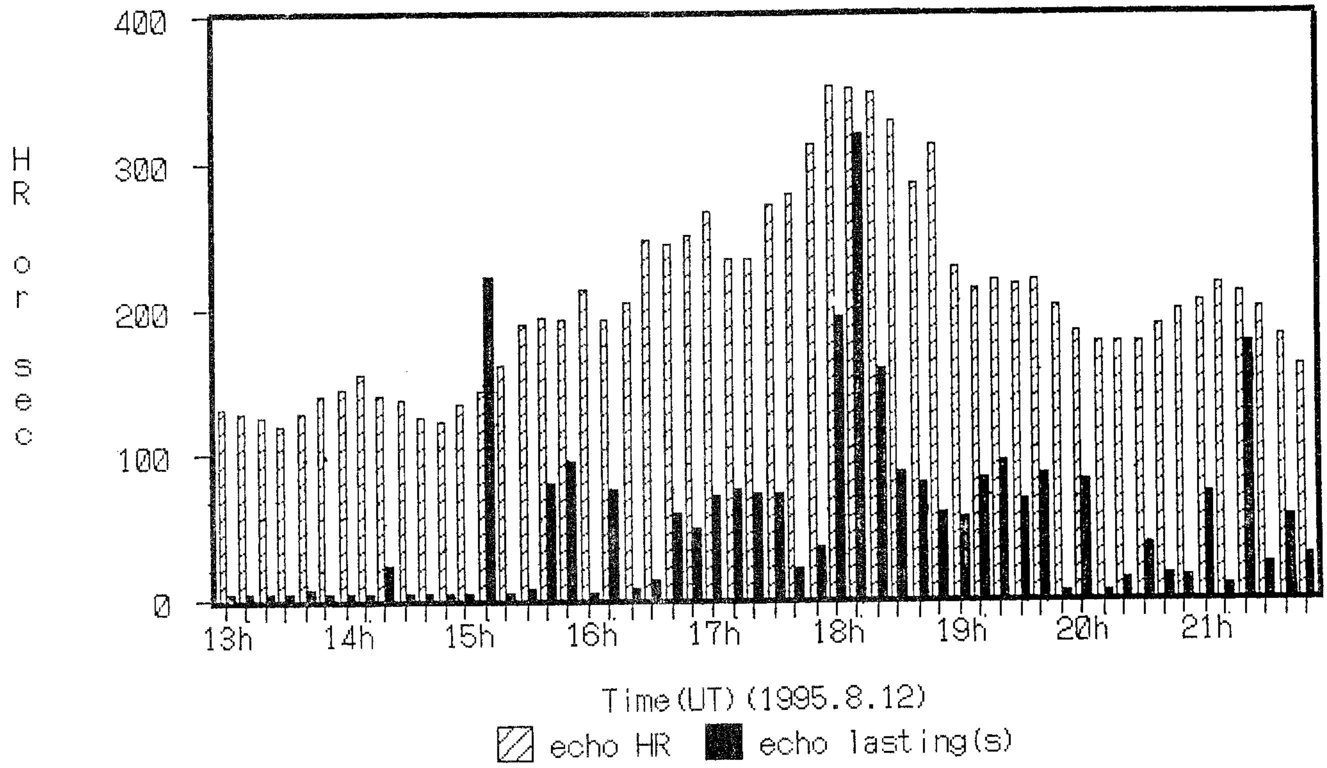

Figure 1 – Evolution of the Perseid echoes on August 12, 1995, as observed by a Japanese forward scatter system.

3. Conclusions

The following conclusions can be drawn regarding time of maximum activity and duration of strong activity:

- The strongest activity of the 1995 Perseids occurred at 18^h10^m UT on August 12, and the corresponding solar longitude was $\lambda_\odot = 139.^\circ63$ (Eq. 2000.0). As the outburst of the 1991 Perseids occurred at $\lambda_\odot = 139.^\circ56$ (Eq. 2000.0) [3], this peak also seems to be one of a series of the new Perseid peaks having started in 1991.

- According to Figure 1 and Table 2, the strongest activity of the 1995 Perseids lasted for about 50 minutes (from 17^h50^m UT to 18^h40^m UT) on August 12. As the 1991 and 1992 Perseid outbursts lasted for 90 and 120 minutes, the maximum strength of the 1995 Perseids might be weaker than that of the past few years.

Table 2 – The detailed rate data of the Perseid (+sporadic) meteor echoes around the maximum activity during 13^h–22^h UT on August 12, 1995. For each period (in UT), the echo rate per 10 minutes (−106 dBm⁻) and the total dead time due to persistent trains (in seconds) are given.

Period (UT)	Echo rate	Dead time	Period (UT)	Echo rate	Dead time
13^h00^m–13^h10^m	26	5+	17^h30^m–17^h40^m	39	72
13^h10^m–13^h20^m	18	5+	17^h40^m–17^h50^m	61	20
13^h20^m–13^h30^m	20	5+	17^h50^m–18^h00^m	49	36
13^h30^m–13^h40^m	20	5+	18^h00^m–18^h10^m	59	193
13^h40^m–13^h50^m	22	5+	18^h10^m–18^h20^m	66	319
13^h50^m–14^h00^m	24	5+	18^h20^m–18^h30^m	59	158
14^h00^m–14^h10^m	27	5+	18^h30^m–18^h40^m	47	87
14^h10^m–14^h20^m	23	5	18^h40^m–18^h50^m	46	80
14^h20^m–14^h30^m	29	24	18^h50^m–19^h00^m	38	59
14^h30^m–14^h40^m	14	5+	19^h00^m–19^h10^m	37	56
14^h40^m–14^h50^m	25	5+	19^h10^m–19^h20^m	30	82
14^h50^m–15^h00^m	15	5+	19^h20^m–19^h30^m	37	95
15^h00^m–15^h10^m	27	5+	19^h30^m–19^h40^m	42	68
15^h10^m–15^h20^m	23	221	19^h40^m–19^h50^m	35	86
15^h20^m–15^h30^m	30	5+	19^h50^m–20^h00^m	31	5+
15^h30^m–15^h40^m	27	8	20^h00^m–20^h10^m	26	81
15^h40^m–15^h50^m	46	79	20^h10^m–20^h20^m	30	5
15^h50^m–16^h00^m	26	95	20^h20^m–20^h30^m	30	14
16^h00^m–16^h10^m	29	5+	20^h30^m–20^h40^m	31	37
16^h10^m–16^h20^m	41	76	20^h40^m–20^h50^m	26	16
16^h20^m–16^h30^m	32	7	20^h50^m–21^h00^m	38	15
16^h30^m–16^h40^m	33	13	21^h00^m–21^h10^m	37	72
16^h40^m–16^h50^m	58	59	21^h10^m–21^h20^m	35	9
16^h50^m–17^h00^m	39	48	21^h20^m–21^h30^m	33	176
17^h00^m–17^h10^m	36	71	21^h30^m–21^h40^m	34	24
17^h10^m–17^h20^m	44	76	21^h40^m–21^h50^m	31	56
17^h20^m–17^h30^m	36	73	21^h50^m–22^h00^m	22	29

Acknowledgment

This observation was supported by the MU radar of Kyoto University. The author is greatly indebted to Dr. Takuji Nakamura for his valuable comments and suggestions.

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Fireballs and Meteorites

Bright Bolide

Sunderland, England, July 28, 1995, 22^h53^m UT

Alastair McBeath and Don Simpson

A bolide which probably reached magnitude −20 at a late-stage fragmentation event, passed over the city of Sunderland, England, around 22^h53^m UT on 1995 July 28, creating a series of sonic and electrophonic effects.

1. Observations

By late September 1995, in excess of 100 reports of a brilliant fireball that passed directly over the city of Sunderland in north-east England ($\lambda = 1°25'$ W, $\varphi = 54°55'$ N) on July 28, 1995, had been compiled from sites across northern England. Many of these were casual sightings, and very few amateur astronomers with experience of meteor observing were fortunate enough to see the meteor. So far, no videos or photographs of the event have been secured, but despite these problems, a reasonable estimated track for the meteor has been established.

Of the reports received, 79 were regarded as reliable enough to allow us to reconstruct the object's most probable track and derive other details. Nevertheless, the various figures quoted here should be treated with caution. The spread of observers was 46 south of the track, 27 north, 2 west or south-west, 2 virtually beneath it, and 2 still unlocated. All but six sites were located within about 20 km of the fireball's late fragmentation event. Weather conditions were generally calm and mostly clear, although several sites reported some cloud and mist. North of Newcastle, conditions seem to have been generally poorer.

2. Fireball details

The meteor appeared between 22^h52^m and 22^h55^m UT, most probably at 22^h53^m UT, and moved west to east, as shown in Figure 1. Assuming a luminous start height of 80 km (which gives the best fit for the two better start positions that could be approximately triangulated), suggests the ground track was around 70 km long, beginning a few kilometers north-east of the village of Alston ($\lambda = 2°23'$ W, $\varphi = 54°45'$ N). The meteor descended, passing over the town of Washington and the city of Sunderland and ending up several (4?) kilometers out over the North Sea ($\lambda = 1°15'$ W, $\varphi = 54°51'$ N). Around 12 km before the end of the ground track (between Washington and Sunderland), the meteor flared rapidly two or three times, fragmenting severely into 2–3 main objects, and creating a shower of "sparks," some of which may have fallen virtually under the influence of gravity alone, since some observers mentioned seeing a "rain" of sparks, but no meteor after the main flaring.

Based on the above figures, and using the rough acoustic noise timings from around Sunderland about 1.5–5 minutes after the meteor, which were assumed to have occurred as a result of its late-stage fragmentation, we have estimated the atmospheric path at about 90 km, with a mean entry angle of 38°, making the luminous end height about 26 km. A mean flight duration of 3.5 seconds yields an atmospheric velocity of 26 km/s. If correct, these calculations would put the splashdown point for any meteorite following the meteor's luminous path approximately 40 km off the River Wear's mouth.

The fireball's peak brightness was probably around magnitude −20 at the fragmentation flares. It had already reached fireball magnitude status very early in its flight, but the late flare event raised its brightness dramatically, creating a sky brighter than daylight according to some witnesses who were outdoors at the time, this in spite of the city's light pollution problems. The colors seen were generally brilliant white, sometimes with a yellow or blue tinge, while the sparks seen falling from the trail were generally described as orange.

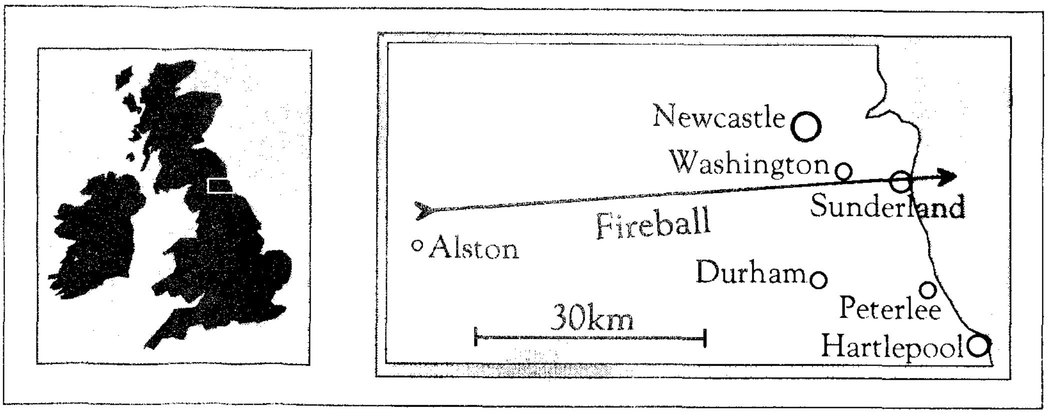

Figure 1 – Approximate trajectory of the Sunderland Bolide over north-east England.

3. Sonic and other unusual effects

In all, 48 reports noted sounds heard either simultaneous with the meteor's flight (or within 30 seconds of its passing; such events were treated as "near-simultaneous") or within a few minutes of its ending. The post-meteor acoustic reports generally describe a noise compatible with an explosion of the meteoroid, either as a detonation sound, or a thunder-like rumbling. The simultaneous/near-simultaneous sounds recorded were primarily of a crackling or low rumbling nature, with several people reporting either a single detonation noise or two similar sounds. All of the 13 (7 simultaneous) sites recording these sounds were within 4.5 km of the projected line of flight, all but three within 1.1 km of the ground track. In addition, six sites reported objects rattling as if vibrated or shocked. There was one report of a ground shock and one of an air shock.

Two reports noted that "large numbers" of electronic car alarms were set off in the Ashbrooke area of Sunderland, a small area about one kilometer square, which lies less than 1.25 km south of the fireball's path, and about 5–6 km away from the projected track's end. It is not clear how many alarms were activated in this way, although most were set off at virtually the same time, nor is it clear what the time delay after the meteor was in these events. These were most probably activated by the sonic shock wave, however.

We also received notices of four instances of curtains at open windows being moved simultaneous with the meteor's main flare being seen, three of these within 1.5 km of the flight line, and all south of the ground track. The three closest instances had curtains blown into rooms, and may be due to ELF/VLF activity, since the curtains were light-weight summer or nylon net curtains, light enough to be so affected perhaps, and also with the potential for storing/discharging static electricity in some form. No electric shocks were noted on touching these curtains, however. The fourth event was about 18 km south of the meteor's path and had probably nothing to do with the fireball. The three Sunderland "curtain events" all lay near the southern limit of the main simultaneous/near-simultaneous events, and as the outermost two were about 4.5 km apart east-west, it seems unlikely that a chance breeze, unnoticed by others with open windows and drawn curtains at the time, was responsible.

4. Conclusion

We would like to thank all the observers who have contributed data and the *Sunderland Astronomical Society* who assisted in collecting the data. If anyone still has a report to submit on this fireball, or any others, please do so with all speed. We are aware that there are some largely unpublicized and rather garbled accounts of a possible second bright meteor seen traveling south-north at about the same time on July 28 from sites in southern England. Unfortunately, there seem to be no genuine sightings of this meteor (if it was a separate event) available at the time of writing.

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