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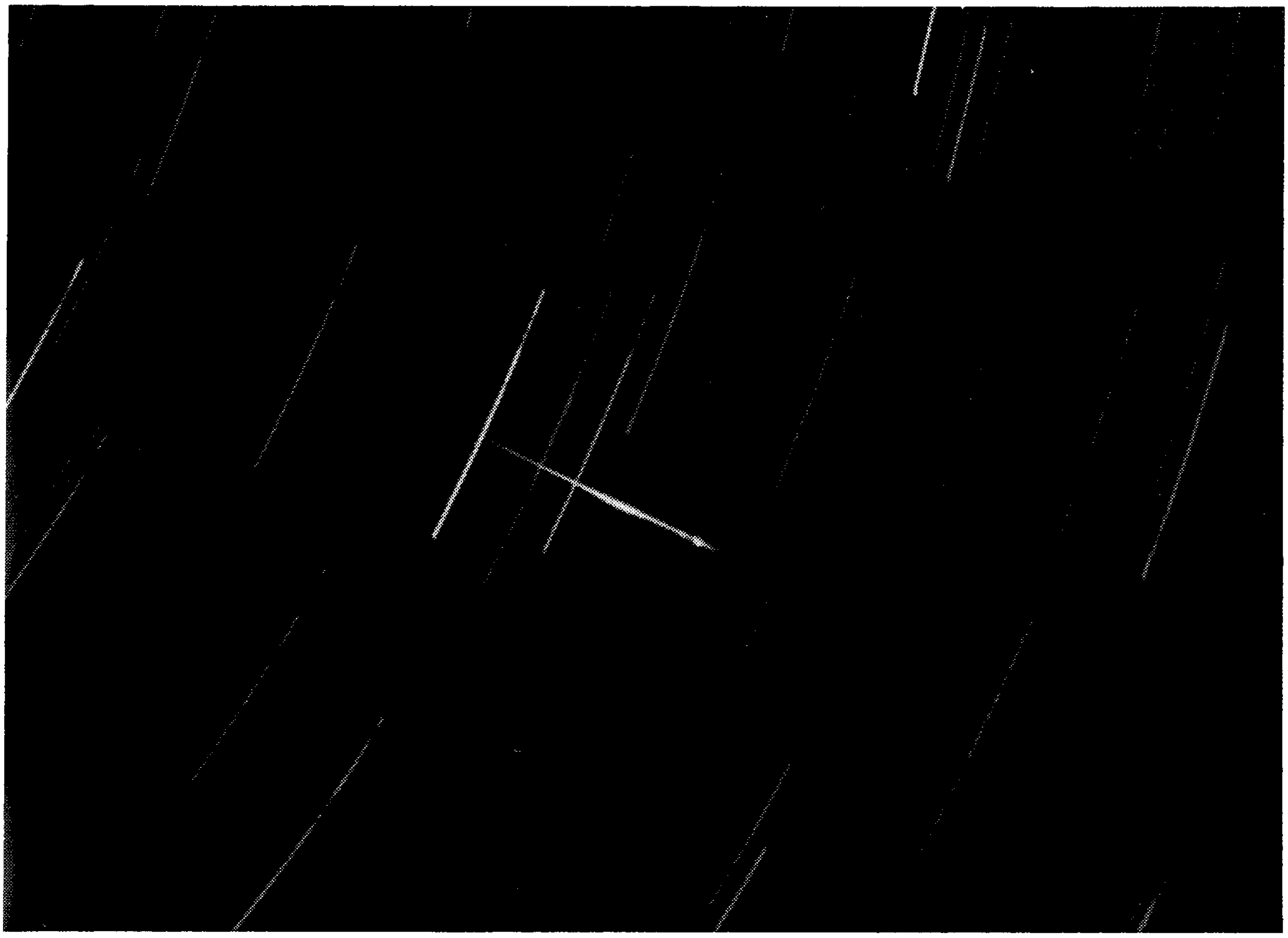

This beautiful Perseid in Perseus of magnitude −5 with a persistent train of 25 seconds was photographed by Pavol Rapavý during a Slovak Meteor Expedition in Žliabky on August 12, 1996, at $1^h36^m10^s$ UT. It was photographed with a 30 mm $f/3.5$ lens on FOMA T800 film.

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- New International Leonid Watch Bulletin
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- Overview of a decade of η-Aquarid observations
- History of meteor astronomy
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Useful Information

The December Issue *(WGN 24:6)*

The *December issue* will be mailed towards the beginning of December. Contributions are due on *November 15* 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

It seems from this summer's observations that the Perseids are well on their way back to "normal" again. An analysis based on all available data at the time of writing is included in this issue.

As each year, one of the main events in the passed period was the International Meteor Conference (IMC) *in Apeldoorn, the Netherlands, organized for the* IMO *by the Meteor Section of the Dutch Association for Meteorology and Astronomy (or* NVWS *by its Dutch abbreviation) at the occasion of their 50th anniversary.*

The event was very well organized and the very international audience ensured further that it became a success. It was especially encouraging to see a large number of participants from Southeastern Europe. The presentations at the 1996 IMC *were very diverse and covered all modes of observing. Particularly encouraging is that video observing is apparently acquiring a certain maturity. Many of the talks were thought-provoking. You can read more about the 1996* IMC *elsewhere in this issue.*

At the IMO *Council Meeting in Apeldoorn, it has been decided to have the 1997* IMC *at the Petnitca Science Center near Valjevo, Yugoslavia. We hope that not only the "regular"* IMC *participants will come, but also that other meteor workers in Southern and Eastern Europe will take advantage of the location to attend!*

Finally, October is also the month that we ask you to renew your membership or subscription. We decided to maintain the basic subscription fee for the journal unchanged at the level of 35 DEM or 25 USD, despite the fact that it is now printed by a commercial printer and despite increased mailing costs. We try to control these mailing costs by sending WGN *from Belgium or Germany depending on the thickness of the issue, to obtain the most favorable postal rates. Nevertheless, the rates for airmail have steeply increased, both in Belgium and Germany, and therefore we have to raise the airmail subscription fee significantly. We ask for your understanding.*

More information about renewal can be found in the following article. Please help us keep our records straight by renewing promptly. Also please observe the payment instructions. Years of experience taught us that these simple rules minimize costs involved in international money transfers. For yourself, you can further save on banking costs by ordering any IMO *publications you are interested in together with your renewal in one payment. A complete list with available publications figures on the back cover.*

You see this thick issue a little later than the previous few issues. The main reason for this is that the timing of the IMC, *together with some other minor things, interfered with the preparation. The December issue however, will be back on schedule and sent out at the very beginning of December to avoid the annual Christmas jam in the mail. Meanwhile, enjoy this issue!*

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Ina Rendtel

General information

Please help us in keeping our records straight by renewing right now. In this way, you insure that your subscription is processed well in time before the February issue has to be sent out and you save the already overloaded *IMO* officers to have to run on and off to the post office to mail back issues. All relevant information is concisely summarized below.

International payments invariantly involve costs. Therefore, if you also wish to buy 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 Report 8 containing the 1995 visual observations, and the Proceedings of the 1995 and 1996 *IMCs*, the latter of which you will appear shortly and can already be ordered. You can also pay your subscription for *two* years.

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

Letters to WGN

compiled by Marc Gyssens

More on the 1966 Leonid outburst and the role of the IMO

Marco Langbroek's letters in the June issue replying to reactions to his earlier letters, sparked a lot of other reactions. Some people wrote lengthy letters, while others informed that after careful consideration they finally decided not to write a formal reply. What struck me is that many letters become very emotional, particularly with regard to the role of the IMO. *Since I do not want the discussion to get out of hand, I decided to shorten the letters significantly and not to publish the parts referring to the role of the* IMO, *especially since the points they make are essentially covered by my postscript in the June issue.*

Only the factual information pertaining to the Leonids has been retained. Since I believe that now all the facts and arguments have been given, I also consider this discussion closed.

By the way, upon editing this part of the Letter Section, I noticed that in Marco Langbroek's letters in the June issue and in my introduction to them, 1966 was consistently mistyped as 1996. Apparently, nobody stumbled over this typo...

I want to add a very short comment on the topic so vividly argued about in the discussion: the "jump" of the Leonid rate coinciding with the change of the observing technique. It is known from investigations [1]—and experienced observers will certainly confirm this—that the perception decreases with higher numbers of meteors, since observers miss a fraction of faint meteors if the frequency of bright meteors is high. This happens already with activity levels reached during regular returns of major showers. So I would like to put Marco Langbroek's question the other way around: Was there not an increasing loss of meteors counted with the "traditional" observing technique, while the change allowed to cope with the very high rate? Since there is no overlapping period in which both methods were applied, we can perhaps try to make similar experiments during future outbursts.

[1] R. Koschack, R. Arlt, J. Rendtel, "Global analysis of the 1991 and 1992 Perseids", *WGN, The Journal of the IMO* 21, 1993, pp. 152–168.

Jürgen Rendtel, July 24, 1996

In his letters, Marco Langbroek in my opinion misses the point. Due to saturation problems, radar observations cannot record the real activity level and thus *cannot* show a jump in the activity profile. Observers used tricks such as estimating the number of Leonids in relatively small areas in the sky, estimating what this has been in terms of meteors per second over the entire visible sky. Nobody ever stated that 40 objects were accurately noted.

I would compare this case with an ordinary rain shower. Counting raindrops is a hopeless attempt. One can count the drops falling on a small surface, a tile, for instance, and estimate how much this would be for an entire floor. Is Marco Langbroek leaving without an umbrella when it is raining since he believes, for psychological reasons, that he cannot see more than 4 rain drops at once and hence fails to distinguish a rain shower from a few rain drops per second?

This comparison is not that ridiculous: the most common description of Leonid outbursts is as if you are in the middle of a snow storm under a starry sky... Thus one may count Leonids in a small area every 10 or 20 seconds and estimate from this what the rate per second is over the entire sky.

I sympathize with the remarks of one of the 1966 Leonid outburst observers at Kitt Peak to the Jenniskens paper in a letter in one of the recent *Sky and Telescope* issues. The observers laugh away the comments from those who try to tell them 30 years after the facts what they are allowed to have seen in 1966!

Paul Roggemans, July 30, 1996

I would like to comment on the recent discussion of the Leonid ZHRs in 1966. Not so much the contents, but the current style of the arguments, frightens me a bit. In his last letter, Marco Langbroek emphasizes the philosophy of science [1], which should guide our work and our discussions. Disagreement is a natural way to gain scientific progress. However, the style of discussion is as important as the arguments themselves. Some of the latest letters read more like a flame from some Internet news groups than like a scientific argument.

In his two letters [1,2], Marco mentions interesting facts, some of them I agree with, others sound suspicious to me. Let me raise the following question on the Leonid discussion. Marco complains, that Paul Roggemans and Jürgen Rendtel missed the main point, when they "circumnavigated" the questionable change of observing technique in 1966. I agree that it is quite strange, if just at that time the rates increased by a factor of 8 or so. Something is wrong at this point, and this is what Peter Jenniskens discussed in his paper [3].

However, the original question was, which figure (15 000 or 150 000) is the right (or, better, the most probable) one. In fact, we can interpret Marco's argument of the changing observing methods just the other way around: those observers did not change the method "for fun" but because they realized that the standard method did not work out anymore for those incredible high rates. Could it not be as well, that the last/first values obtained with the standard method were systematically too low, whereas the new method resulted in better values? In that case, the high figure of 150 000 would be correct despite the suspicious jump in the activity profile, which is most probably an artifact.

Another question concerns the statement that a human observer cannot distinguish more than 5 objects at one instant. It is probably correct, that we can only *accurately* distinguish up to 5 objects, but the real question is how good we are in *estimating* a larger number of meteors in one second? Curious about that, I conducted a little experiment. A friend of mine took 10 pieces of paper and plotted an arbitrary number (1–100) of meteors on them. Later, I looked just one second at each of those plottings and estimated the number of lines I saw (without any training beforehand). The result was, that I always overestimated the number of "meteors." However, even my worst estimate was wrong by a factor of 1.6 only. On average, the error was of the order of +30%. What can we conclude from this experiment? The experiment was quite simple compared to the real observing situation, of course. However, a visual observer is indeed able to distinguish at one instant between, let us say, 4, 14, and 40 meteors.

By the way, I do not see a real problem in this discussion of Leonid rates in 1966. When I talked about this subject to Peter Jenniskens a month ago, we both suspected, that the true value is somewhere in between 15 000 and 150 000. The situation is difficult to judge only from literature references, because nobody of us actually *saw* the event. So we have to wait until 1998/99 and see, what we do obtain during the (hopefully returning) Leonid storm with both visual techniques and much more objective video observations.

[1] M. Langbroek, *WGN* 24, 1996, pp. 102–103.

[2] M. Langbroek, *WGN* 24, 1996, pp. 101–102.

[3] P. Jenniskens, "Meteor Stream Activity II. Meteor Outburst", *Astron. Astroph.* 295, 1995, pp. 206–235.

Sirko Molau, August 27, 1996

After reading the recent letters [1-4] about the Leonid activity in 1966, I would like to comment on some points raised by Marco Langbroek in his last letter [4].

In this letter, Marco expresses his suspicion and surprise about the fact that the sudden jump in visual meteor rates as reported by Milon et al. coincides with a change in observing technique. I agree this means special attention and suspicion are due here, but this does not *a priori* mean the reported rates are an artifact induced by the change in observing method. In fact, let us suppose Milon and his colleagues *did* experience a sudden exponential jump in meteor rates up to tens of meteors per second. It would clearly be impossible to count all these meteors, as pointed out by Marco in [4], so the observers would have no choice but to *change their observing method*! What I mean is that such a jump in meteor activity will probably always be directly followed by a change in observing method if the observers are smart enough. Hence, rejecting such a meteor activity jump on the ground of its coincidence with a change in observing technique is more or less equivalent to rejecting the idea of such a jump by itself. I think we should not do this, and so in my opinion it makes sense to try to compare Milon's results with radio and photographic work (albeit radio techniques suffer from oversaturation with meteor rates like both those suggested for the 1966 Leonids).

A second question I want to raise is about the psychological inability to count more than 5 objects in one instance. As I understand it, this means the human brain is not able to grasp more than 5 objects at once, which seems very likely to me indeed. Certainly the human eye is able to hold some tens of light streaks which fell on it during a second when the eyes are closed. I suppose everyone knows from experience that one can still see such light streaks seconds after they originated, leaving some *time* for the observer to count them (i.e., the observer does not count these light patterns in one instance but he takes his time). I think it is possible to distinguish 5 meteors from 10, 20, or 40 in this way, although the count will not be very accurate. If this argument holds, there are no a priori reasons convincing me that Milon's results are definitely wrong. Of course, in that case the high rates can still be due to the change in observing technique, but this is just some possibility, not corroborated by psychological evidence.

In [4], Marco Langbroek interprets the Poisson character of meteor counts in short time intervals as the combination of periods with almost no meteors and periods with very much meteors. Marco argues that with an average activity of 4 meteors per second, it would be possible to explain the much higher number of 40 (or, say, 20 or even 10, since the counts are probably not accurate) meteors per second, as being a period of higher-than-average activity, a statistical fluctuation of the Poisson distribution. If we check a table of a Poisson distribution X for an average λ of 4 meteors, we notice that the probability that $X \geq 10$ equals $P(X \geq 10) = 1 - P(X \leq 9) = 1 - 0.9919 = 0.0081$. The table I consulted, giving four decimal places, stops at $P(X \leq 14) = 1.0000$, meaning $P(X \geq 15) < 0.0001$. This means that if rates of 10, respectively 15 meteors per second are seen, it is very unlikely, respectively virtually impossible, that the average number of meteors per second is only 4. *If* Milton et al. really saw 20 or 40 meteors per second, this means average rates were much larger than 4 meteors per second *beyond any reasonable doubt*.

[1] M. Langbroek, "Letters to WGN", *WGN* 24, 1996, pp. 2–4.
[2] J. Rendtel, "Letters to WGN", *WGN* 24, 1996, pp. 4–5.
[3] P. Roggemans, "Letters to WGN", *WGN* 24, 1996, p. 79.
[4] M. Langbroek, "Letters to WGN", *WGN* 24, 1996, pp. 101–104.

Cis Verbeeck, September 9, 1996

Strange object over Danish oil rig

Back in WGN 21:6, pp. 246–247, Erik Hoeg of the Copenhagen University Observatory contacted the *IMO* for further observations of an unusual object or glow seen from two Danish North Sea oil rigs on October 20, 1993. Although at the time Marc Gyssens requested all correspondence be addressed only to Erik Hoeg, I have recently come upon an explanation for this event, and some additional similar sightings, which I thought might be of interest to *IMO* members.

A short article by Ron Livesey in the *Astronomical Society of Edinburgh Journal*, number 35 (July 1996), p. 11, entitled "Tygorms," briefly reviews the original apparition, noting that no British sightings of it were made. However, two other UK observations of similar phenomena are reported, both occurring as light from sub-horizon flare stacks at oil refineries being reflected from upper troposphere ice-crystal clouds. Danish investigations have shown that this type of light source, in this instance from sub-horizon oil rig flares, was also what produced the October 20, 1993, event, and that observations of such phenomena have continued since then. The glows have been called "tygorms" after the two rigs which provided the original reports, Tyra and Gorm.

Although not mentioned in Livesey's discussion, it would be interesting to know whether any unusual tygorms were detected around February 16-17 this year, when a wide-scale sheet of mesospheric clouds occurred, seen from the surface across the UK, Ireland, and Scandinavia as rainbow-colored nacreous or "Mother-of-Pearl" clouds.

Alastair McBeath, August 28, 1996

Results of meteor watchers survey

In the process of administering the world-wide survey of meteor watchers (*WGN* 24:3, pp. 85–87), I have been able to come into contact with a large number of fellow meteor observers and *IMO* colleagues from many different and far-off places. Their unlimited support and cooperation in getting the questionnaire across to as many observers as possible and their painstaking endeavor to translate the 20 questions into local languages have served as sources of personal satisfaction as well as encouragement.

Each case and each person would be a separate story. I will limit myself to sharing with you the appeal by Khalil Konsul, president of the *Jordanian Astronomical Society*. The *JAS* Meteor Group is small but enthusiastic, composed mainly of middle-aged professionals enjoying the wonderful clear skies resulting from the country's arid conditions. The group however has no expert to turn to in matters regarding meteor observation and data analysis.

Hence I launch the following appeal to all seasoned meteor observers: if anyone is willing to finance his or her way to Amman, Jordan, the *JAS* will be pleased to cover all the local expenses of this volunteer visitor for a short stay, preferably coinciding with a major meteor shower (Perseids or Leonids). This visit will serve as an opportunity to learn first-hand the mystic ritual of standardized meteor observation and the ensuing equally esoteric process of data reduction. If readers are interested in pursuing this, then they should contact *Khalil Konsul, P.O. Box 35022 (Haya Cultural Center), Amman 11180, Jordan.*

There may be other groups out there, as well as various *IMO* members, who may be interested in a similar form of exchange.

Godfrey Baldacchino, September 19, 1996

The 1996 International Meteor Conference

Apeldoorn, the Netherlands, September 19–22, 1996

Detlef Koschny

Below is an account of the latest *IMC* from my personal perspective.

When it comes to meteors, the tradition and fame of the Netherlands is extensive. You hear a lot from the Dutch meteor observers, even though in the annual "phone book" (the *WGN Report Series*) they rank only eighth. However, there are different observer groups, and not all of them send their data to the *IMO*, so from what I hear I tend to believe the true number of meteor observations in the Netherlands much larger than the 210 hours given in the above-mentioned reference.

This was not the first time an *IMC* took place in the Netherlands. In 1983, the *Werkgroep voor Sterrenkunde* invited us to the "Third International Weekend of Meteors" in Denekamp. Actually it was the fourth I am aware of, after Bonn and Munich in Germany and then Hasselt in Belgium. In the list of participants, you already find the names of those people that are always there: Casper ter Kuile, Paul Roggemans, Marc Gyssens, ... Oh, but I do not find Axel Haas in the list. Well, maybe he was ill or had an exam.

Five years later, we had the next conference in the Netherlands, the 1988 *IMC*, near Oldenzaal. It was organized by the *HASA*, the Astronomical Society of the city of Hengelo. I was not able to attend, since I stayed overseas at that time, but from other members of our observer team I heard that it was a good conference. This was also the time when the plans to form the *IMO* took on shape.

So now, after another 8 years, we were back in the Netherlands. This time, the local organization of the *IMC* was in the hands of the *NVWS Werkgroep Meteoren*, the Meteor Section of the Dutch Association for Meteorology and Astronomy. In February, we received the first invitation to the 1996 *IMC*, which took place from September 19 to 22 in the youth hostel "De Grote Beer," i.e., the Great Bear or Ursa Major, in Apeldoorn.

This year's conference followed the tradition that "a weekend is not enough" and started on Thursday evening. So I told my boss that I would take two days off, and on Thursday around noon I started my car. For the first time, I had to go to an *IMC* all by myself—no astronomy friends, no family with me..., the latter probably much to the delight of some people who still remember my little son's comments to some of the talks at the 1995 *IMC* in Brandenburg.

Driving to Apeldoorn was horrible. I prepared my talk the night before and was tired. About 10 minutes away from home, I got stuck in the first traffic jam. My map (dated 1991) mentioned a certain part of the highway around Osnabrück being under construction. It gave end of 1992 as estimated time of completion. Well, it lied. It was still under construction, and I actually had to drive through the city for a while... After 6 exhausting hours, I arrived at "De Grote Beer." There, I heard from people from Rumania, Bulgaria, and this general area that some of them had been on the road for 50 hours! I decided not to complain about my 6 hours.

Figure 1 – The lecture room.

So, what did the conference offer? Lectures, a party, an excursion, a bar and dancing, posters, workshops, discussions, computers, video, pool... So, let us go through the program. If I omit something, do not be offended—I could not be everywhere, did not listen to every talk, and did not know during the conference that I had to write this article. If you want to get details of the lectures, read the proceedings!

Thursday evening started with a welcome from the organizers and a talk from the representative of some private company that sets up a system to communicate by reflecting the radio beam on meteor trails. The advantage is clear: since meteors are high in the atmosphere, only three transmitters are necessary to cover all of Europe. The disadvantage is also clear: meteors cannot be predicted and do not last very long. So, typically, this system is used to transmit only about 100 characters of information. This, however, is enough to allow, e.g., determining the location of trucks, directing them to places where they are needed next, etc. The firm has been in the process of getting started for about 1 year, and plans on going commercial soon. So—another area of science that had a commercial spin-off! We were happy to hear that cooperation with radio amateurs is planned.

After that, we had the first chance to test the bar. A bar is very convenient in a conference room, it encourages discussions and side talks.

On Friday morning, the first session started with reports from meteor observations from different groups. The highlights of the morning were two subsequent talks: Rainer Arlt reported the results of "Radiants from simulated meteors." He (almost) randomly generated simulated meteors in a computer and used them as input files for his RADIANT software. "Almost" means that he adjusted his simulations such that they follow the overall distribution actually observed in the sky, i.e., decreasing numbers close to the horizon etc. He concluded that, with randomly distributed meteors, you still find several—artificial and non-existent—radiants, if you define a radiant as a small area in the sky where several meteors seem to come from.

Immediately after Rainer's talk, Valentin Velkov presented an analysis of Bulgarian meteor observations, finding several radiants of minor showers in the data. So here we go: how real are they? How realistic are the simulations? This has been and still is a matter of ongoing debate in our community.

Another talk worth mentioning was Godfrey Baldacchino's first evaluation of his meteor observer questionnaire. He looks at the people behind all the meteor data and tries to find out what brings us to becoming a meteor observer, whether we prefer group or single watches etc. He warns, however, that we should not try to define an "average" observer, but still, research such as this helps us to understand how we can spread our passion. He complained that only 20% of the observers are female. This, actually, was also about the percentage of female listeners to the lectures.

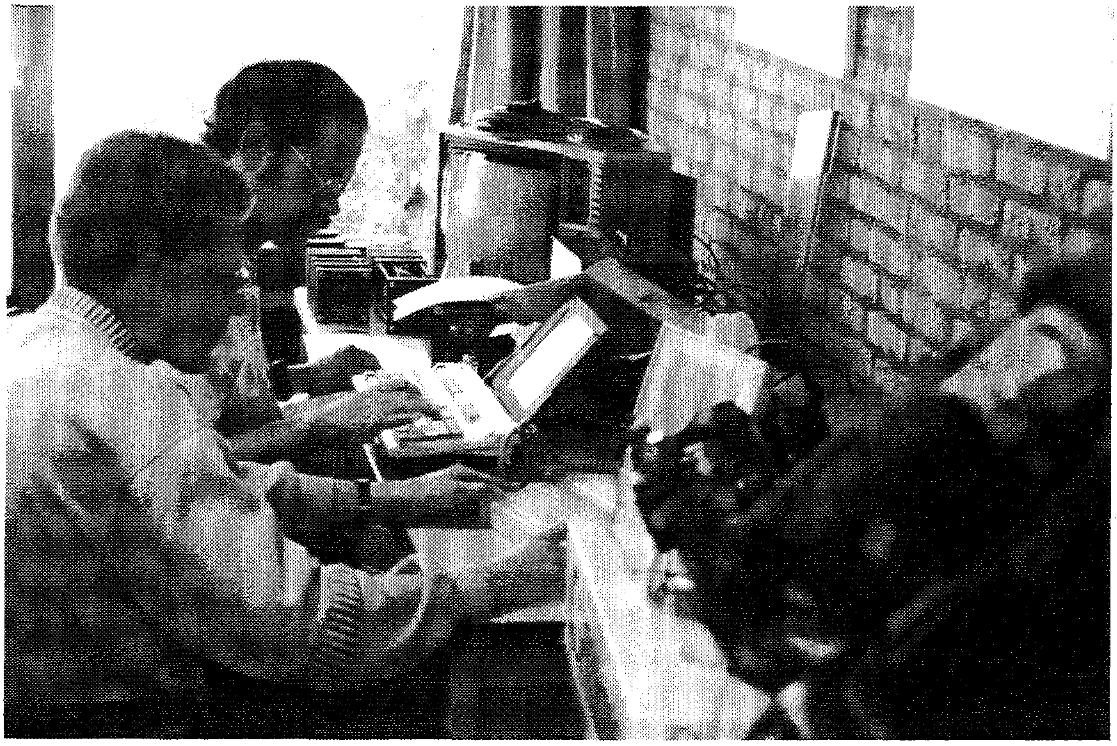

Figure 2 – Sirko Molau and André Knöfel working at the computer.

After lunch, we had the 8th General Assembly of the *IMO*. The various commission directors reported about their activities and a new Council member was proposed (Robert Lunsford). After that, several talks about radar and radio meteor work were presented. Cis Verbeeck's calculation of "... the Sensitivity of a Forward Scatter Setup for Shower Meteors" will be unforgettable for all of us. Formulae all over the viewgraph! Wow. At the end of this session, Sirko Molau presented "*IMO* goes on-line." Sirko gave us an overview of the *IMO*'s World Wide Web pages. This talk was especially noteworthy, since he really explained everything starting from the basics. So, even people who did not know the Web learned about its advantages and *IMO*'s philosophy behind our Web pages.

This is the time to mention the other room. In a smaller room adjacent to the conference room, two computers were set up. One was connected via a telephone to the Internet and allowed the conference participants to get hands-on experience with the World Wide Web. Some prepared their talks there, only hours before they had to present it... The list of participants was also put together "on line," so that it was finished by the end of the conference. In this room, camera batteries used to photograph meteors as well as several intensified video cameras were on display.

In the evening, there were some workshops on the Internet, on software, and on the coming Leonid return. After that, we again had a chance to socialize. André Knöfel and myself found out that the pool table allows for joyful hours.

Saturday was the day of the video observers. Mirko Nitschke presented the image-intensified video camera set-up he developed. Six (or was it seven?) almost identical models were built and started collecting data with the 1996 Perseids. The cameras use a 50 mm $f/0.75$ lens, a Hamamatsu-compatible second-hand image intensifier, and a low-cost single-board video camera. A little box generates a time signal synchronized to a DCF receiver, so the exact time of each individual frame can be determined.

Sirko Molau reported about calibration and data evaluation of his video camera MOVIE. He also currently develops an automatic meteor detection software. This topic was treated also by Chris Trayner. He suggested to use the half-transform ("half" is actually spelled "Hough"—I guess this is the name of the guy having invented the transform). This Hough-transform can detect lines in an image and is therefore a possible candidate for fast meteor detection routines.

Felix Bettonvil presented another video camera, with a CCD chip coupled directly to the output of the image intensifier. This system is called SUMO, the Super Meteor Observer. Which reminds me that I wanted to mention that we actually had a Japanese *IMO* member as a guest at this conference, Nagatoshi Nogami. Other speakers that day were Marc de Lignie and Alastair McBeath, who presented a talk prepared by Graham Wolf.

Figure 3 – Group photograph at the rear steps of Palace "Het Loo."

In the afternoon, a bus took us to the nearby Palace "Het Loo." A Dutch lady explained us the history of "Het Loo." The palace was built in 1686 by the Dutch Stadholder Willem III, and his wife, Mary II of England, who became King and Queen of England in 1686. It was the favorite summer residence of the present Dutch Royal Family until 1975. In 1984, it became a museum. After our brief guided tour, we were free to explore the palace on our own.

Most striking were the beautifully reconstructed baroque gardens. Especially noteworthy in these gardens was an oversized Earth globe used as a fountain. Supposedly, it showed the continents how they were known about 400 years or so ago. It actually looked very close to reality. The star globe in another part of the garden was harder to get familiar with. We were fortunate that on the day of our visit the roof terrace of the palace was open to the public, which allowed us a splendid view of the gardens.

In the evening, we were treated to a party to celebrate 50 years "NVWS Werkgroep Meteoren." We learned a lot about the history of meteor observations in the Netherlands, and were treated with drinks and small things to eat. The right mood was given by a string quartet playing classical music. After this delightful event, we had our last dinner and again a long night for socializing. Just before morning twilight, there were still people around the bar, dancing to "Born to be wild" ...

Only a few hours later, Sunday morning started with the "Detection of VLF Radio Emission." A group from Croatia used an old NASA VLF receiver in parallel to visual meteor observations. They recorded a signal just when they saw a −4 fireball and assume that the fireball was the source of the signal. In theory, VLF emission would be expected from meteors, but it is hard to detect due to background noise and the weakness of the signal. VLF emission could be the reason for instantaneous sound reports from fireballs. They conclude that this is still a very open field, prone for future exploration.

After that, I reported on the plans we have for parallel observations between one of the above mentioned video cameras and a backscatter radar. Actually, in the time between the conference and the writing of this article, we did gather 30 minutes of parallel data (after the beginning of the recent lunar eclipse, until clouds came up...) and believe we have one parallel meteor. Of course we want large numbers of meteors to be able to get some science out of this. Thanks to all the comments from the participants, helping me in adjusting our experiment parameters to optimize the set-up.

Next, Alastair McBeath gave an update on the *Dark Meteor Database*. The dark meteors were subject of discussion in several issues of *WGN* already, and Alastair was successful in showing that these observations deserve respect, be they illusions or real. However, he needs much more observers to send—positive or negative—reports to be able to find out what dark meteors really are.

After the final talk "Presolar Inclusions in Meteorites," by the well-known Dutch astronomer Prof. Em. dr. C. de Jager, the 1996 *IMC* was closed by Felix Bettonvil and Jürgen Rendtel. They said thanks to each other and to us and everybody else—and I have to agree: it was a great conference.

Thanks for the hard work to the organizers, you did well! Next year's conference will be in Yugoslavia—see you there!

P.S.: It took me only four hours to go back—I took the highway via Arnhem. So this is the lesson to learn from this article: Avoid Osnabrück's highways!

The 1997 International Meteor Conference

Petnica, Yugoslavia, September 25–28, 1997

Vladimir Lukic

The 1997 *International Meteor Conference* will take place at Petnica Science Center, from August 25 to 28, 1997, as usual Thursday till Sunday. The village Petnica is situated near the town of Valjevo (70 000 inhabitants), some 100 km south-west of Belgrade. The entire region, located on the southern edge of the Panonian Basin, is a hilly area, open to the lowlands to the north, with mountains with well-preserved nature in the back. This area is famous for its fruit production and its world-recognized plum brandy. Valjevo is easily reached from Belgrade by an hourly bus or train. The town has old part dating from Turkish times, and several ancient monasteries in the surrounding.

Within the Science Center, there are facilities to accommodate about 100 people, large classrooms, a huge library, and a computer room. Petnica Science Center cars and vans secure a non-stop connection with Valjevo. The Center is intentionally built in a quiet, natural surrounding, away from city noise, and provides ideal conditions for intellectual work. Within a couple of hundreds of meters from the Science Center there are an old village church, the Petnica cave with its archeological site, an artificial lake, and a recreational center.

The original purpose for which the Center was set up is involving young, gifted people into science. However, conferences such as the *IMC* are often organized there.

The price of accommodation, including the usual *IMC* registration as well as organized bus transport from and to Belgrade, is 140 DEM. Some reductions are possible on request. Detailed information on registration will be provided in the December issue of *WGN*.

Dark Meteor Database—First Results

Alastair McBeath

1. Introduction

Data submitted to the author following the publication of [1] was added to pre-existing reports on the dark meteors phenomenon, and the results outlined below were produced and presented to the Apeldoorn *IMC*. More details on these results, and additional discussion, can be found in the forthcoming 1996 *IMC Proceedings* [2].

Owing to concerns expressed by a small number of people, this and all future such reports will not identify individual observers. This anonymity is extended to the computerized databases which are used to hold partial information on dark meteors provided to the author.

2. Observations received and analyzed

So far, 36 observers have provided data, 11 reporting no dark meteor sightings, 25 with at least one positive event noted, which determines that some 69% of the sampled individuals have seen a dark meteor. Four dark meteor observers gave numbers of meteors and observing hours carried out around their dark meteor sightings, yielding very approximate mean "dark meteor rates" of about 1 for each 155 meteors seen, or 1 in about every 19 hours. These figures should not be taken to represent an actual level of dark meteor activity, however. The spread on the figures is quite large, but there is a suggestion that better sky conditions tend to yield marginally higher chances of a dark meteor being seen, although this cannot be seen as significant at this stage.

3. Conclusion

Please keep making and submitting observations of any dark meteors seen in line with the guidelines in [1]. Anyone who has still not responded to the original request for past observations—whether positive or negative—is invited to do so too.

References

[1] A. McBeath, "A Dark Meteor Database", *WGN* 24:1-2, February-April 1996, pp. 12–15.
[2] A. McBeath, "Dark Meteor Database—Update", in *1996 IMC Proceedings*, IMO, in preparation.

Practical Meteor Photography
Part IV: The Multi-Camera Set-Up

Marc de Lignie

Preface

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

Introduction

In previous installments of this series, the essential parts of a camera set-up for meteor photography were described. If you want to further improve your camera set-up, probably the best thing to do is using multiple cameras and putting them together on a single platform, the so-called camera battery.

This may seem a rather advanced subject and it may remain a dream for many meteor photographers. One cannot forget, however, that many of the published results of meteor photography were obtained with camera batteries.

Using multiple cameras has the following advantages:

- It makes double-station work easier. If the cameras together cover a large single area of the sky, it is not necessary to aim the camera battery very precisely at a specific point of the sky.
- You have more chance to catch that splendid fireball.
- When you only have a limited number of nights available for observing (due to sky conditions, work, family, etc.) you can exploit these nights more effectively.

1. Design considerations

Compared to constructing a set-up with a single camera, a camera battery requires a little bit more thought. The following aspects have to be taken into account:

- The cameras have to be positioned such that they cover a single large area of the sky. Apart from taking into account some practical mechanical limitations due to the shape of a camera, this requires some calculations.
- As with a single-camera set-up, the motor of the rotating shutter and the cameras themselves preferably must have separate mounts to avoid vibrations of the cameras.
- For manually operated cameras there must be some means (i.e., covering plate, see Figure 1) to start and finish the exposures of all cameras simultaneously. This will ease the administration of exposure times, which must be accurate to one second.
- For a ring of cameras aimed at low elevations a flat shutter blade can no longer be used.

2. Camera positioning

The most practical way of positioning the cameras on a camera battery is to place them in a regular way in a circle (see Figure 1). Depending on the elevation of the aiming points of the cameras, a certain number of cameras is required to complete the circle. A problem now is that the fields of neighboring cameras do not nicely fit together.

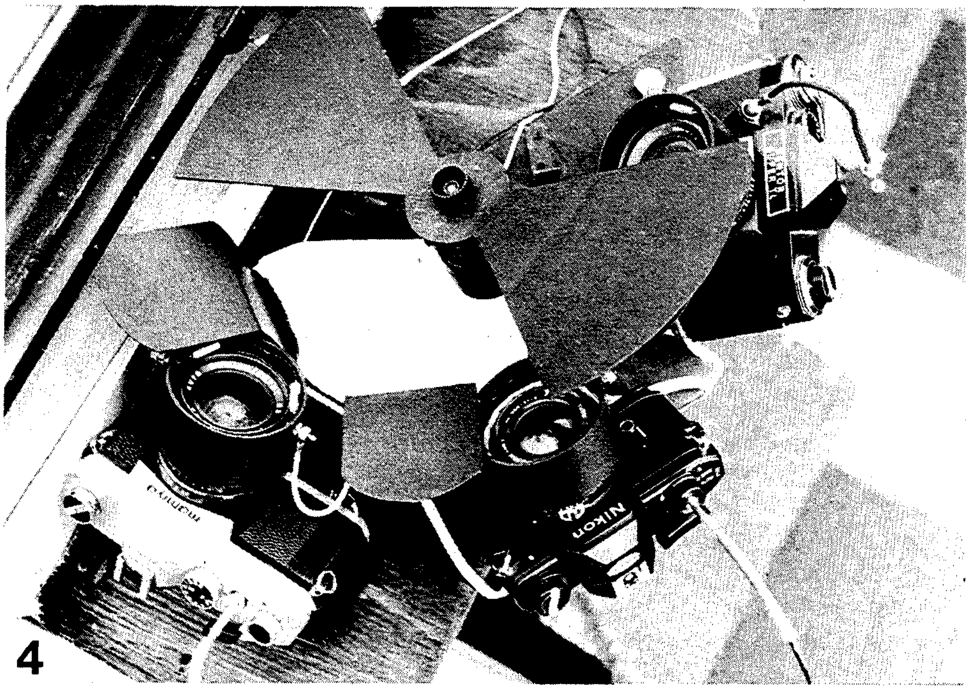

Figure 1 – Example of a small camera battery (photograph by Klaas Jobse). Lens heating, the bicycle dynamo, and a rotatable plate (not the shutter blade) to cover the lenses of all cameras are visible.

There are two different strategies you can take here: a conservative and a liberal one. In the conservative strategy, you try to cover the entire sky and you do not care so much about a little bit of overlap between neighboring camera fields. In the liberal strategy, you want to cover as much of the sky as possible with a limited number of cameras. Note that the conservative strategy is not so wasteful as you might think, because it will result in less truncated meteors or meteors photographed at the very end of the negative.

Table 1 – Required elevation of the center of the camera field to have a circle of fields touch at the lower or upper corners, depending on the number of cameras in the circle. It is assumed that 35 mm cameras with a f=50 mm lens are used.

Number of cameras	Upper corner Liberal	Lower Corner Conservative
2	64°	-
3	57°	84°
4	50°	77°
5	43°	70°
6	35°	62°
7	26°	53°
8	14°	41°
9	-	21°

Assuming that you use cameras with an $f = 50$ mm lens, Table 1 shows at which elevation the ring of cameras has to be aimed when you either choose the conservative or the liberal strategy. In the conservative strategy, you let the camera fields touch at the lower corner, which implies that the fields overlap at the upper corners. In the liberal strategy, you let the camera fields touch at the upper corner, which implies that at the lower corners part of the sky is not covered.

For lenses with other focal lengths, you can use the formula

$$h = \arccos\left(\frac{n}{180}\arctan\frac{18}{f}\right) \pm \arctan\frac{12}{f},$$

with h the elevation, f the focal length in mm, and n the number of cameras. All angles must be computed in degrees. The plus sign is for the lower corners, the minus sign for the upper corners.

Let us look at an example to cover the entire sky for both strategies. We then need several camera batteries where in each battery the cameras are pointed at a different elevation. Since an $f = 50$ mm camera has a field height of 27°, the difference in elevation between the batteries should be 27° for the liberal strategy and, let us say, 25° for the conservative strategy. We arrive then at aiming elevations of 77, 50 and 23 degrees for the liberal strategy and elevations of 78, 53 and 28 degrees for the other. From table 1 we can see that we need the following numbers of cameras:

Liberal: 2×77, 4×50, 8×23 (14 cameras);
Conservative: 4×78, 7×53, 9×28 (20 cameras).

Of course, these are just examples and many other configurations are possible (and used in practice). I happen to own a single camera battery myself with five cameras aimed at 65° elevation and one at 90° elevation (from which you can derive my political view on constructing camera batteries).

3. Construction details

The basis of the camera battery can be a simple plate of wood or a box on which the cameras are mounted in a circle. If you want a light-weight set-up, a plate is more practical. If you want an orderly set-up in which all power supplies, control electronics, etc. are incorporated, the box is the better choice.

A good way to mount the cameras on the ground plate is with bent pieces of aluminum plate. However, it may be difficult to bend the plates in the right angle. You might want to check your local tool shop for hinge-like parts that allow easier adjustment.

If the cameras are aimed at a low elevation, the tips of the shutter blade have to be bent upwards so that the cameras can not look below the shutter. Of course, when sawing the shutter blade, one already has to take into account the future shape of the blade. It is important that the opposing edges of the shutter blade are exactly 180 degrees apart (for later measurements of photographed meteors), which may not be easy for a bent shutter blade. The best way to realize this is to illuminate the rotating shutter blade with a stroboscope, so that both sides of the blade are visibly overlapped. One can now file and bend the blades until both sides seem to perfectly overlap.

Especially for light-weight camera batteries that use a strongly vibrating bicycle dynamo as a rotating shutter motor, it is necessary to mount the dynamo separately from the cameras. This can simply be realized by making a hole in the center of the ground plate. For heavier camera batteries it is possible to mount the shutter motor on the same ground plate as the cameras. However, the motor should not induce vibrations and the shutter blade must be balanced very well.

Instead of the type of cover plate visible in Figure 1, it is also possible to use a simple flat cover plate above the rotating shutter. A proven design to attach such a cover plate to the ground plate, is to use a long, 10 mm diameter bolt and a number of rings and nuts (see Figure 2). When the nuts at both sides of the cover plate are tightened sufficiently fast, the cover plate can still be rotated but does not bend. One can prevent the nuts to get loose, when rotating the plate for starting and finishing an exposure, by locking them with an additional nut.

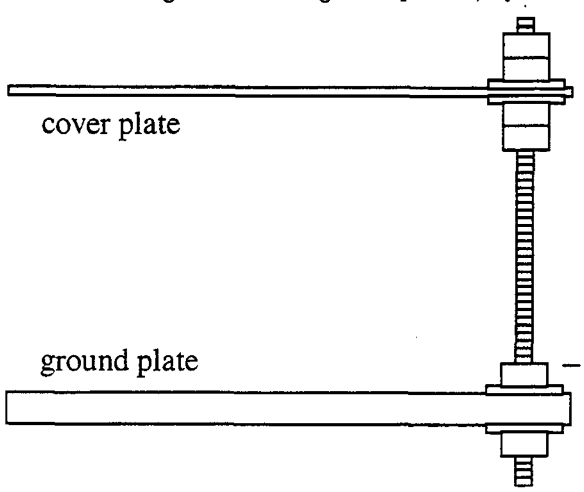

Figure 2 – Alternative way to attach a cover plate to the ground plate of the camera battery.

4. Conclusion

The description above is not an exhaustive instruction for building a camera battery and still leaves a lot to the fantasy of the photographer. However, it provides solutions for the most obvious problems and pitfalls you will encounter when building such a set-up.

The Leonids
Bulletin 8 of the International Leonid Watch

Peter Brown

The 1995 Leonid meteor shower had excellent observer coverage. Enough useful magnitude data were also reported to permit the first tentative r-profile for the Leonids from *ILW* data. The visual observations show clear evidence of a general increase in rates as compared to previous years between $\lambda_{\odot} = 234.5^{\circ} - 235.7^{\circ}$. The r-profile shows a near-constant value throughout the stream of 1.8 in 1995 with a peak ZHR of 34 ± 10 occurring at $\lambda_{\odot} = 235\overset{\circ}{.}5 \pm 0\overset{\circ}{.}1$. A significant enhancement in the shower profile near $\lambda_{\odot} = 235\overset{\circ}{.}0$ is due to only a few observations and hence its reality remains questionable.

1. Introduction

As reported in Bulletin 7 of the *ILW* [1], the fifth *ILW* period (November 5–25, 1995) showed evidence of enhanced activity based on a preliminary analysis of initial rate data. The findings from all observations reported here supports the overall conclusions from the original preliminary analysis and also adds considerably more details. It is now clear from the outbursts in 1994 and 1995 that the Leonids are building to some higher levels of activity in the next few years. The amount of interest in the stream and also the activity of observers is building at least as fast as demonstrated by the highly successful 5th ILW period.

2. Visual Results from the fifth ILW period

In total, several hundred Leonid observations were reported to the *IMO* after November, 1995. By selecting only those observations for which the total correction factor was less than 5, we are left with 3117 Leonids from 417 reporting intervals recorded in 404 hours of effective observing time by 137 observers. This is by far the most successful of the *ILW* periods to date.

Of particular value in 1995 is the large number of magnitude estimates reported to the *IMO*. In all, some 2316 of the reported Leonids also had magnitude data. This is enough data to permit an initial attempt at constructing an r-profile which is shown for the entire period in Figure 1. The majority of the magnitude information was recorded very near the traditional Leonid peak at $\lambda_{\odot} = 235\overset{\circ}{.}5$ and hence the large error in values after the peak where little information was collected. No clear trends as a function of time are visible in the profile and we may simply conclude that the present shower can be best represented by a nearly constant r-value of about 1.8. This value is somewhat lower than the value of 2.3 adopted by Jenniskens [2] for the 1995 shower, but is in good agreement with the outburst value found by Jenniskens [3] in 1994.

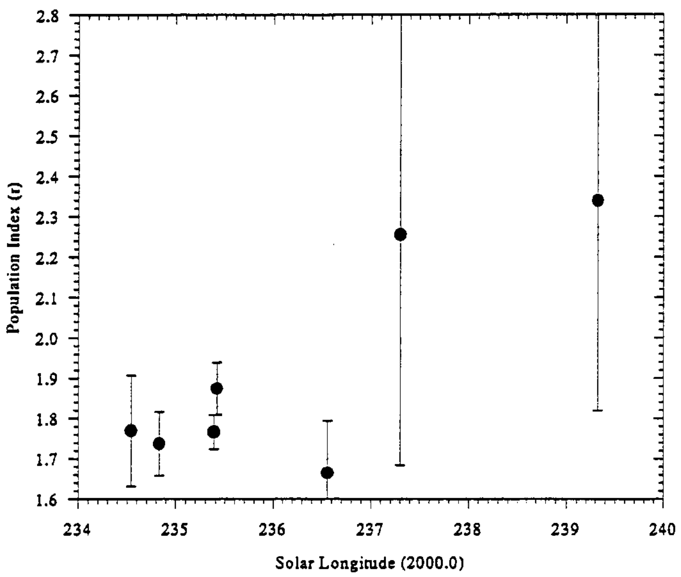

Figure 1 – The r-profile of the 1995 Leonids.

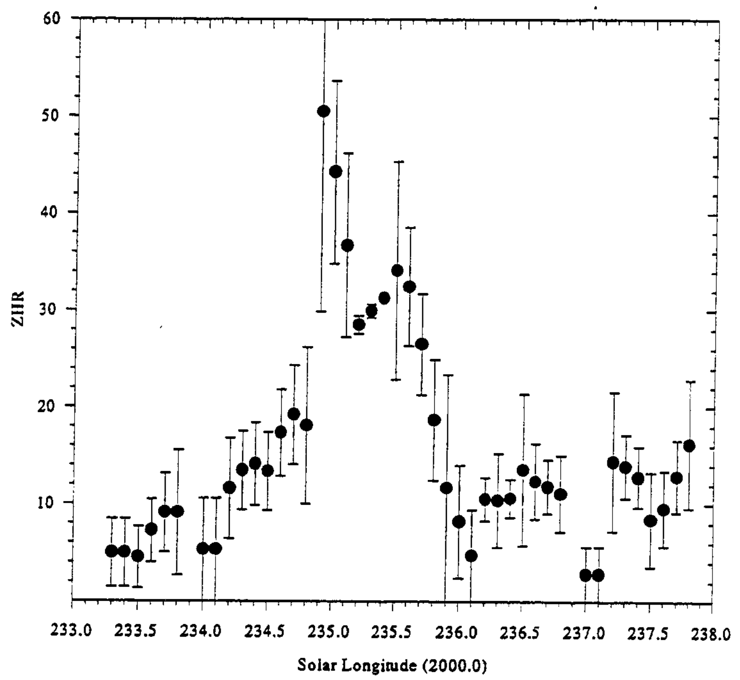

Figure 2 – The ZHR-profile of the 1995 Leonids.

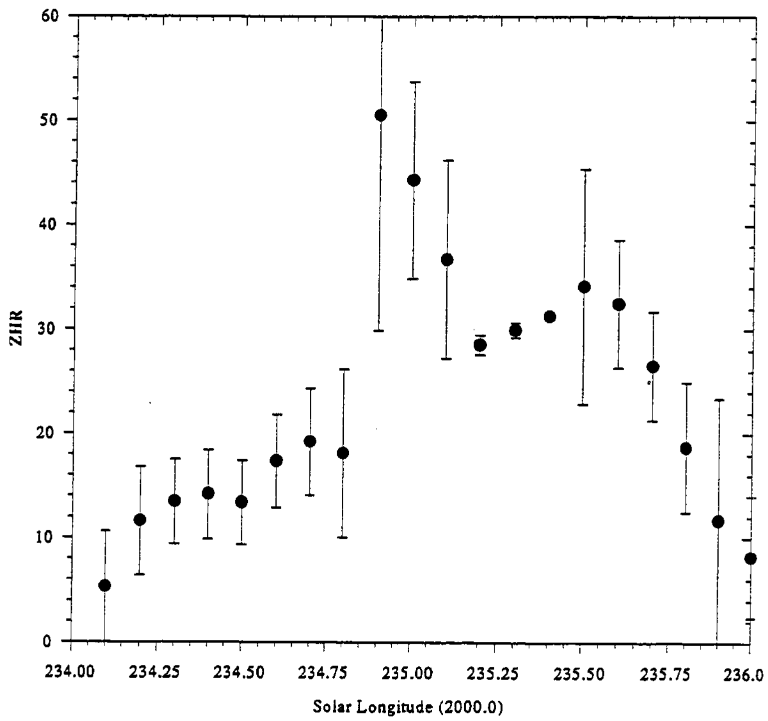

Figure 3 – Detail of Figure 2.

The ZHR-curve for the entire period is shown in Figure 2. An enlargement of the central portion of the curve near maximum is shown in Figure 3. For these curves, an averaging interval of 0°2 shifted by 0°1 was used. The error bars represent the standard deviation of the individual measurements about the mean in a given interval.

A slow rise in activity begins near $\lambda_\odot = 234^\circ\!.3$ and continues until nearly $\lambda_\odot = 235^\circ\!.0$. Here an abrupt quasi-"outburst" seems to occur, but the large error bars and the very small number of observers (2) reporting these rates leave doubt as to its reality. Additional doubt is cast on this feature as the sporadic rates recorded during this interval are approximately three times that of rates on either side of the maximum. It is interesting to note, however, that this is approximately

0°1 from the nodal position of Comet 55P/Tempel-Tuttle in 1966 and might represent the first material from the main, narrow, outburst component of the stream. It is very important that observers closely monitor this position in 1996, which will recur near November 17, 0^h UT. If this does represent recent material close to the comet, then this time offers the greatest potential for high rates in 1996.

After this apparent quasi-"outburst" peak, the increase to maximum continues with nearly the same slope and reaches a clear peak near $\lambda_\odot = 235\overset{\circ}{.}5 \pm 0\overset{\circ}{.}1$. The ZHR data are particularly abundant in the interval $\lambda_\odot = 235\overset{\circ}{.}25$–$235\overset{\circ}{.}50$, making this determination reliable. In contrast to the relatively slow rise to maximum lasting roughly 1°, the falling portion of the profile is much steeper reaching background levels less than 0°5 after the maximum. The apparent continuation of Leonid activity after $\lambda_\odot = 236°$ is due, at least in part, to the higher values of r found after this time. The large errors in the r-profile in this region suggest that this continued plateau is most probably an artifact.

3. Outlook for the sixth ILW period

In 1996, the sixth *ILW* period will take place from November 5 to 25, 1996. Observers are asked to concentrate on the shower during these dates, with special emphasis on the nights from November 16 to 18. This year, the Moon will be out of the way for most of the *ILW* period, with a First Quarter Moon on November 17. This implies that observations made in the early morning hours near the peak should be very dark. The time of the apparent peak observed in 1995 at $\lambda_\odot = 235\overset{\circ}{.}5$ corresponds to 12^h UT on November 17. Enhanced activity is most likely in the interval from 0^h to 12^h UT on November 17.

Acknowledgment

The author wishes to thank Rainer Arlt for help with the visual analysis.

References

[1] Brown P. and Rendtel J., "Bulletin 7 of the International Leonid Watch (ILW): Another Leonid Enhancement", *WGN* 23:6, December 1995, p. 196.

[2] Jenniskens P., "A Second Leonid Outburst in 1995", *WGN* 23:6, December 1995, p. 198.

[3] Jenniskens P., "Meteor Stream Activity. III. Measurement of the first in a new series of Leonid outbursts", *Meteoritics and Planetary Science* 31, 1996, p. 177.

The Perseids

Perseids 1995 and 1996—An Analysis of Global Data

Jürgen Rendtel and Rainer Arlt

This analysis is based on a sample of more than 14 000 Perseids of 1995 and 7 500 Perseids of 1996. Peak activity re-occurred in 1995 at $\lambda_\odot = 139\overset{\circ}{.}63 \pm 0\overset{\circ}{.}02$ (2000.0) and in 1996 at $\lambda_\odot = 139\overset{\circ}{.}66 \pm 0\overset{\circ}{.}03$. Due to the coincidence of Full Moon and the Perseid maximum in 1995, the sample is small and of limited quality compared with the 1996 data. Therefore, we were not able to obtain a well-resolved profile of the population index r in 1995, while the 1996 r-profile indicates a *higher* value of $r = 2.03 \pm 0.02$ during the peak period than in the surrounding time intervals where we found values of $r \approx 1.8$. Based on a number of 10-minute counts, the maximal EZHR of the 1996 peak reached a level of 120 with a kind of plateau of ZHRs above 100 lasting from $\lambda_\odot = 139\overset{\circ}{.}64$ to $139\overset{\circ}{.}67$ (i.e., August 12, 0^h40^m–1^h25^m UT). The position of the 'outburst peak' is found to have shifted backwards in solar longitude from $\lambda_\odot = 139\overset{\circ}{.}78$ in 1988 to $139\overset{\circ}{.}48$ in 1992, and then forward to $\lambda_\odot = 139\overset{\circ}{.}67$ in 1996. During this period, the peak was closest to the ascending node of 109P/Swift-Tuttle in 1992.

1. Introduction

After the 1995 Perseid maximum interfered with moonlight, many observers in Europe awaited the ideally located peak of the Perseids in the night of August 11-12, 1996. Unfortunately, most of them suffered from the bad weather in that and the following night.

Until now 14 092 Perseids of 1995 and 7 557 Perseids of 1996 are available in the *Visual Meteor Database* (*VMDB*). The following observers contributed to the analysis of the Perseid maxima in 1995 and 1996:

Vida Angel, Rainer Arlt, Mária Bartolomejová, Jozef Bezak, Nikola Biliškov, Lucian Boboc, Grzegorz Bonikowski, Emil Brezina, Bob Brown, Marek Bujdos, Jacek Burda, Branko Burmaz, Jaroslava Cablkova, Anja Cervek, Jiang Chang-gui, Vratislav Cillik, Koen Clement, Peter Craven, Jozef Csipes, Mark Davis, David de Wolf, Monika Diallova, Marta Dikova, Iveta Dobrovolna, Joachim Draeger, Radek Dreveny, Jozef Drga, Tomasz Dziubiński, Bert Everaert, Andrea Friebel, Josipa Friščić, Marcin Gajos, Slaven Garaj, Paweł Gembara, Jaroslav Gerboš, Ivanka Getsova, Benny Geys, Vincent Giovannone, George W. Gliba, John Glover, Lew Gramer, Neven Grbac, Valentin Grigore, Andrey I. Grishchenyuk, Adam Grzeszuk, José Luis Guixeras Romero, Andrej Guliš, Peter S. Gural, Wayne T. Hally, Pavol Hanzlíček, Peter Harmady, Yukiti Hattori, Robert Hays, Monika Hazukowa, Veerle Herrygers, Sylwia Hołowacz, Kamil Hornoch, Filip Hroch, Vladimír Hrušovský, Su Hua, Richard Huziak, Oomi Iiyama, Daiyu Ito, Jan Janča, Miroslav Jedlicka, Jaroslava Jelchova, Liu Jing, Michał Jurek, Vaclav Kalas, Stanislav Kaniansky, Fumihiko Kanno, Niladri Kar, Jana Kasparova, Kevin Kilkenny, Timo Kinnunen, Hitomi Kisanuki, André Knöfel, Ľubica Kobová, Ralf Koschack, Detlef Koschny, Jaroslav Kovarik, Ales Kratochvil, Dita Krcmarova, Gotfred M. Kristensen, Øyvind Kristiansen, Silvija Križak, Jan Kucera, Martin Kundrat, Alexander Kupco, Lívia Kusá, Ralf Kuschnik, Jari Kuula, Maciej Kwinta, Jan Kyselý, Juraj Lacko, Jean-Christophe Lernould, Inge Leyssens, Vladimir Lukić, Robert Lunsford, Kouji Maeda, Peter Majchrak, Urszula Majewska, Veikko Mäkelä, Miroslava Mala, Štefan Malár, Radek Maly, Katuhiko Mameta, Petr Masek, Jan Masiar, Alastair McBeath, Tom McEwan, Norman McLeod, Jana Micikova, Vasile Micu, Carl B. Miller, Koen Miskotte, Radovan Misovic, Hidekatu Mizoguchi, Jan Mojzsis, Sirko Molau, Ivelina Momcheva, Tibor Mrmus, Adrian Mrska, Hisayuki Nagai, Tomas Nasku, Dragana Okolić, Arkadiusz Olech, Jens O. Olesen, Jan Ondrus, Artyom E. Oreshonok, John Penner, Christian Pinter, Jiri Polak, Mila Popović, Lilia Porozhanova, Tim Printy, Wen Qingliu, Leo Rajala, Pavol Rapavy, Ina Rendtel, Jürgen Rendtel, Maciej Reszelski, Alberto J. Roldán Piracés, Manca Rotner, Julián Ruiz-Garrido Zabala, Łukasz Sanocki, Koetu Sato, Branislav Savic, René Scurbecq, Peter Sedlak, Miguel Serra Martin, Francisco Sevilla, Gregory Shanos, Yasuo Shiba, Anna Sikchina, Eva Skvarkova, Zbynek Slama, Jana Slizova, Lukas Smahel, Alexander Smetanko, James N. Smith, Milos Sochan, Manuel Angel Solano Vinuesa, Manuel Solano Ruiz, Zdeno Sovcik, Ulrich Sperberg, Jiři Srba, Elisa Stefani, Katarina Stefanikova, Svetozár Štefeček, Enrico Stomeo, Wesley Stone, Niko Štritof, Marta Svancarova, Pavel Svozil, David Swann, Richard Taibi, Marko Toivonen, Jiri Tomcik, Daniel Toth, Manuela Trenn, Mihaela Triglav, Josep M. Trigo Rodriguez, Juraj Trojak, Peter Trojak, Elena Valero Rodriguez, Hendrik Vandenbruaene, Michel Vandeputte, Maarten Vanleenhove, Cis Verbeeck, Jan Verbert, Marco Virsek, Bruno Wagner, Thomas Westphal, Linda Wilson, Jean-Marc Wislez, Nikolai Wünsche, Zhou Xingming, Yasuo Yabu, Satiko Yamaguti, Vasilij Yaremchuk, Hiromiti Yosidome, Ilkka Yrjölä, Jerzy Zagrodnik, George Zay, Goran Zgrablic, Peter Zimnikoval, Beata Zimnikovalova, Krzysztof Żurek

A detailed investigation of the recent Perseid activity revealed that it consists of three major parts [1]:

1. a broad plateau displaying weak activity (background Perseids);
2. a more concentrated component centered around the traditional Perseid peak (core Perseids); and
3. a strongly time-varying component of short duration which appears in all profiles shortly after the nodal longitude of the parent comet (outburst Perseids).

Traces of the outburst Perseids situated roughly 12 hours before the regular Perseid maximum near $\lambda_\odot = 140°$ were found in the 1988 and 1989 Perseid analyses [2]. A peak of very high ZHRs was first observed in 1991 and in all subsequent years. Generally, the peak ZHR decreased since 1991 from about 400 to 120 in 1996. This is in agreement with model calculations of Wu and Williams [3] who predicted enhanced rates for the remainder of the century. However, the activity level may decrease to a level which makes its separation from the regular Perseid rates very difficult.

The position of this peak varied from one return to the next, and the pattern of the variations seemed to be unpredictable. The 1996 peak occurred quite close to the 1994 and 1995 positions.

The population index r determined from the magnitude data showed no peculiarities during the activity of the outburst Perseids. However, there seems to occur a significant local maximum of r in the 1996 data. It has to be checked with the complete data whether this feature is really a new phenomenon associated with the increasing distance from the high activity part of this component of the Perseids.

In our analysis, we restrict ourselves to the time period $\lambda_\odot = 139.^\circ5$ to $140.^\circ1$, i.e., the outburst Perseids and the ascending branch of the regular maximum, designated as core Perseids.

2. The population index r

As explained above, the 1995 data do not allow a detailed analysis of the changes in r due to the strong disturbance by moonlight. The analysis showed that there is no obvious structure in the profile of r in the vicinity of the peak. Surprisingly, the figures of $r \approx 2.2$ are higher than during the previous Perseid peak returns when r was of the order of 2.0 (see Table 1).

We already mentioned a feature found in the 1996 data analyzed for this report (Figure 1). Here, the value of the population index r seems to steadily decrease from $\lambda_\odot = 138°$ from 2.1 towards 1.9 close to $139.^\circ0$. Coinciding with the position of the peak, we find $r = 2.03 \pm 0.02$, while the later figures can be interpreted as a continuation of a general dip with an ascending branch reaching $r = 2.1$ just after the regular Perseid maximum. If this is a significant structure, this indicates a change in the particle population as compared to the previous passages of the Earth through this region with an increasing portion of fainter meteors. Profiles of the population index r [1] did not show any local structure in the vicinity of the outburst peak.

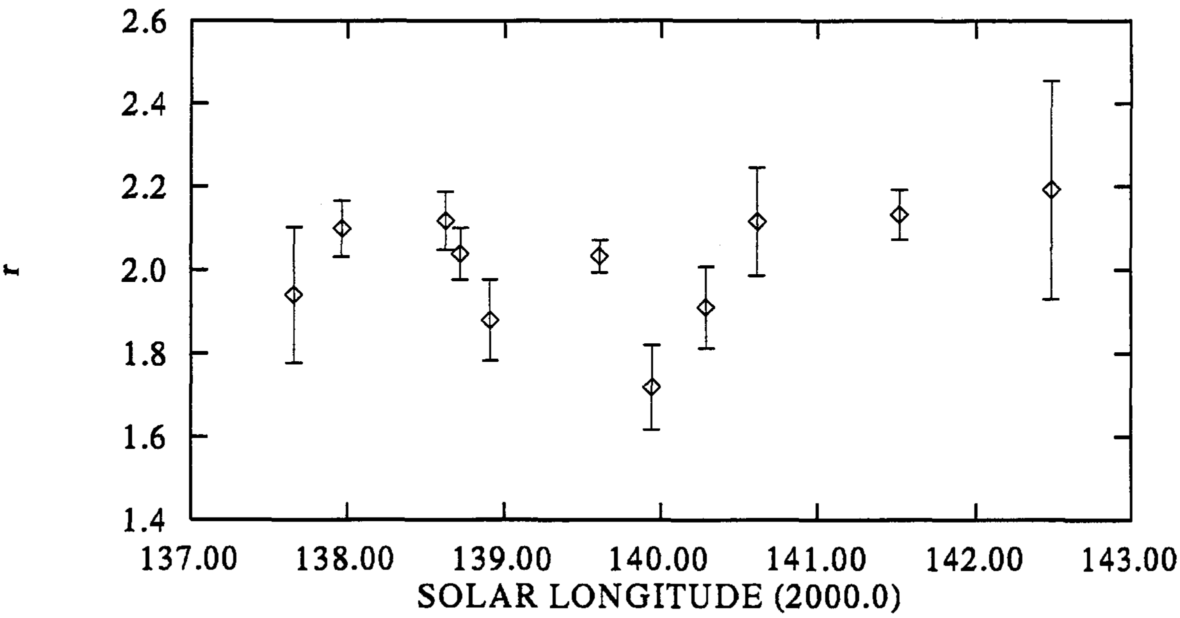

Figure 1 – Profile of the population index r for the 1996 Perseids obtained from all available magnitude data (as of September 1996). The point at $\lambda_\odot = 138.^\circ911$ coincides with the peak period and indicates that the particle size distribution may be different from the surrounding region where r shows a wider dip, just interrupted by the mentioned value. Considering the error bars, the higher figure of r at this moment seems to be significant.

3. The activity profile

Again, we can derive only little information from the 1995 data concerning the details of the activity profile (Figure 2). The peak at $\lambda_\odot = 139.^\circ63 \pm 0.^\circ06$ is obvious. The maximal ZHR obtained from the data stored in the *VMDB* is 170. It is very difficult to determine to which extent the higher figure of r or the uncertainties of the counts themselves lead to an overestimate of the ZHR. Hence we want to restrict the conclusion to the fact that the outburst Perseids in 1995 showed a ZHR which is lower than the figures found from the 1994 analysis [4].

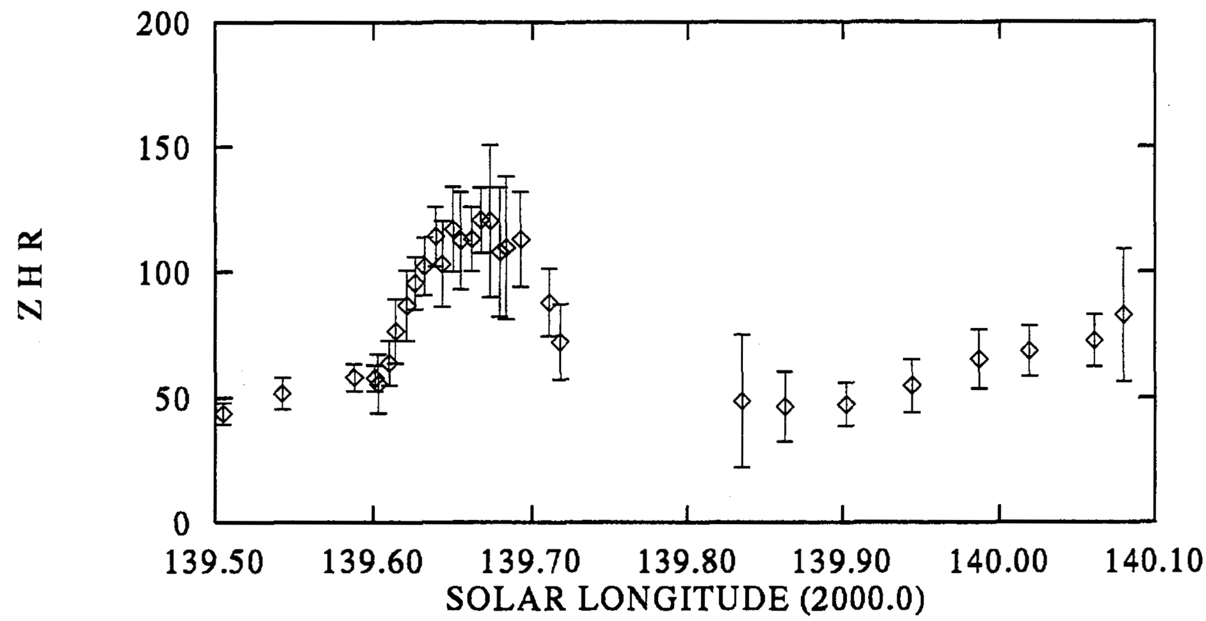

Figure 2 – Profile of the ZHR for the 1995 Perseid peak and the ascending branch to the "regular maximum." The small sample did not allow a better temporal resolution.

The typical profile of the peak as observed in the years 1991 to 1994, particularly well observed in 1993 and 1994, consisted of an ascending branch lasting for some hours, a short peak, and a quite rapid decrease of the ZHR [1]. Leaving out the value of 1992, average full width at half maximum (FWHM) was 0°11, or 2.8 hours.

Since the ascending and descending branches were different, we distinguish between the half widths at half maximum (HWHM) for the two periods. These are 0°06 (1.5 hours) and 0°04 (1.0 hours) for the ascending and descending branches, respectively.

The 1996 peak showed a slightly different shape (Figure 3).

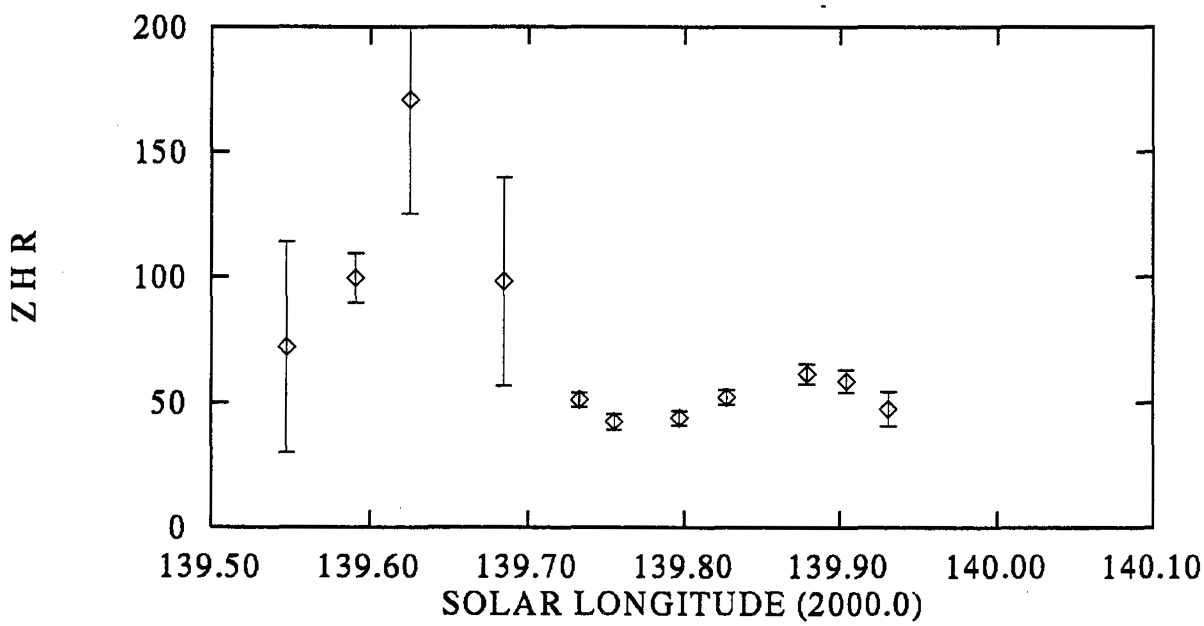

Figure 3 – ZHR profile of the 1996 Perseid peak and the ascending branch to the "regular maximum." The larger error bars during the peak period result from the scatter of the individual ZHRs of the short count intervals used here.

Until $\lambda_\odot = 139°55$, there was almost no increase in the ZHR, while, at $\lambda_\odot = 139°60$, an almost immediate rise has been reported. This ZHR rise coincided with the occurrence of a number of fireballs as well, but according to the magnitude data and the population index r this part of the activity also included a large portion of fainter meteors. Here the ZHR reached a level of 120. Most interestingly, this enhanced ZHR lasted for more than one hour. The FWHM is almost 3 hours, the respective HWHMs are 1.3 and 1.7 hours for the ascending and descending branches again. This also shows the rapid increase of the ZHR mentioned above.

Although disturbed by moonlight and hence of less weight, we can detect a similar trend already in the 1995 data, when the duration of the ascending and descending branches was of about the same lengths, considering the HWHM values (see Figure 2).

If we use the FWHM as a measure for the width of the peak, we refer to a rate profile consisting of three components (see above). Since the ZHR of the background and core Perseids can be regarded as constant for each return, we suggest to use the width of the graph at a ZHR level above that of the other components as a measure for the width of the outburst component. This method also avoids errors caused by the uncertainty of the peak ZHR values, which may have been influenced by a possibly incorrect value of the population index r *and* fluctuations in the observers' perception due to varying moonlight influences. We chose a ZHR of 80 as a reference level. This is sufficiently above the ZHR which occurred near the outburst peak position before the peak itself appeared, say before 1988. Except for 1990, where the ZHR of the peak remained below 80, the average duration of the period with a ZHR exceeding 80 is $0°20 \pm 0°12$ (about 5 ± 3 hours). The scatter of the individual values is remarkable, and there is no trend within the series between 1988 and 1996.

So, the main feature of the 1996 Perseid ZHR profile is the different relative duration of the ascending and descending branches as compared to the previous returns. The duration of the peak does not significantly differ from the 1991–1995 averages, neither in exceeding a given ZHR level nor considering the FWHM.

Table 1 – Summary of Perseid peak data for the period 1988 to 1994 [1] and this work. The 1990, 1992, and 1995 results should be considered as rough estimates only since these severely suffered from the full moon disturbance.

Year	$\lambda_\odot$ (outburst)	r	ZHR	$S_{6.5}$	$\lambda_\odot$ (max)	r	ZHR	$S_{6.5}$
1988	$139°78 \pm 0°03$	2.0	86 ± 4	97 ± 16	$140°08 \pm 0°04$	2.1	106 ± 22	94 ± 14
1989	$139°56 \pm 0°03$	2.1	102 ± 10	127 ± 23	$139°80 \pm 0°09$	2.1	94 ± 6	120 ± 20
1990	$139°55 \pm 0°05$	1.8	75 ± 10	45 ± 35	$140°54 \pm 0°2$	2.1	81 ± 61	66 ± 5
1991	$139°55 \pm 0°03$	2.2	284 ± 63	494 ± 150	$139°94 \pm 0°04$	2.1	97 ± 2	124 ± 20
1992	$139°48 \pm 0°02$	(2.1)	220 ± 22	257 ± 60	$140°13 \pm 0°2$	2.0	84 ± 34	96 ± 15
1993	$139°53 \pm 0°01$	2.0	264 ± 17	242 ± 62	$139°91 \pm 0°04$	1.9	98 ± 5	79 ± 34
1994	$139°59 \pm 0°01$	1.8	238 ± 17	151 ± 28	$139°84 \pm 0°04$	1.9	86 ± 2	69 ± 12
1995	$139°62 \pm 0°05$	(2.2)	171 ± 30	290 ± 90	$139°90 \pm 0°15$	2.1	65 ± 20	95 ± 20
1996	$139°66 \pm 0°03$	2.0	121 ± 17	114 ± 24	$140°08 \pm 0°04$	1.7	85 ± 10	76 ± 20

The high figure of the number density of meteoroids causing meteors of magnitude at least 6.5 ($S_{6.5}$ in Table 1) for the 1995 Perseid peak is probably an artifact caused by the value of $r = 2.2$ which has been discussed above. Since this is very uncertain, the number density itself is an upper limit at best. While there are known problems with the determination of limiting magnitudes under moonlit conditions, there are obviously further effects which reduce the value of such observations for detailed analyses. These effects are expected to act in a systematic way. One might think about perception differences particularly of meteors close to the given limiting magnitudes and about selection effects in the procedures to determine the population index r. It is known that counts of high, observable rates under good conditions suffer from a kind of saturation [5], whereas in the case of disturbance by moonlight the number of visible meteors remains low even during the peak period. We suspect that the derived ZHRs during the moonlight-disturbed periods are closer to an upper limit than under "regular" conditions.

4. Conclusions

Although the analysis of the 1996 Perseid return is based only on a part of the entire data becoming available later, the results should be expected to be quite close to the final values. This is particularly valid for the peak period, although there may be some fine structures in this time interval which can be derived from a larger sample.

The uncertainties of quantities obtained from moonlight-disturbed observations, such as 1992 and 1995, underline that such data can only be used for deriving upper/lower limits of some parameters. Obviously, there are systematic effects from the moonlight disturbance which are difficult to separate. It seems that both the meteor magnitude data (hence the population index r) and the limiting magnitude estimates (hence counts and ZHRs) are affected. Of course, the effects on the values of r and the ZHR do also yield erroneous figures of the spatial number density S.

The average of the 1991–1994 outburst peaks yields HWHMs of the ascending and descending branches of $0.^{\circ}06$ (1.5 hours) and $0.^{\circ}04$ (1.0 hours), respectively. For the 1996 Perseid ZHR profile, we find a different relation between these branches with 1.3 hours and 1.7 hours, respectively. With caution, this can be suspected also from the 1995 data. However, the duration of the 1995 and 1996 peaks is not significantly differing from the 1991–1994 averages, neither in exceeding a given ZHR level nor considering the FWHM.

As shown in Table 1, the position of the peak varied from one return to the next. Some years ago, the changes in the position looked rather accidental, but seen the entire series as given in Table 1 (plotted as Figure 4), there seems to be a systematic decrease in the solar longitude from $139.^{\circ}78$ in 1988 back to $139.^{\circ}48$ in 1992, and a subsequent increase in the solar longitude of the peak arriving at $139.^{\circ}66$ in 1996. The ascending node of the comet 109P/Swift-Tuttle is at $139.^{\circ}44$ [6], hence the 1992 passage was the closest to the orbit of the Perseid parent comet. We also find the longest duration of the outburst peak in 1992: The ZHR exceeded 80 for $0.^{\circ}40$, i.e. roughly 10 hours, and the FWHM was of the order of 7 hours. However, these figures have been derived from moonlight-disturbed data, and one should regard the values as additional information.

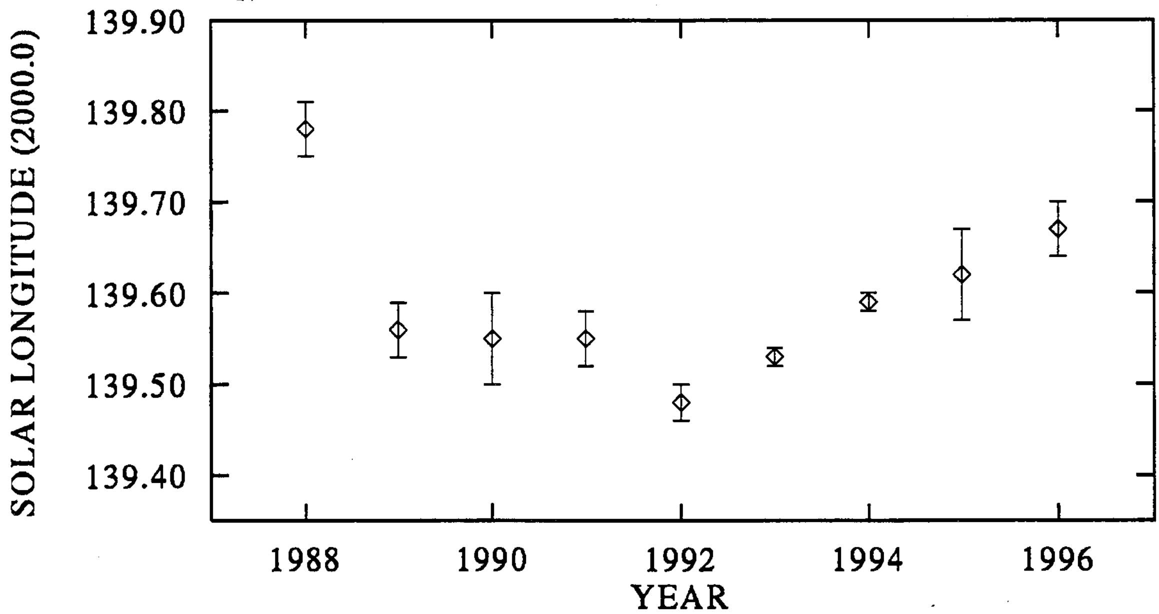

Figure 4 – Position of the outburst peak of the Perseids observed in the period 1988 to 1996. There is a systematic drift of the peak position towards the node of the Perseids' parent comet, 109P/Swift-Tuttle, at $139.^{\circ}44$ until 1992, and a subsequent drift to a later position again until 1996.

Both the change in the solar longitude of the peak and the peak activity level indicate that the new peak might fall below the detection limit again within the next few years. Perhaps the solar longitude of the peak further increases, thus shifting the peak to a position with a higher ZHR of the core Perseids, making its detection even more difficult.

Acknowledgments

We wish to thank all observers who sent in their data very soon after the Perseids. This enabled us to present a reliable analysis based on a substantial sample already a few weeks after the event.

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Review of the NAMN 1996 Perseid Program

Mark Davis

A review of the activities of the *North American Meteor Network* (*NAMN*) is presented for the 1996 Perseids. A summary of observing totals for August is included. In addition to providing 99.25 hours of observations in July, *NAMN* members submitted a total of 117.78 hours of Perseid observations during the month of August.

With the prospects of a favorable Moon and possible short-lived bursts of activity, the *North American Meteor Network* (*NAMN*) planned its largest effort yet for the 1996 Perseid meteor shower.

In the United States, media coverage prior to the shower made it possible to educate the public as well as collect scientific information. Dozens of e-mails were answered informing non-observers of the dates, times and fields that would best insure them a successful watch. The *Christian Science Monitor* contacted us wanting to collaborate on a summer science project for children between the ages of 10 and 14, the goal being to collect data about the Perseids. Many people wrote back with a report of their success with comments such as ... *it was memorable*... and ... *something none of us will ever forget*. The success of our educational program can best be expressed by those comments.

Of course, the main focus of our campaign was the coordination of observations. The *IMO* lists the Perseids as being active during the period July 17 through August 24, and *NAMN* observers were able to carry out observing programs over most of this period. During the month of July, for example, at least one observer was out on the mornings of July 14–21, 24, 27, and 28.

Early Perseids were observed beginning on the morning of July 14 and continued until the published beginning date was reached. During this time, 31 Perseids were observed in 13.50 hours over the three mornings of July 14 to 16. This suggests that the Perseids may become active a little before the published dates, and it will be interesting to see if future observations in fact confirm this.

However, our main focus was during the month of August. *NAMN* members were out on August 6, August 8–14, August 21–23 and finally, August 25. During these twelve mornings, members provided 117.78 hours of observing. A total of 2 869 meteors were seen, the greatest numbers being Perseids (1 565) and sporadics (1 032). The remainder were a combination of several less active showers and are discussed below.

From several communications sent to us, the *NAMN* assumed maximum activity would occur on August 12 at approximately 1^{h} UT. Observers along the East Coast of the United States had planned sessions to start as soon as the sky was dark enough, but many arrived outside to find complete cloud cover, including the author. I was forced to watch the maximum through the results of others posted to the *IMO* and *NAMN* Internet mailing lists!

Not all of North America was clouded out, however, as several observers were able to carry out their planned watches. During the morning of August 12, six observers logged a total of 20.18 hours under clear skies, seeing a total of 539 Perseids. The highest rates were seen by Robert Lunsford who observed 49 Perseids from $10^{\text{h}}00^{\text{m}}$ to $11^{\text{h}}00^{\text{m}}$ UT and 53 Perseids during the period from $11^{\text{h}}00^{\text{m}}$ to $12^{\text{h}}00^{\text{m}}$ UT.

Several people commented on how bright this year's Perseids seemed to be, with many being recorded as negative magnitudes. Martin Gaskell, astronomer at the University of Nebraska reported as follows:

> *Visual observations of the Perseid meteor shower from the Behlen Observatory (University of Nebraska) on August 12, 1996, from 4^{h} to 6^{h} UT gave a mean Perseid magnitude of* 1.1 ± 0.5 *(corrected to limiting magnitude 6.5). The mean magnitude (similarly corrected) for sporadics was 3.2. I note that the mean Perseid magnitude was almost two magnitudes brighter than historic means for this phase of the shower (see Kronk 1988). We observed a similar, but more dramatic, brightening of the mean apparent magnitude during the 1993 passage through the orbit of P/Swift-Tuttle. Although the population index was unusually flat during our 1996 Aug 12 observations, our provisional ZHR of 80 was not exceptional. Crossing the central ribbon of material in the comet orbit seems to be marked not only by a spike in the ZHR curve, but also by a change in the population index and mean magnitude.*

Several other streams were monitored by *NAMN* observers. The Southern δ-Aquarids and Northern δ-Aquarids provided a few meteors per hour over most of the month, and were the most active showers other then the Perseids, producing a total of 91 and 83 meteors respectively. Activity from the α-Capricornids produced only 32 meteors and became almost non-existent after August 14 agreeing well with the August 15 date published by the *IMO*. Members of the κ-Cygnids were visible August 8 to August 22 producing 44 meteors for observers. This shower was a surprise to some people as I began to receive e-mail wanting to know if activity from this area of sky was normal. Information on this shower was quickly dispersed via the Internet and more observers began an effort to monitor this shower. It is unfortunate that the Perseids were "advertised" by *NAMN* almost exclusively at the expense of some of the above less active showers. Nevertheless, I have considered this a learning experience, and found once again the benefit of rapid communications that the Internet provides.

In conclusion, the 1996 Perseid campaign was the most successful effort yet for the North American Meteor Network. I would like to thank the following observers for submitting data on the Perseids: Mark Davis, Martin Gaskell, George Gliba, John Glover, Lew Gramer, Pete Gural, Wayne Hally, Kevin Kilkenny, Robert Lunsford, Joan McLeod, Norman McLeod, Carl Miller, John Penner, Tim Printy, David Swann, Richard Taibi, and George Zay.

The 1996 Perseids from Poland

Arkadiusz Olech, Warsaw University Observatory

An overview is given of the author's observations of the 1996 Perseids.

The predictions concerning the moment of the Perseids' 1996 maximum were very hopeful for European observers. The maximal ZHRs were expected on August 12 at 0^h UT.

I started my observation at 19^h35^m UT. After the first hour, with limiting magnitude 6.00, I detected only 11 Perseids (it gave ZHR $\approx$ 38). The two next hours were better, but the activity was still low. Unfortunately, during the last 15 minutes of the third hour of observing, a few clouds appeared in my field of view. The clouds were present until 1^h10^m UT. Nevertheless, the hourly rates of Perseids became higher. What happened further, you can see in Figure 1. The highest ZHR is 231 ± 46 and was noted during the 15 minutes interval from 0^h50^m UT to 1^h05^m UT ($\lambda_\odot \approx 139\overset{\circ}{.}65$), almost one hour later than was predicted. I finished my run at 1^h55^m UT. The observation was made in Chełm (Eastern Poland).

Summing up, during my six hours' watch, I observed 193 Perseids and 48 sporadic meteors. At the beginning of the observation, the ZHRs were low but gradually they exceeded 200 around 1^h00^m UT, and quickly dropped to 130–140 after this moment.

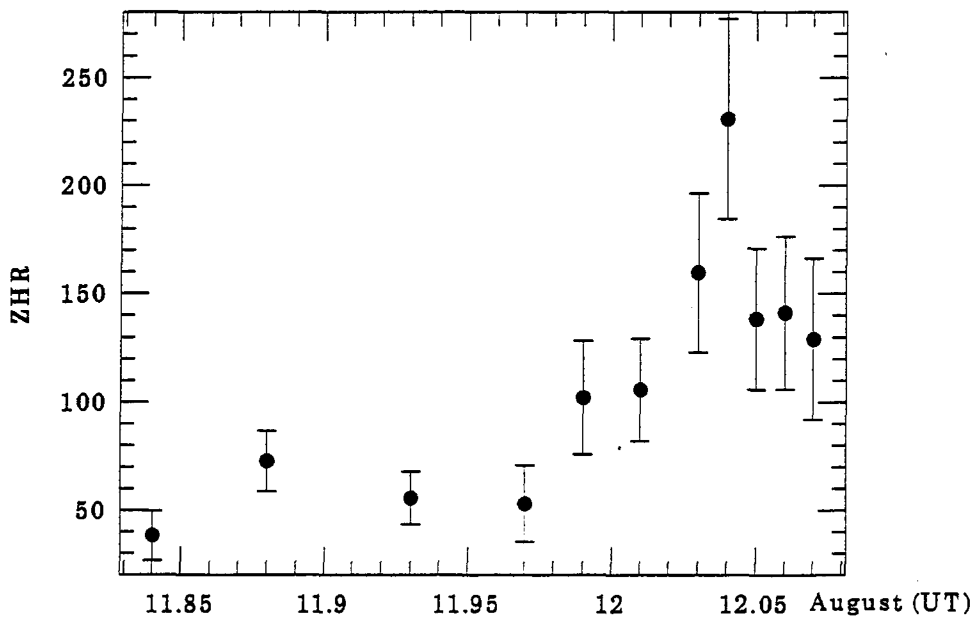

Figure 1 – The author's ZHRs of the 1996 Perseids.

The 1996 Perseids from Jordan

Sanaa'Abdo, Moh'd Hamdan, Moh'd S. Odeh, and Hanna A. Sabat

An overview is given of the Jordanian observations of the 1996 Perseid meteor shower around its peak

The *Jordanian Astronomical Society* (*JAS*) organized an observing camp devoted to the 1996 Perseid meteor shower. The camp was held from August 10 to 13 in a site close to Al-Azraq Oasis which is located 150 km south of Amman, the capital of Jordan. The coordinates of the observing site are $\lambda = 37°06'50''$ E, $\varphi = 31°43'00''$ N.

The participants were

Dr. Ali Abanda, Eng. Khaled Al-Tall, Sanaa'Abdo, Eng. Moh'd Hamdan, Moh'd Odeh, Hani Al-Dalii, Moh'd Awadalla, Ibrahim Jamil, Muammar Al-Hadidi, Moh'd Alawneh, Ziad Al-Saleh, Ramez Moala, Amira Al-Himsi, Ibrahim Iljcaj, and Alaa'Al-Himsi.

The observing conditions in the site were ideal, since it was a magnificent moonless and cloudless night, except for the south-eastern horizon, which was partly illuminated due to a slight light pollution. Unfortunately, at around 1^h30^m UT each day (at the beginning of the morning twilight) the Moon and Venus combined with the zodiacal light somehow distorted the observing conditions in the eastern horizon. During the first night we did not pay enough attention to the meteors in a part of the southern sky, which may have affected our results.

The overall number of meteors observed was 2 133, 1 481 of which were Perseids. Furthermore, 12 fireballs were observed, one of which magnificently exploded reaching a magnitude of −7. The limiting magnitude during the three nights was 6.2. Table 1 gives the Perseid magnitude distribution for the three nights.

Table 1 – The magnitude distribution of the Perseids in August 1996 by Jordanian observers.

Date	−7	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot	$\overline{m}$	Lm
10-11						2	6	18	40	54	64	56	23		263	2.57	6.2
11-12		3	1	4	3	11	39	58	99	129	136	137	62	1	683	2.23	6.2
12-13	1		1	2	3	11	19	49	85	115	126	88	43		543	2.19	6.2

The 1996 June Lyrids and Possible ξ-Draconids

The 1996 June Lyrids

Miloš Weber

An overview is given of the author's observations of the 1996 June Lyrids, which have shown activity. Historical background of this shower is provided. Comments are given on the possibility of activity from a radiant near ξ Draconis on June 16, 1996.

1. Introduction

The author of this communication observed visually during his program of systematic meteor spectrography in the following nights: June 10-11, 11-12, 13-14, and 14-15, 1996, with the aim to check possible activity of the June Lyrids (JLY). Meteors were counted, but not plotted. The observations were carried out at Chouzavá ($\lambda = 14°13'$ E and $\varphi = 49°50'$ N). The June Lyrids were listed in the radiant catalogues after Hindley's paper of 1969 [1], in which the author summarized the observations of S. Dvorak, USA, 1966, of F.W. Talbot's group of observers, UK, 1966, of R. Nolthenius, USA, 1968, and of organized observations of 46 observers in the USA and the UK in 1969.

Z. Sekanina published in 1976 [2] the result of radar observations. The *IMO* removed the June Lyrids from the 1996 Meteor Shower Calendar. Hindley asserts that this shower has not been observed before 1966. In fact, this shower has been observed as early as in 1940 at Přerov by the group of observers consisting of M. Weber, B. Dobíšek, and M. Dobíšek in the nights of June 2-3, 3-4, 5-6, 6-7, 8-9, and 11-12, 1940. During 11.2 hours, M. Weber plotted 13 meteors that placed the radiant $\alpha = 273.^\circ3$ and $\delta = +37.^\circ5$ (1950.0). This position has been derived from 5 paths plotted during 2 hours according to the rule of IAU Commission 22, Paris 1935. One of these meteors has been plotted simultaneously at Ostrava, by J. Píšala, yielding a base line of 75 km. The position of the group radiant was confirmed by the position of the individual radiant. These observational results from 1940 have been published by Professor V. Guth in the Czech Astronomical Journal *Říše Hvězd* [3]. Probably, the activity of the June Lyrids is irregular with intervals of several years of inactivity.

It should also be noted that it is also possible that Hoffmeister's convergency point No. 319 [4], observed in 1911 at solar longitude $\lambda_\odot = 67°$ (1925.0) ($\alpha = 263°$ and $\delta = +43°$), belongs to the June Lyrids.

2. 1996 observations

In June 1996 the June Lyrids were active. The author of this communication observed 17 sporadic and 11 shower meteors in total during 5.7 hours, with a limiting magnitude of 5.9. The corresponding correction coefficient is based on $r_{\rm SPO} = 3.42$ and $r_{\rm JLY} = 3.0$ and the reduction of rates to limiting magnitude 6.5. Rate and magnitude data are summarized in Tables 1 and 2.

Table 1 – Rate data of the 1996 June Lyrids.

Date, June 1996 Solar longitude (2000.0)	10-11 $\lambda_\odot = 80\overset{\circ}{.}33$	11-12 $\lambda_\odot = 81\overset{\circ}{.}28$	13-14 $\lambda_\odot = 83\overset{\circ}{.}15$	14-15 $\lambda_\odot = 84\overset{\circ}{.}15$
$\rm HR_{SPO}$	9.2 ± 6.5	10.8 ± 4.0	7.8 ± 5.6	6.5 ± 4.9
$\rm ZHR_{JLY}$	3.1 ± 5.3	4.5 ± 4.5	–	8.9 ± 5.4

Table 2 – Magnitude data of the 1996 June Lyrids

Magnitude	+1.5	+2.0	+2.5	+3.0	+3.5	+4.0	+4.5	+5.0	Tot
Sporadics	1	1	0	2	2	3	2	0	11
June Lyrids		2	4	1	3	4	1	2	17

Unfortunately the data in Tables 1 and 2 are probably contaminated with the activity of another radiant near the radiant of June Lyrids, as suggested by Marco Langbroek in a recent issue of *WGN* [5].

Marco Langbroek observed a radiant at $\alpha = 280°$ and $\delta = +55°$ (1950.0), near ξ Draconis, in the night of June 15-16, 1996. An activity of a shower with $\alpha = 274°$ and $\delta = +54°$ has been observed by Robert Lunsford, USA, and with $\alpha = 280°$ and $\delta = +53°$ by George Zay, USA.

Unfortunately, Marco Langbroek neglects the activity of the June Lyrids. His map shows that the plotted paths 203, 219, and 234 can belong to both the June Lyrids and the ξ Draconids. The paths 204, 219, and 234 and probably also 225 in my opinion pertain to the June Lyrids. The fact that many of the observed June Lyrids were near the radiant—one meteor was quasi-stationary—shows that the activity of the June Lyrids was real and that all rates, i.e., of sporadic meteors, of June Lyrids, and of possible ξ Draconids, are mutually contaminated.

3. Summary

- The June Lyrids were active in June 1996, with a probable maximum in the night of June 14-15, 1996.
- The observed rates of the June Lyrids and the sporadics are probably contaminated by the rates of a radiant near ξ Draconis (and vice versa).
- The observed activity begun in 1940 at solar longitude $\lambda_\odot = 72°$, and in 1911 at $\lambda_\odot = 67°$, if Hoffmeister's observation is related to the June Lyrids.

Table 3 – Overview of radiant data for the June Lyrids and possible ξ-Draconids.

Reference	α	δ	Drift	Area
June Lyrids				
Hindley 1969	278°	+35°		
Sekanina 1976	281°.9	+43°.6		
IMO 1995	278°	+35°	+0°.8; 0°	5°
Weber 1940	273°.3	+37°.5		3°
Hoffmeister 1911	263°	+43°		
ξ-Draconids				
Langbroek 1996	280°	+55°		
Lunsdorf 1996	274°	+54°		
Zay 1996	280°	+53°		

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Observations of Suspected ξ-Draconids around June 16, 1996

Rainer Arlt

An overview is given of *IMO* observations which may confirm activity of a radiant near ξ-Draconis around June 16, 1996, as reported by Langbroek [1]. Problems regarding the velocity of the meteors are indicated.

In reference to the meteor activity from $\alpha = 280°$ and $\delta = +55°$ (1950.0), observed by Marco Langbroek [1] on 1996 June 15-16, I would like to summarize the results of other observers in this period. Marco reported 13 meteors from that radiant between 22^h40^m and 00^h50^m UT.

Valentin Velkov and Katja Koleva from Bulgaria observed from Avren in the same night between 20^h35^m and 00^h25^m UT. Valentin is a very experienced observer, and his meteors converge best in an area at $\alpha = 283°$, $\delta = 50°$ where 5 meteors can be associated. The resulting ZHR averaged over the entire observation ($T_{\text{eff}} = 2^h.59$) is 3.2 at a radiant elevation of 78°. Interestingly, when using the probability functions of the RADIANT software [2], the highest prominence is achieved for a geocentric velocity of 72 km/s or higher. This suggests that the true radiant of at least a part of the associated meteors lies farther away from their path than the ξ-Draconid radiant. Some of the meteors actually line up with both the ξ-Draconid radiant and the radiant of the June Lyrids.

George Zay observed on June 16 from Descanso, California, between 4^h55^m and 11^h27^m UT with 1 possible ξ-Draconid giving a ZHR of 0.3 averaged over the entire observation. Two other meteors also lined up with the radiant, but one of them was very long in the vicinity of the radiant, and the other one was given a "very fast" velocity close to the radiant. Even a 60-km/s shower does not exceed 5°/s at that distance, which is unlikely to be misclassified by George. Most of the meteors (60%) George associated with the ξ-Draconid radiant were reported to be "very fast." The highest rates were seen on June 12 when George observed between $05^{h}00^{m}$ and $11^{h}30^{m}$ UT with 5 shower members; 4 of these appeared between $7^{h}58^{m}$ and $8^{h}30^{m}$ UT. The hour framing these meteors yields a ZHR of 7.1 at a radiant elevation of 67°, and the average ZHR over the observation is 1.5. The observations on June 9 and 10 showed 1 and 3 possible ξ-Draconid members, respectively.

Bob Lunsford observed on several nights except June 15 and 16 from Descanso, California. He reported all meteors coming from a large area around the suspected ξ-Draconid position. The resulting radiant derived from 23 meteors is at $\alpha = 300°$, $\delta = 58°$, which is 11° north-east from Marco's result. Six of Bob's meteors can be associated with that radiant. Considering that Marco's meteors are mainly located in the south-western sector as seen from the radiant, allowing for an uncertainty in the direction in which most of the meteors moved, we may reasonably consider both positions to be the same radiant. The highest prominence of the radiant, calculated by probability functions is achieved at a geocentric velocity of 47 km/s. Marco gave an estimate of the velocity from the meteors' appearance of about 50 km/s (comparable to the Lyrids). All observers reported medium-fast to fast meteors. A calculation of the pre-atmospheric velocity of the shower (including gravity of the Earth) yields a value of 35 km/s for Marco's radiant position assuming a maximum heliocentric velocity of 42 km/s for members of the Solar System. As the position of Bob's radiant is closer to the apex, the resulting pre-atmospheric velocity is 40 km/s being closer to the suggested estimates.

The fastest angular speed of a 40 km/s meteor is 23°/s when it is in the zenith and 90° from the radiant. However, as the radiant is at about 70° elevation for George's and Bob's observations, the highest speed possible is 16°/s. The radiant elevation for Marco's observation is about 80° resulting in a maximum angular speed of 15°/s. Most of his meteors appeared just in the area where the ξ-Draconids have their highest speeds. Hence, his impression may have led to a somewhat higher geocentric velocity estimate.

References

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[2] R. Arlt, "The Software Radiant", *WGN* 20:2, pp. 62–69.

Editor's postscript

Two of the letters discussing the 1966 Leonid activity (see elsewhere in this issue) also had brief comments on last issue's article by Marco Langbroek on possible activity from a radiant near ξ Draconis (Sirko Molau and Paul Roggemans). Their main criticisms refer to the designation of the term (mini-) "outburst" to the phenomenon and the amount of detail supplied in view of the low numbers of meteors involved. Nevertheless, both admit that it is reasonable to conclude that some activity from a radiant near ξ Draconis has occurred, and other observations around the same time, as summarized by Rainer Arlt above, seem to confirm this conclusion.

However, in some of the observations, there seems to be a problem with the velocity of the meteors seen. Taking into account the article by Miloš Weber and the remark made by Rainer Arlt regarding the observations by Velkov and Koleva, mutual contamination of the observational samples of June Lyrids and ξ-Draconids by each other could perhaps provide a way out of this problem.

Finally, a word of caution is in place, since, at this time, we have insufficient information about possible negative observations from the period concerned. Only after all observations have been taken into account can we draw some more definitive conclusions.

Ongoing Meteor Work

The Makings of Meteor Astronomy: Part XIII

Martin Beech, University of Western Ontario

In 1848, Sir John Lubbock advanced the hypothesis that meteors shine by reflected sunlight. He developed a set of equations describing the geometry of meteor encounters, and for a decade or so, his idea was at least marginally supported by other observers.

1. The shining

Visually, the most striking thing about meteors is their sudden appearance, rapid brightening, and then sudden disappearance. The historical arguments for the origin of this behavior have been many and varied, and indeed, we have discussed several of them in previous essays. The combustion of gases, the burning of "solid fats," the frictional heating of stones, electrical discharges—all have been suggested as the mechanism responsible for the appearance of shooting stars. In 1846, John Lubbock advanced the idea that shooting stars were small, rapidly moving planetary bodies that reflect sunlight. He used this idea to suggest that the end point of a meteor should lie in that region of the sky shielded by the Earth's shadow. Lubbock's theory was never widely accepted, but its development offers some interesting insights into the way in which Victorian scientists occasionally worked.

2. J.W. Lubbock (1803–1865)

John William Lubbock is a classic example of a Victorian amateur hobbyist. Although by profession a banker, Lubbock spent a great deal of his time studying science, astronomy and mathematics. He published many scientific papers, but only one relates to meteoric phenomena (see Section 3, below).

Lubbock was fortunate to be born into rich and influential family, and, in 1840, he inherited both his father's mercantile bank and his baronetcy [1]. Lubbock was educated at Eton and at Trinity College, Cambridge, where he graduated *Senior Optimes* in 1825. He was elected a Fellow of the Royal Astronomical Society in 1828 and a Fellow of the Royal Society in 1829. He served as treasurer and was twice vice-president of the Royal Society and was one of the treasurers of the Great Exhibition of 1851. He was elected a Fellow of the Geological Society in 1848. He married Harriet Hotham in 1833 and fathered eleven children.

Lubbock's chief claim to fame was for his work on lunar theory. His researches were mostly concerned with the testing of theory against detailed observations, with the aim of constructing better predictions of the tides and the orbit of the Moon. Not lacking in any self-confidence, Lubbock wrote of himself in 1860, *I am confident that a just posterity will give us*—that is, to Plana, Ponteculant, and Lubbock, who in 1846 furnished the means of constructing tables of the Moon without an empirical hypothesis—*the credit of first bringing the Lunar Tables within the limits of error of observations.* It is interesting to note, however, that while endorsing the sentiments behind Lubbock's self-eulogy, his anonymous obituarist commented *it is to be much regretted that he did not take one step more, and that the comparatively easy step, of causing the Tables to be constructed.*

Lubbock's scientific interests roamed widely. He published papers on probability theory, eclipse predictions, astronomical refraction, the properties of conic sections, the Arabic naming of stars, and the stability of the Solar System. He also published in 1849 an interesting, if not politically inflammatory, paper in the *Quarterly Journal of the Geological Society* indicating how the Earth's spin axis might be changed so as to account for the better redistribution of water and land masses.

3. The rise and fall of Lubbock's reflection theory

The one and only paper that Lubbock published in the area of meteor astronomy was simply entitled *On Shooting Stars*. Published in 1848, in the *Philosophical Magazine*, Lubbock's paper neatly summarized the then prevailing ideas on the origins of meteor luminosity [2]. In particular, however, Lubbock directed his attention to the *cause of the sudden disappearance of shooting stars*. He ventured three possible explanations:

1. *The body shines by its own light, and then explodes like a sky-rocket, breaking into minute fragments too small to be any longer visible to the naked eye*;
2. *Such a body having shone by its own light, suddenly ceases to be luminous ...*; and
3. *The body shines by reflected light of the Sun and ceases to be visible by its passing into the Earth's shadow, or, in other words is eclipsed.*

Having decided that there were three possible explanations for the "sudden disappearance" phenomenon, Lubbock offered an interesting argument for why it is that the third mechanism should be studied. Lubbock's argument is interesting because rather than appealing to physical mechanisms, he dismisses the self-luminous arguments, because, if they were true, one could not derive as much information from a given set of observations in comparison to that which might be deduced if the solar reflection argument was true. He wrote,

> *...the two first suppositions leave us without instruction as to the orbit or position in space of the body* [the meteor] *in motion, the case is far different in the third hypothesis; for knowing the time when and the place in the heavens where the star disappeared, the elements of the geometry of three dimensions furnish the means of determining the exact distance of the body from the place of the spectator or from the center of the Earth.*

This is a wonderful piece of self-delusion. Rather than consider the merits of each hypothesis in turn and compare how each accounts for the observations, Lubbock simply says, would it not be nice if the solar reflection mechanism is true because then we can apply straightforward geometrical arguments to derive distances. In other words, Lubbock argued that the reflection argument was the right one to study because it yielded apparently useful numbers.

Having decided that the solar reflection hypothesis was the one to pursue, Lubbock set about developing a set of equations for deriving the distance to a meteor at the time of its eclipse (the sudden disappearance point) in the Earth's shadow. Not entirely dismissing the actual observations of meteors and fireballs, however, Lubbock suggested that the brightness variations observed in many meteors were due to their rapid velocities and to changes in the relative viewing angle. He wrote, *they may become larger and more brilliant because their distance to the spectator is diminished, but also because the visible portion of their illuminated disc is increased. Or, on the other hand, their distance from the spectator increasing, and the visible portion of the illuminated disc decreasing, they cease to be perceptible to the naked eye without being eclipsed.* He also noted, *it seems to me that the splitting of the falling stars, like a rocket and trains of light, a phenomenon often witnessed, might, if other circumstances were favorable to the explanation, be accounted for by supposing the star to graze the surface of the shadow before immersion.*

In all, it has to be said, Lubbock's explanation for the appearance of meteoric phenomena is a weak one. Lubbock's arguments were not so vague, however, that no one adopted his ideas. Within a few months of the appearance of Lubbock's paper, Archibald Smith published a detailed mathematical report accounting for meteor eclipses given that the Earth projects a conical shaped shadow into space [3]. Likewise, Piazzi Smyth published a paper [4] concerning *an ascending shooting star*. Smyth concluded, *the distance of the body from the observer* [was] *1721 miles; and that entry into the Earth's shadow was the true cause of the disappearance...* Also in 1849, "Mr. Lowe" published a paper in the *Monthly Notices of the Royal Astronomical Society* [5] in which he argued that there were in fact several different "types" of meteors. Lowe arranged meteors into three classes:

1. *falling stars, which leave luminous streaks behind them*;
2. *stars which do not leave such streaks*; and
3. *luminous bodies, with defined discs.*

Lowe continued, *The first probably shine by inherent light, for otherwise it is difficult to account for a luminous streak which lasts several seconds (in some cases even minutes) after the meteor itself has disappeared. The second may shine by reflected light, as described by Sir John Lubbock, and the third are probably atmospheric, as they chiefly move in discordant paths, are various in shape, and not unfrequently change color.*

What is particularly interesting about Lubbock's work, and also that by Lowe, is that it clearly indicates that the ideas set out by Chladni in the late 1700s [6], i.e., that meteors were extraterrestrial in origin, and shone through their interaction with the Earth's atmosphere, had not been accepted by some astronomers even by the mid-1800s.

4. Out of the darkness

Perhaps the most important paper to appear after Lubbock's publication was that by James Joule [7]. Joule's paper appeared just two months after Lubbock's, but was not an endorsement of his hypothesis. Rather, Joule wrote to advance his own ideas. He wrote,

> *I have for a long time entertained an hypothesis with respect to shooting stars, similar to that advocated by Chladni to account for meteoric stones, and have reckoned the ignition of these miniature planetary bodies by their violent collision with our atmosphere, to be a remarkable illustration of the doctrine of the equivalence of heat to mechanical power.*

At last, we are beginning to see some real physical reasoning being applied to meteoric observations, and indeed, the argument presented by Joule is the basis of modern meteoroid ablation theory.

In relation to Lubbock's theory, Joule offered only one comment: *he has advanced three hypotheses to account for the sudden disappearance of these bodies* [meteors], *the last of which he has enabled as to prove or disprove by actual observations.* In every sense, Joule has hit upon the only redeeming feature of Lubbock's reflection theory: it stands or falls by its predictions. If meteors do not behave as the hypothesis predicts, then the hypothesis is no longer viable.

Robert Greg, in 1860 [8], was the first person to really tackle the problems presented by Lubbock's reflection theory. Rather than attempting to argue that meteors do not behave as one might expect under a reflection hypothesis (i.e., meteors can be seen at the zenith even at local midnight, meteors fragment, etc.), he adopted the argument of incredulity—not the best philosophical approach, but one that often works. Greg wrote,

> *I do not propose entering into the nature of these calculations* [Lubbock's eclipse equations], *or to question either the results or the data, but merely by a different treatment show, If I can, how unlikely, if not impossible, it is that ordinary shooting stars (I mean, of course, those not showing symptoms of active ignition within the lower limits of the Earth's atmosphere) can ever shine by reflected solar light; and this simply from the fact that they would be quite too far off for us to observe such small bodies at even the minimum distance at which... they actually could be visible.*

Greg, as promised in his introduction, set about showing that the minimum distance at which a shooting star might be eclipsed in the Earth's shadow, at an angle of 45° to the horizontal, at midnight for an observer on the equator is some 5 500 miles. This minimum distance, Greg argued was *far to great to admit our seeing ordinary shooting stars.* One can see what Greg is trying to get at in his argument, but the one important point he never mentions is that he has no idea how large the meteoroid bodies might be—a large reflecting object can be seen a long way off. In essence, Greg attempted to turn Lubbock's hypothesis upon it self—he used the theory to derive a result that could not be believed, which implies that the theory must have been wrong in the first place.

It is probably fair to say that Lubbock's reflection theory was never a strong and popular contender for the explanation of the behavior of shooting stars. It had its apparent followers (indeed, Greg noted that it was *frequently referred to*), but it was a theory without a good foundation and it was one that eventually drifted into obscurity.

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A Decade of Visual η-Aquarid Meteor Observations

Tim Cooper

In September 1995, the author presented a paper entitled 'The Rate Profile of the η-Aquarid Meteor Stream' to the Third Biennial Symposium of the Astronomical Society of Southern Africa. The paper gave a historical account of observations from a South African perspective, and summarized the activity profile based on southern hemisphere observations between 1986 and 1995 (the post Halley-perihelion decade). This article is an adaptation of that paper, which in addition compares the activity as seen by northern hemisphere observers in the last two years.

1. Introduction

The Earth passes through the debris stream left behind by Comet Halley twice each year. In May, it encounters the stream on its inward journey around the Sun, resulting in visibility of the η-Aquarid meteor shower, and, in October, it encounters the stream on its outward passage into space, when we see the Orionid meteor shower. The observation of these two showers enables us to study conditions and changes in the dust matrix of this well known comet. The Orionids are well observed each year, principally by northern hemisphere observers, favored by longer October nights and the northerly declination of the radiant at $+16°$. In contrast, the η-Aquarids have been somewhat neglected. This is a pity, since the radiant rises to a respectable altitude before dawn for southern hemisphere observers, rates are generally reliable for several days, and the meteors are impressive to watch.

The purpose of this article is to show the behavior of the η-Aquarids over the past decade, and to convince further observers of the need to collect observational data on this shower in future years.

2. The importance of the η-Aquarids

With the passage of Comet Halley around the Sun in early 1986, it was firstly important to determine if there would be any change in the rate profile of the shower. The rate profile, or activity curve, shows the meteor rate as a function of the position of the Earth in its orbit. Thus, determining the meteor rate over a wide range of solar longitude enables us to determine the mass density of meteors over the width of the dust stream. The recent outburst peak in the Perseid activity curve due to the return of Comet Swift-Tuttle is by now well known [1]. The Leonids have started to show signs of increased activity, several years before the return of comet Tempel-Tuttle [2]. More importantly, the Orionids, the other shower associated with Comet Halley, showed an outburst peak in their 1993 activity curve, 7 years after passage of the parent comet [3,4]. Unlike comets Swift-Tuttle and Tempel-Tuttle, whose orbits make close approaches to the orbit of the Earth, the orbit of comet Halley does not pass close to the orbit of the Earth, and the meteors we see from the η-Aquarids were probably released from the comet thousands of years ago. Thus no enhanced rates were observed from the η-Aquarids in the 1980s [5]. Nevertheless, it is still important that we monitor the η-Aquarids carefully to determine whether a similar peak shows up analogously to the Orionids, to detect any changes in the Halley dust matrix, and contribute to the understanding of the evolution of the dust stream.

3. Listed shower activity

According to *IMO* listed details, the η-Aquarids are detectable from April 19 to May 28 each year [6]. These dates correspond roughly to solar longitudes ($\lambda_\odot$) 29° to 66°. The date of maximum is quoted as May 3. Various other sources have given date of maximum between May 3 and May 6, corresponding to solar longitudes approximately 42°.5–45°.5.

The activity curve shows a broad maximum, and on several occasions has shown two maxima, with the second maximum occurring about May 8 ($\lambda_\odot = 47°.5$). Orbital studies of radio meteors have indicated that the η-Aquarids consist of two sub-streams, the η-Aquarids "proper," and the Halleyids [7]. Since the two streams radiate from closely situated radiants and their maxima are separated by only 4–5 days, the streams appear either as one maximum or two closely spaced maxima.

4. Reduction of observations 1986–1995

To ensure some consistency in the calculated rates, I used data from the *IMO Visual Meteor Database* made by a selected number of observers who have observed the shower over many years in the last decade. These included 10 from South America, 10 from Australasia, and 4 from southern Africa for the southern hemisphere and 5 from the USA, 6 from Europe and 6 from Japan for the northern hemisphere.

The simplest way of depicting activity is to plot hourly counts against time (Rate = N/T), where N is the number of meteors observed and T the observation time in hours, but this does not take into account different atmospheric conditions of observers, differing elevations of the radiant, and other variables. Therefore, Zenithal Hourly Rates (ZHR) were calculated for each watch according to the following formula:

$$\mathrm{ZHR} = N\, r^{(6.5-\mathrm{lm})}/(T_{\mathrm{eff}}\, c_{\mathrm{p}}\, \sin h),$$

where r is the population index of the shower, lm is the limiting magnitude of the watch, c_{p} is the perception coefficient of the observer, h is the mean radiant altitude, and T_{eff} is the effective observing time.

The population index for the η-Aquarids was taken as 2.3. The value of c_p, normally ranging from 0.4 to 2.5, and calculated from the number of observed sporadic meteors against the predicted number, was taken as 1.0. This was due to the fact that observers were not consistent in differentiating sporadic meteors from other showers active at the same time, principally the May Capricornids, which have at least three possible radiants.

Thus, to avoid inaccurate corrections, the factor was omitted. All watch times were corrected for cloud cover, to give effective time T_{eff}. Finally, all observations for $h < 10°$ were rejected for the southern hemisphere observers. This treatment resulted in ZHR values, which were plotted against solar longitude for the time of observation according to epoch 2000.0 to give activity curves as shown in the accompanying figures. ZHR values were averaged for each 0°.1 of solar longitude, and error bars were determined according to the formula

$$\Delta\mathrm{ZHR} = \mathrm{ZHR}/\sqrt{N}.$$

5. Results

The earliest recorded η-Aquarid in the decade was April 19 ($\lambda_\odot = 29°$) and the latest was May 20 ($\lambda_\odot = 59°$), on three occasions. However, on all occasions, the last sighting was followed by about a week when no observations were made or was the last date of observation, and thus the end limit of the shower activity cannot be determined more accurately. Clearly, the observing season needs to be extended in future years beyond these dates to cover the start and end of shower activity.

The rate profiles based on visual observations for individual years by the southern hemisphere observers are shown in Figures 1–3. These cover the period 1986 to 1993, excluding 1987 and 1991 when insufficient observations were recorded. In 1986, the shower was observed only by a few observers in South America, despite the favorable lunar phase and the call by the *International Halley Watch* for observations of the shower, Comet Halley having passed perihelion only three months earlier.

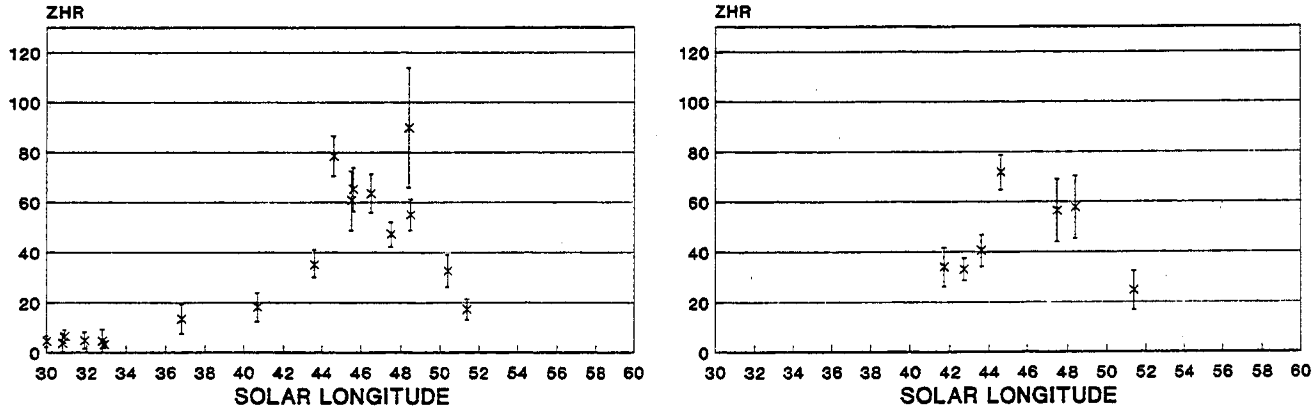

Figure 1 – Southern hemisphere rate profile of the 1986 (*left*) and the the 1988 (*right*) η-Aquarids.

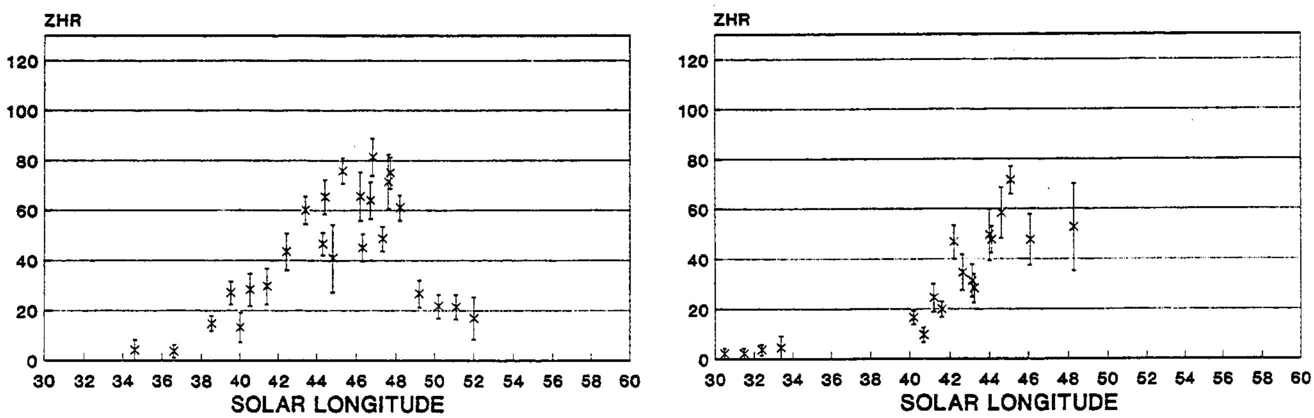

Figure 2 – Southern hemisphere rate profile of the 1989 (*left*) and the the 1990 (*right*) η-Aquarids.

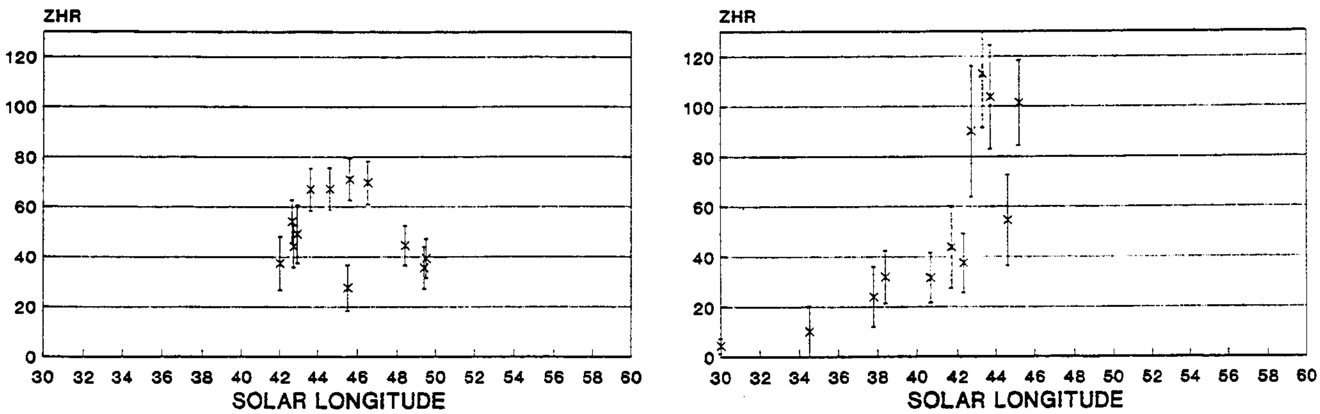

Figure 3 – Southern hemisphere rate profile of the 1992 (*left*) and the the 1993 (*right*) η-Aquarids.

The southern hemisphere profiles of 1988 to 1992 appear to show similar behavior, with a slow increase in activity from $\lambda_\odot = 30°$ to $\lambda_\odot = 40°$, whereafter the activity increases more rapidly to a broad maximum. The ZHR at maximum is typically 60–70 meteors per hour. In general, it is not possible to determine an accurate date from these years due to too little data.

The rate profile in 1993 is clearly different. Already the rate increase in the period $\lambda_\odot = 30$–40 is steeper, and the ZHR at maximum is much higher than in any other year, with a peak ZHR of 110 at about $\lambda_\odot = 44°$. This activity was witnessed both from South Africa and New Zealand. A similar outburst reported in 1980 was witnessed from Australia [8].

In Figures 4 and 5, I have plotted the profiles for 1994 and 1995, comparing the southern hemisphere and northern hemisphere profiles. The 1994 data show some similarities, especially the peak at $\lambda_\odot = 43{.}^\circ5$ with ZHR 80. The southern hemisphere data shows a second peak at $\lambda_\odot = 46°$. The 1995 profiles are however quite different. The peak at around $\lambda_\odot = 44°$ was not seen by the northern hemisphere observers, where ZHRs remained below 40 for the entire campaign.

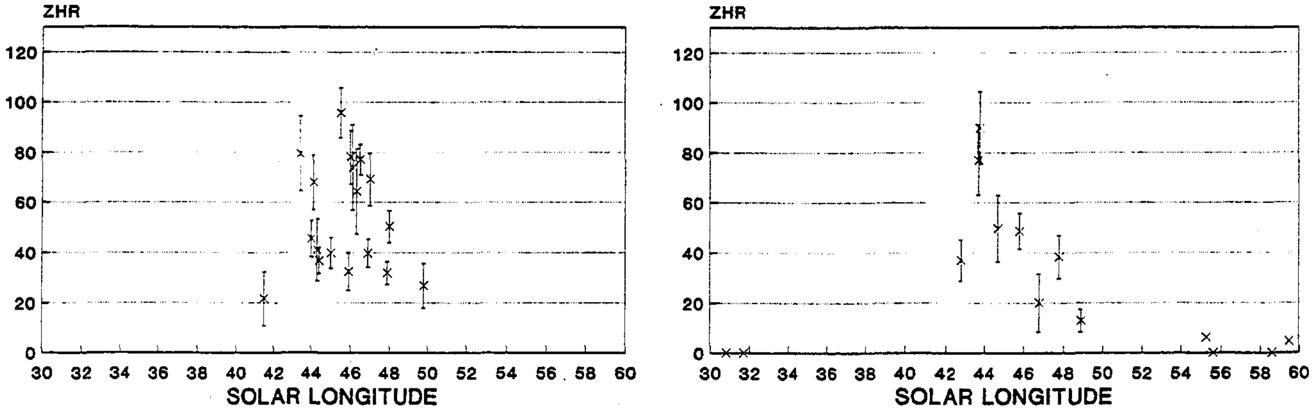

Figure 4 – Southern (*left*) and northern (*right*) hemisphere rate profile of the 1994 η-Aquarids.

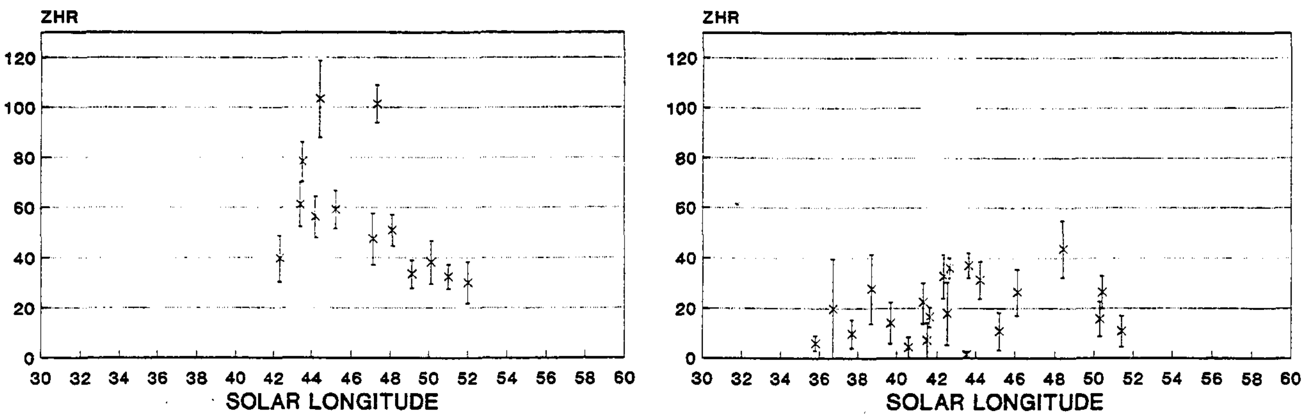

Figure 5 – Southern (*left*) and northern (*right*) hemisphere rate profile of the 1995 η-Aquarids.

Finally, in Figure 6, I combined the southern and northern hemisphere data to give global activity curves for 1994 and 1995.

6. Conclusions and future prospects

The rate profile of the η-Aquarids based on observations over the last decade indicate activity from at least April 19 to May 20. A maximum of typically 60–70 meteors per hour occurs around $\lambda_\odot = 43{.}^\circ5$–$44°$, with a possible second maximum on occasions around $\lambda_\odot = 46°$–$47°$. Occasionally, the shower exhibits incidences of enhanced activity (ZHR > 100). The sparsity of good quality data prevents more accurate conclusions, and, in light of the high activity from the shower, the η-Aquarids would benefit from more attention by the *IMO* members in both hemispheres in the future.

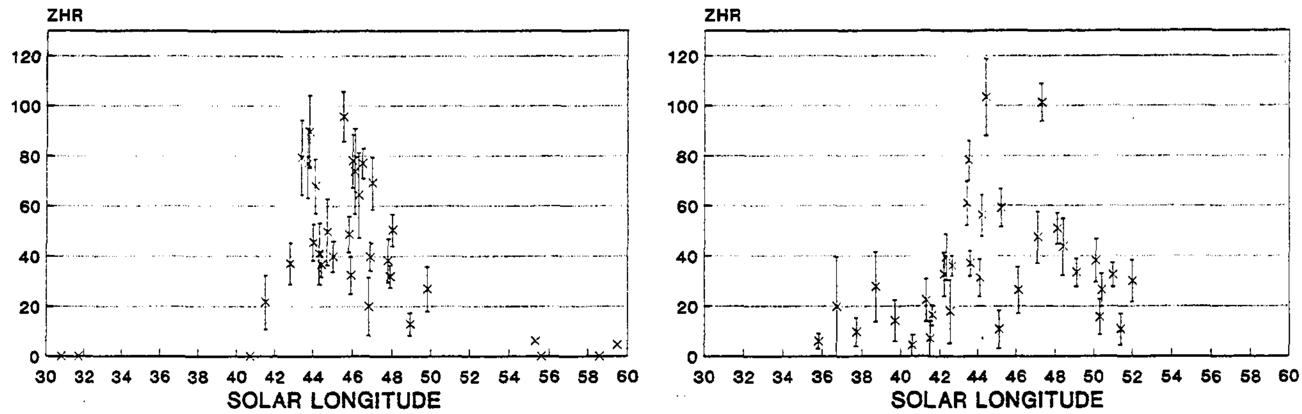

Figure 6 – Combined rate profile of the 1994 (*left*) and the 1995 (*right*) η-Aquarids.

Observing conditions in May 1996 were not favorable, with near Full Moon at shower maximum. In the following two years, conditions are favorable; in 1997 New Moon occurs on May 6, and in 1998 the waxing Moon only interferes from May 8 onwards.

7. Acknowledgments

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Double-Station TV Meteor Observations (Part II)

Yoshihiko Shigeno, Hiroyuki Shioi, and Shoichi Tanaka

Double station TV meteor observations were carried out in three nights in December 1995–January 1996. The observation nights were December 16, December 25, and January 3, separated by 9 days each. In total, 82 meteors were observed. The analysis yielded associations to 22 streams.

1. Observations

1. On December 16, 1995, we made our 16th double-station TV observation. During the observing period 18^h40^m–20^h45^m UT, we recorded 21 double-station meteors. We used an objective lens $f/1.2$, $f = 50$ mm. This gives a field size of $13° \times 17°$.

The achieved limiting stellar magnitude was 8.8 at station P1, and 8.4 at P2. The average of the measurement errors is 125″, and the average of the cross angles is 29°. The mean radiant position errors are 0°95.

The locations used for the observations were as follows:

P1: Miho Ibaraki, Japan, $\lambda = 140°19'09''7$ E, $\varphi = 36°01'38''8$ N, $h = 1$ m;
P2: Monoi Chiba, Japan, $\lambda = 140°11'57''7$ E, $\varphi = 35°40'51''1$ N, $h = 12$ m.

The sites are separated by 39.9 km.

2. On December 25, 1995 we made our 17th observation. The observing period was 15^h45^m–18^h03^m UT. This time, 14 double-station meteors were observed. Again, we used the $f/1.2$, $f = 50$ mm lens.

   The limiting stellar magnitudes were 9.1 at P1, and 8.6 at P2. The average of the measurement errors was 112″, the mean cross angle was 23°. The mean of the radiant position errors was 0°78.

   The locations used for the observations were as follows:

   P1: Noda Chiba, Japan, $\lambda = 139°54'58''2$ E, $\varphi = 35°58'00''2$ N, $h = 5$ m;
   P2: Monoi Chiba, Japan, $\lambda = 140°11'57''7$ E, $\varphi = 35°40'51''1$ N, $h = 12$ m.

   The sites are separated by 40.7 km.

3. The 18th observation took place on January 3, 1996. The observing periods were 16^h00^m–18^h25^m and 18^h41^m–21^h00^mUT. In total, 47 double-station meteors were observed.

   The camera set-up was identical to the previous observation, with limiting stellar magnitudes of 7.8–8.9 at P1 and 7.8–8.9 at P2. The average of the measurement errors was 117″, the average of the cross angles was 38°. The mean of the radiant position errors was 0°57.

   The locations used for the observations were as follows:

   P1: Noda Chiba, Japan, $\lambda = 139°54'51''1$ E, $\varphi = 35°58'03''9$ N, $h = 8$ m;
   P2: Monoi Chiba, Japan, $\lambda = 140°11'57''7$ E, $\varphi = 35°40'51''1$ N, $h = 12$ m.

   The sites are separated by 40.9 km.

2. Shower association

The Leonids in December–January have been observed in Japan [2]. Possibly a part of this stream is a tail of the Leonids occurring in November. The stream south of the ecliptic plane like in the case of the Leonids in November actively appeared in December too.

Table 1 – Averages and standard deviations of the streams.

Str	Date (UT) (yyyymmdd.ddd)	α (2000.0)	δ (2000.0)	SD	V_G (km/s)	a (AU)	e	q (AU)
11	19960103.835	230°1	+48°8	0°3	40.2	2.44	0.599	0.976
	SD ± 0.029	1°7	0°9	0°3	1.8	–	0.078	0.004
17	19951225.746	193°1	+40°6	0°2	57.8	8.93	0.895	0.938
	SD ± 0.009	0°8	3°5	0°0	2.1	–	0.012	0.018
18	19960103.846	158°7	+21°5	0°5	51.5	1.61	0.936	0.104
	SD ± 0.007	1°9	2°2	0°2	0.3	–	0.020	0.034
19	19951216.820	147°0	+12°5	0°6	63.7	6.43	0.944	0.360
	SD ± 0.021	0°4	0°5	0°4	3.9	–	0.101	0.080
20	19951216.820	161°0	− 7°6	2°2	65.4	2.18	0.578	0.919
	SD ± 0.034	4°3	1°6	1°3	2.0	–	0.165	0.082
21	19960103.819	195°6	+12°4	2°4	66.1	2.79	0.651	0.971
	SD ± 0.017	1°7	2°2	1°5	2.7	–	0.199	0.012

On January 3, 1996, we recorded the Quadrantids as well as some other interesting minor streams.

Table 1 lists averages and standard deviations for 6 streams.

Tables 4–6 lists orbital elements of all 82 double-station meteors.

Figure 1 shows a map with corrected radiant positions.

Figure 2 shows error ellipses of the apparent Quadrantid radiants. These ellipses show the standard deviations of the apparent radiant positions. The radiant position exists inside the ellipse with a probability of 47%.

There are 22 streams which appear in our sample. The numbers refer to the lines listed in Table 1.

(1) February Bootids (ID: Iz). Bootids at high-speed in February.

(2) Coma Berenicids (ID: H8, IC). We think H8 was the initial activity (uncertain).

(3) Northern branch of Coma Berenicids (ID: I3). The γ-Coma Berenicids.

(4) Geminids (ID: GB). The final activity.

(5) ε-Hydrids (ID: IG). Not the main stream, unless the perihelion longitude has changed (uncertain).

(6) Leonids (ID: GA, HD). We think this is the final activity, and a part of the stream could be a tail of the Leonids occurring in November.

(7) Northern branch of Leonids (ID: GJ, H3). We think this is the final activity. A part of the streams of Leo's tail of the Leonids in December–January.

(8) December Leo Minorids (ID: GM). This stream is different from the Coma Berenicids.

(9) Monocerotids (ID: GO). December-Monocerotids.

(10) Northern χ-Orionids (ID: GL, H2). The northern χ-Orionids of the ecliptic system.

(11) Quadrantids (ID: IF, IH, IK, IM, IP, IV, IW, Id, Ig, Im, In, Iu, Iw, Ix, I# ,I$).

(12) Northern branch of Quadrantids (ID: IQ, Iq).

(13) Northern Taurids (ID: H6). The Radiant shifts north after mid-December.

Table 1 – continued.

Str	Date (yyyymmdd.ddd)	ω	Ω	i	Obs Mag	H_b (km)	H_e (km)
11	19960103.835	169°3	282°8	71°1	4.7	102.2	88.1
	SD ± 0.029	3°5	0°0	2°5	1.8	2.1	3.2
17	19951225.746	205°4	273°5	107°2	3.6	114.3	96.4
	SD ± 0.009	5°2	0°0	5°4	2.7	3.3	0.1
18	19960103.846	328°5	282°8	127°0	4.9	99.8	88.6
	SD ± 0.007	5°6	0°1	5°5	2.3	3.0	0.6
19	19951216.820	109°4	85°1	178°7	4.9	107.6	99.9
	SD ± 0.021	13°6	1°0	1°8	1.6	7.3	-
20	19951216.820	29°7	84°4	153°5	5.6	108.1	92.4
	SD ± 0.034	23°3	0°0	1°4	0.9	6.9	3.6
21	19960103.819	193°1	282°8	148°3	4.9	105.1	96.6
	SD ± 0.017	10°6	0°0	4°5	1.9	7.2	4.8

Table 2 – D and D' criterion between comet Hale-Bopp and the Quadrantids, ID=GD, H4.

ID	Date	UT	α	δ	SD	V_G (km/s)	a (AU)	e
Hale-Bopp (1995 O1)							164	0.994
Quadrantids			230°	+50°		41	2.9	0.661
MSSIGD	19951216	$19^h56^m53^s$	206°.7	+37°.2	0°.3	54.0	3.41	0.727
MSSIH4	19951225	$16^h33^m49^s$	212°.1	+31°.8	0°.6	55.7	3.47	0.734

Table 3 – Averages and standard deviations of the Quadrantid orbits.

Obs	Date (UT) (yyyymmdd.ddd)	α (2000.0)	δ (2000.0)	SD	V_G (km/s)	a (AU)	e	q (AU)
1	19540103.478	230°.31	+49°.23		41.3	3.06	0.681	0.977
	SD ± 0.032	2°.74	0°.88		0.7	–	0.011	0.004
2	19550103.801	230°.64	+49°.58		40.5	2.88	0.661	0.978
	SD ± 0.042	1°.81	0°.97		0.8	–	0.027	0.003
3	19910103.795	229°.91	+49°.28		41.4	3.02	0.677	0.978
	SD ± 0.033	1°.60	0°.67		0.3	–	0.015	0.003
4	19960103.835	230°.09	+48°.76	0.3	40.2	2.44	0.599	0.976
	SD ± 0.029	1°.70	0.85	0.3	1.8	–	0.078	0.004

Table 4 – Orbital elements (eq. 2000.0) for December 16, 1995.

ID	1995 Dec 16 (UT)	α	δ	SD	V_G (km/s)	a (AU)	e	q (AU)
MSSIGL	$20^h33^m03^s$	82°.9	+26°.3	1°.8	22.0	2.34	0.750	0.584
MSSIGO	$20^h37^m13^s$	107°.2	+ 9°.9	3°.5	40.2	4.83	0.965	0.167
MSSIGB	$19^h46^m33^s$	116°.1	+31°.4	0°.3	37.0	1.63	0.925	0.122
MSSIGK	$20^h19^m25^s$	120°.5	+47°.5	0°.3	27.5	1.08	0.702	0.320
MSSIG3	$18^h53^m22^s$	139°.0	+ 3°.6	2°.4	64.5	– 7.34	1.048	0.351
MSSIG6	$19^h18^m24^s$	146°.9	+12°.3	0°.3	61.0	2.39	0.873	0.304
MSSIGG	$20^h01^m48^s$	147°.4	+13°.1	1°.0	66.5	–27.3	1.015	0.416
MSSIG2	$18^h44^m15^s$	158°.6	– 6°.7	0°.7	64.2	2.00	0.587	0.826
MSSIG8	$19^h30^m27^s$	159°.8	+56°.6	1°.6	43.4	1.86	0.673	0.609
MSSIGC	$19^h50^m16^s$	162°.8	+ 3°.5	2°.0	67.5	2.78	0.701	0.832
MSSIGH	$20^h07^m26^s$	163°.7	– 9°.3	2°.5	67.7	3.64	0.739	0.951
MSSIGM	$20^h36^m17^s$	164°.6	+31°.3	0°.2	67.1	– 6.96	1.106	0.739
MSSIG9	$19^h34^m56^s$	167°.6	–18°.1	1°.6	68.1	10.9	0.910	0.982
MSSIGI	$20^h12^m41^s$	168°.1	– 9°.6	3°.3	64.3	1.66	0.410	0.979
MSSIGA	$19^h43^m42^s$	177°.7	+14°.6	1°.3	70.4	10.7	0.908	0.978
MSSIGJ	$20^h17^m30^s$	177°.7	+18°.5	0°.3	67.1	3.20	0.698	0.966
MSSIGP	$20^h39^m18^s$	187°.4	+ 6°.4	0°.7	60.1	1.08	0.329	0.727
MSSIGN	$20^h36^m56^s$	188°.8	+29°.3	1°.2	52.1	0.988	0.014	0.974
MSSIGD	$19^h56^m53^s$	206°.7	+37°.2	0°.3	54.0	3.41	0.727	0.932
MSSIG7	$19^h18^m55^s$	208°.0	+ 2°.3	0°.7	61.4	3.70	0.901	0.365
MSSIG5	$18^h57^m52^s$	225°.1	+56°.3	1°.0	36.9	2.27	0.568	0.979

Table 2 – continued.

ID	Date	UT	q (AU)	ω	Ω	i	D	D'
Hale-Bopp (1995 O1)			0.913	130°.7	282°.5	89°.4	–	–
Quadrantids			0.978	171°	284°	71°	0.74	0.30
MSSIGD	19951216	$19^h56^m53^s$	0.932	151°.0	264°.4	101°.3	0.57	0.22
MSSIH4	19951225	$16^h33^m49^s$	0.924	149°.0	273°.5	105°.7	0.51	0.21

Table 3 – continued.

Obs	Date (yyyymmdd.ddd)	ω	Ω	i	References
1	19540103.478	171°.0	283°.2	71°.9	7 meteors Super-Schmidt
	SD ± 0.032	4°.4	0°.0	1°.5	(Jacchia, Whipple 1961)
2	19550103.801	171°.2	283°.3	71°.0	6 meteors Tokyo Astron. Obs.
	SD ± 0.042	3°.5	0°.0	1°.3	(Hirose, Tomita 1955)
3	19910103.795	171°.3	283°.0	72°.1	6 meteors Tokyo Meteor Net.
	SD ± 0.033	2°.9	0°.0	0°.7	(Ohtsuka 1995)
4	19960103.835	169°.3	282°.8	71°.1	16 meteors of this paper
	SD ± 0.029	3°.5	0°.0	2°.5	

Table 4 – continued.

ID	ω	Ω	i	Obs Mag	H_b (km)	H_e (km)	Str
MSSIGL	266°.7	264°.5	2°.2	6.5	98.2	95–	10
MSSIGO	133°.6	84°.5	30°.2	6.5	108.5	105–	9
MSSIGB	325°.3	264°.4	25°.9	6.0	101.8	87.7	4
MSSIGK	309°.4	264°.5	33°.2	5.5	100+	85.6	–
MSSIG3	104°.9	84°.4	149°.3	6.5	111.8	99.8	15
MSSIG6	119°.0	84°.4	177°.4	3.8	112.7	99.9	19
MSSIGG	99°.7	85°.9	179°.9	6.0	102.4	92–	19
MSSIG2	55°.7	84°.4	152°.2	6.3	103.2	90.1	20
MSSIG8	267°.0	264°.4	79°.1	6.8	98.3	88.3	–
MSSIGC	51°.4	84°.5	173°.4	3.3	116.0	95.4	–
MSSIGH	23°.0	84°.5	153°.3	4.5	113.0	96.5	20
MSSIGM	238°.3	264°.5	136°.6	6.0	110.7	99.6	8
MSSIG9	355°.0	84°.4	143°.0	3.5	113.8	104–	–
MSSIGI	10°.6	84°.5	155°.0	6.0	100+	90.6	20
MSSIGA	189°.0	264°.4	158°.4	5.3	104.2	95.0	6
MSSIGJ	197°.2	264°.5	151°.5	4.5	111.9	94.6	7
MSSIGP	86°.7	264°.5	161°.8	3.8	102.7	94.0	–
MSSIGN	107°.2	264°.5	119°.5	5.3	110.3	101.4	–
MSSIGD	151°.0	264°.4	101°.3	4.8	101.8	90–	16
MSSIG7	70°.9	264°.4	147°.1	3.8	112+	100.3	22
MSSIG5	170°.2	264°.4	64°.7	3.8	99+	84.7	–

Table 5 – Orbital elements (eq. 2000.0) for December 25, 1995.

ID	1995 Dec 25 (UT)	α	δ	SD	V_G (km/s)	a (AU)	e	q (AU)
MSSIH6	$17^h19^m19^s$	67.°9	+29.°0	1.°0	13.6	2.34	0.641	0.842
MSSIH2	$16^h17^m05^s$	85.°7	+27.°8	0.°5	17.2	1.94	0.638	0.702
MSSIH9	$17^h30^m53^s$	104.°5	+ 5.°7	0.°8	34.1	7.77	0.952	0.371
MSSIHB	$17^h38^m13^s$	137.°2	−16.°6	0.°6	51.4	2.68	0.837	0.437
MSSIH7	$17^h23^m35^s$	169.°8	+20.°0	2.°1	67.2	17.8	0.962	0.675
MSSIH3	$16^h24^m02^s$	173.°8	+17.°9	1.°2	68.9	35.9	0.978	0.784
MSSIH5	$17^h09^m02^s$	177.°8	− 4.°8	1.°2	71.9	19.3	0.950	0.972
MSSIH8	$17^h25^m55^s$	180.°3	+22.°1	0.°8	68.8	−26.6	1.033	0.881
MSSIHD	$17^h48^m41^s$	183.°0	+ 9.°2	1.°4	70.3	7.09	0.864	0.964
MSSIHC	$17^h45^m38^s$	192.°5	+43.°2	0.°2	56.3	8.13	0.886	0.925
MSSIHH	$18^h02^m58^s$	193.°6	+38.°2	0.°2	59.3	9.88	0.904	0.950
MSSIHG	$18^h02^m28^s$	199.°0	+19.°5	2.°7	37.4	0.582	0.707	0.171
MSSIH4	$16^h33^m49^s$	212.°1	+31.°8	0.°6	55.7	3.47	0.734	0.924
MSSIHF	$17^h54^m21^s$	213.°8	− 0.°9	0.°6	63.9	6.32	0.930	0.444

Table 6 – Orbital elements (eq. 2000.0) for January 3, 1996.

ID	1996 Jan 3 (UT)	α	δ	SD	V_G (km/s)	a (AU)	e	q (AU)
MSSIIE	$18^h45^m02^s$	125.°3	− 3.°0	0.°6	17.1	0.877	0.519	0.422
MSSIIa	$19^h56^m05^s$	127.°3	+26.°0	0.°9	37.6	3.37	0.947	0.177
MSSIIe	$20^h06^m13^s$	141.°3	+ 6.°1	0.°8	36.9	0.972	0.951	0.047
MSSIIo	$20^h25^m44^s$	157.°6	+20.°3	0.°4	51.3	1.58	0.949	0.080
MSSIIh	$20^h10^m38^s$	160.°3	+23.°5	0.°6	51.7	1.63	0.922	0.127
MSSII2	$17^h20^m47^s$	165.°0	−14.°4	5.°0	61.8	2.35	0.732	0.631
MSSIIG	$18^h57^m19^s$	167.°2	− 1.°3	2.°2	56.1	1.07	0.727	0.293
MSSII1	$16^h25^m30^s$	170.°3	+15.°3	0.°8	17.8	0.587	0.760	0.141
MSSIIy	$20^h47^m21^s$	174.°2	+ 0.°3	1.°0	63.8	1.83	0.672	0.599
MSSIIj	$20^h11^m22^s$	174.°4	+23.°6	0.°3	59.9	2.69	0.825	0.470
MSSIIR	$19^h37^m47^s$	176.°5	+ 3.°0	1.°1	66.4	2.76	0.753	0.683
MSSIIC	$18^h23^m22^s$	178.°1	+27.°2	0.°7	61.1	4.69	0.874	0.592
MSSII3	$17^h23^m33^s$	182.°7	+31.°1	0.°3	58.8	3.29	0.796	0.672
MSSIIl	$20^h13^m25^s$	191.°8	+29.°2	0.°5	62.7	9.44	0.908	0.870
MSSIIB	$18^h18^m29^s$	193.°4	−27.°1	3.°2	69.3	−29.0	1.031	0.910
MSSIIb	$20^h01^m33^s$	194.°7	+ 9.°9	1.°8	67.3	3.07	0.684	0.973
MSSIIT	$19^h44^m47^s$	195.°3	+13.°9	1.°2	63.0	1.71	0.438	0.958
MSSIIs	$20^h33^m14^s$	198.°4	−12.°8	2.°4	71.2	13.5	0.933	0.910
MSSIIJ	$19^h12^m21^s$	198.°8	+13.°2	4.°1	67.9	5.84	0.832	0.983
MSSIIZ	$19^h50^m44^s$	198.°9	+42.°5	0.°5	54.0	5.49	0.835	0.904
MSSIII	$19^h11^m25^s$	199.°4	+55.°9	0.°4	46.3	9.68	0.908	0.888
MSSIIz	$20^h52^m00^s$	203.°3	+27.°0	0.°7	60.2	3.11	0.686	0.978
MSSII9	$18^h07^m19^s$	203.°4	+33.°4	0.°6	47.1	1.03	0.139	0.891
MSSIIp	$20^h27^m11^s$	205.°3	−12.°4	1.°9	67.1	2.91	0.744	0.747
MSSIIi	$20^h11^m05^s$	213.°5	+56.°9	0.°4	38.9	2.27	0.582	0.948
MSSII5	$17^h33^m39^s$	218.°0	+50.°8	0.°7	46.3	6.56	0.851	0.978
MSSIIN	$19^h24^m23^s$	219.°1	+37.°6	0.°2	40.0	1.03	0.108	0.922
MSSIIU	$19^h45^m13^s$	220.°0	+ 5.°8	2.°3	62.3	3.35	0.816	0.614
MSSIIW	$19^h48^m03^s$	226.°1	+49.°2	0.°8	41.3	2.46	0.601	0.982
MSSIIn	$20^h23^m04^s$	228.°0	+47.°9	0.°3	41.2	2.39	0.591	0.978
MSSIIM	$19^h20^m51^s$	228.°4	+50.°3	0.°3	39.2	2.21	0.555	0.981

Table 5 – continued.

ID	ω	Ω	i	Obs Mag	H_b (km)	H_e (km)	Str
MSSIH6	230°5	273°5	2°7	5.8	93.4	85.4	13
MSSIH2	254°3	273°5	2°3	6.3	94.5	86.4	10
MSSIH9	106°1	93°5	22°8	3.5	105.4	96–	–
MSSIHB	102°7	93°5	99°1	4.0	97+	87.1	–
MSSIH7	248°9	273°5	151°4	6.5	108.0	100.0	–
MSSIH3	233°9	273°5	153°9	3.5	115.2	105–	7
MSSIH5	12°8	93°5	170°8	5.5	115+	102.6	20
MSSIH8	217°3	273°5	143°8	5.8	108.8	94.4	2
MSSIHD	196°7	273°5	163°1	6.0	105.0	92.2	6
MSSIHC	209°1	273°5	103°4	1.8	116.7	96.5	17
MSSIHH	201°7	273°5	111°0	5.5	112.0	96.4	17
MSSIHG	5°0	273°5	101°6	6.5	103.7	100.6	–
MSSIH4	149°0	273°5	105°7	6.5	107.5	103.7	16
MSSIHF	82°0	273°5	151°9	6.5	111.6	101–	22

Table 6 – continued.

ID	ω	Ω	i	Obs Mag	H_b (km)	H_e (km)	Str
MSSIIE	132°2	102°7	15°2	6.0	94.5	86.8	–
MSSIIa	313°2	822°8	14°4	6.3	104.0	97.8	–
MSSIIe	162°3	102°8	37°0	7.0	94.0	84–	–
MSSIIo	332°4	282°8	130.9	6.5	101.9	89.1	18
MSSIIh	324°5	282°8	123°2	3.3	97.6	88.2	18
MSSII2	81°2	102°7	140°1	4.0	104+	98.2	15
MSSIIG	131°9	102°7	163°6	6.5	108.3	101.6	5
MSSII1	349°6	282°6	12°1	5.0	92.6	81.0	–
MSSIIy	88°5	102°8	175°6	6.3	102.8	94.8	–
MSSIIj	278°9	282°8	134°9	4.0	110.8	95.9	–
MSSIIR	253°1	282°7	177°3	6.8	102.7	93–	–
MSSIIC	261°6	282°7	128°6	3.5	112.4	93.5	2
MSSII3	253°5	282°7	120°0	3.0	112.1	92.1	3
MSSIIl	220°8	282°8	123°5	5.3	102.8	90.6	–
MSSIIB	328°6	102°7	145°6	1.5	115+	106–	14
MSSIIb	193°3	282°8	153°5	6.8	110.2	100.6	21
MSSIIT	203°7	282°8	145°2	5.0	100.0	91.2	21
MSSIIs	327°8	102°8	171°7	6.5	119.1	108–	–
MSSIIJ	182°5	282°8	146°0	3.0	110+	97.9	21
MSSIIZ	214°5	282°8	98°5	5.3	107.8	96.7	17
MSSIII	217°2	282°8	78°3	4.5	110.1	98.4	–
MSSIIz	189°3	282°8	120°4	3.8	119.6	102–	1
MSSII9	256°8	282°7	101°0	6.3	110.2	102.8	–
MSSIIp	295°9	102°8	176°6	6.3	100+	93.0	–
MSSIIi	205°5	282°8	68°6	6.5	105.2	98.0	–
MSSII5	188°7	282°7	79°7	3.5	107.9	98.5	–
MSSIIN	110°9	282°8	81°7	5.3	99.3	83.1	–
MSSIIU	99°5	282°8	137°4	4.5	113.4	99–	–
MSSIIW	175°5	282°8	73°4	2.5	107.3	96–	11
MSSIIn	170°1	282°8	73°5	6.3	102.5	88.7	11
MSSIIM	174°0	282°8	69°9	5.8	102.4	90–	11

Table 6 – continued.

ID	1996 Jan 3 (UT)	α	δ	SD	V_G (km/s)	a (AU)	e	q (AU)
MSSIIK	$19^h18^m39^s$	228°7	+47°4	0°3	42.3	2.85	0.658	0.976
MSSIIu	$20^h42^m03^s$	228°7	+48°8	0°2	41.9	2.99	0.672	0.979
MSSIIP	$19^h26^m51^s$	228°7	+49°4	0°2	41.9	3.19	0.693	0.980
MSSIIQ	$19^h31^m05^s$	228°8	+52°8	0°2	38.8	2.54	0.613	0.983
MSSIIm	$20^h19^m42^s$	229°3	+48°4	0°2	40.8	2.50	0.608	0.977
MSSIIg	$20^h08^m27^s$	230°1	+48°6	0°2	41.0	2.72	0.641	0.976
MSSIIV	$19^h47^m38^s$	230°2	+48°6	1°1	42.0	3.31	0.705	0.977
MSSIIF	$18^h48^m08^s$	230°4	+50°0	0°3	38.6	2.17	0.548	0.979
MSSIId	$20^h03^m51^s$	230°4	+50°2	0°3	39.3	2.42	0.595	0.979
MSSIIx	$20^h47^m09^s$	230°6	+48°9	0°2	36.2	1.61	0.396	0.974
MSSII#	$20^h53^m39^s$	231°9	+48°2	0°2	40.1	2.51	0.613	0.972
MSSIIq	$20^h30^m31^s$	232°2	+55°3	0°3	34.5	1.98	0.504	0.983
MSSIIw	$20^h46^m16^s$	232°4	+48°8	0°2	38.5	2.16	0.549	0.973
MSSII$	$20^h54^m40^s$	232°5	+49°2	0°3	37.5	1.98	0.507	0.973
MSSIIH	$19^h06^m13^s$	233°0	+47°0	0°3	41.0	2.80	0.655	0.965
MSSIIY	$19^h49^m32^s$	249°9	+56°8	0°5	33.1	4.00	0.756	0.976

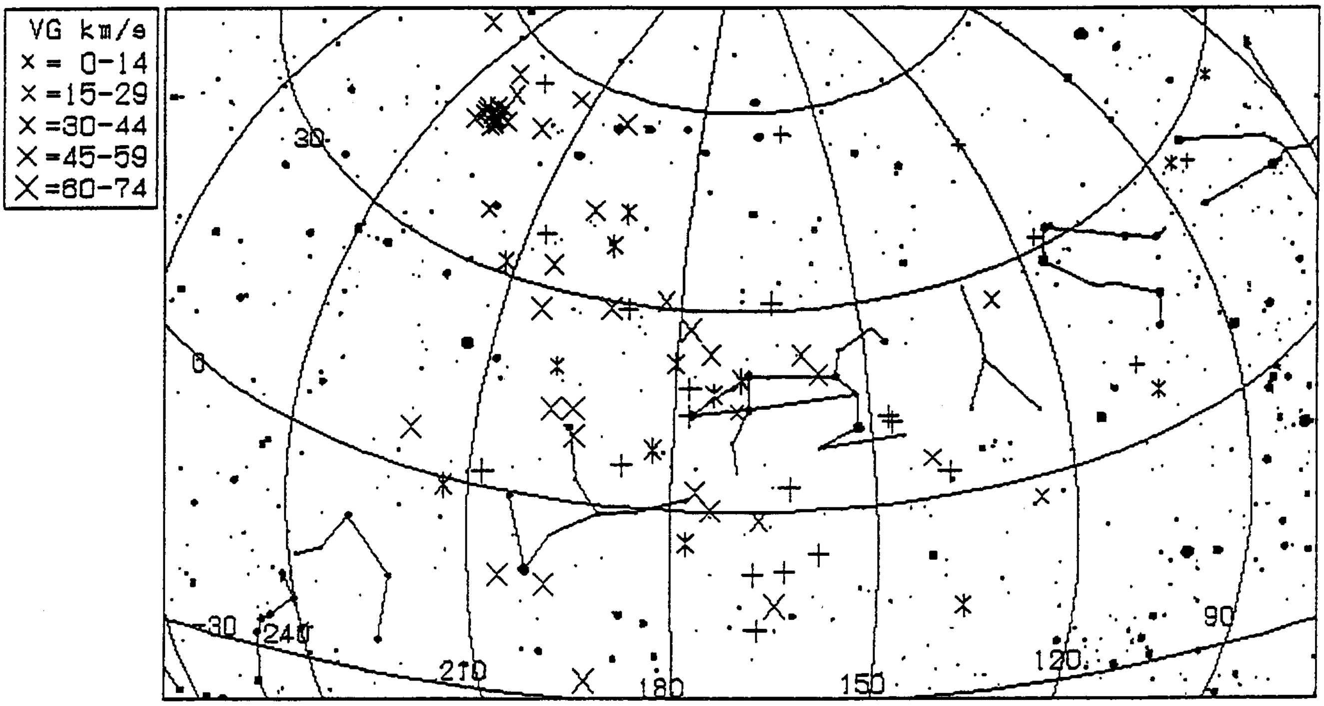

Figure 1 – Corrected radiant map (2000.0). Plusses refer to December 16, 1995, asterisks to December 25, 1995, and crosses to January 3, 1996.

(14) Provisional γ-Hydrids (ID: IB). Cfr. [3] (uncertain).

(15) Provisional ζ-Monocerotids (ID: G3, I2). Different from the main stream, unless the perihelion longitude has changed; cfr. [3] (uncertain).

(16) Provisional γ-Bootids (ID: GD, H4). Has this stream relation to the comet Hale-Bopp (C/1995 O1)? There seems to be a connection with the Bootids in February.

(17) Provisional α-Canes Venaticids (ID: HC, HH, IZ). New detection. Very high orbital inclination. Connection with the Quadrantids?

Table 6 – continued.

ID	ω	Ω	i	Obs Mag	H_b (km)	H_e (km)	Str
MSSIIK	168°7	282°8	74°6	0.3	104.8	92–	11
MSSIIu	171°6	282°8	73°5	4.8	101.5	84.1	11
MSSIIP	172°8	282°8	73°1	2.5	100+	87.3	11
MSSIIQ	178°5	282°8	67°9	4.0	105.7	90.3	12
MSSIIm	169°6	282°8	72°3	3.8	102.3	85.8	11
MSSIIg	169°1	282°8	72°0	5.8	100.0	85.7	11
MSSIIV	169°7	282°8	73°0	6.0	101.0	94–	11
MSSIIF	170°6	282°7	68°6	6.0	101+	91.8	11
MSSIId	171°6	282°8	69°4	5.5	99.9	88–	11
MSSIIx	165°5	282°8	66°3	6.8	101.5	87.4	11
MSSII#	165°9	282°8	70°7	5.3	101.7	88–	11
MSSIIq	179°0	282°8	61°0	7.0	99.5	90.6	12
MSSIIw	165°7	282°8	68°5	3.3	101.1	86.3	11
MSSII$	165°7	282°8	67°1	6.0	100.0	89.0	11
MSSIIH	162°5	282°8	71°8	5.3	104.8	94.9	11
MSSIIY	169°6	282°8	54°3	5.3	103.4	93.7	-

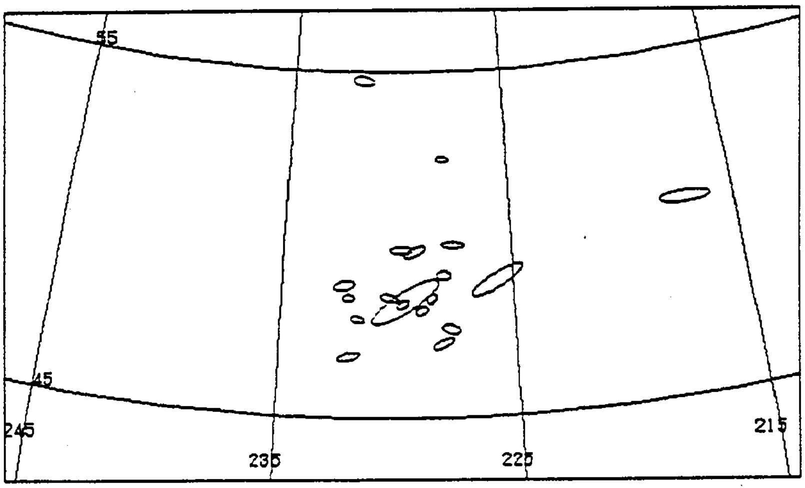

Figure 2 – Error ellipses of the apparent Quadrantid radiants.

(18) Provisional γ-Leonids (ID: Ih, Io). New detection. A part of the streams with radiant in Leo's head possibly related to the Leonids in December–January? This stream differs from the γ-Leonids in November.

(19) Provisional ν-Leonids (ID: G6, GG). New detection. Connection with F3, FB, Ff, Fr? A part of the streams with radiant in Leo's head possibly related to the Leonids in December–January?

(20) Provisional ρ-Leonids (ID: G2, GH, GI, H5). New detection. This stream is the same as F9, Fu. The southern Leonids. The streams seem to spread (uncertain).

(21) Provisional ε-Virginids (ID: IJ, IT, Ib). New detection. A part of the high-speed Virginids in December–January.

(22) Provisional ρ-Virginids (ID: G7, HF). New detection. A part of the high-speed Virginids in December–January.

3. Discussion

1. The orbit of the provisional γ-Bootids (stream 16) is closer to the Comet Hale-Bopp (1995 O1) than the Quadrantids by the D and D' criterion as shown in Table 2, but in fact all values are quite large making an association rather unlikely. As described by Steel [7], there is no link between the Quadrantids and C/1995 O1(Hale-Bopp).
2. The concentrated radiant of the major meteor shower was obtained by our TV observation. The radiant position and the radiant width are the same as the photographic observations as shown in Table 3. However, the error of the velocity is large.

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Fireballs and Meteorites

Meteorite Fall in Italy

September 25, 1996, $15^{\mathrm{h}}30^{\mathrm{m}}$ UT

communicated by Enrico Stomeo

A meteorite fall in Italy on September 25, 1996, is reported.

On September 25 at approximately $15^{\mathrm{h}}30^{m}$, in central Italy, near Fermo (Ancona), a chondrite of 10.2 kg has fallen. The sample, collected from 30 cm deep in the ground, has a size of 24 cm $\times$ 19 cm $\times$ 16 cm and probably belongs to class H5-H6.

Some witnesses have reported a hiss and then a thud, but nobody for now has indicated the atmospheric trajectory of the meteoroid.

The *UAI Sez. Meteore* is trying to retrieve data on the possible fireball as well as the actual meteorite fall.

Observational Results

SPA Meteor Section Results: Late Summer and Fall Update, 1995

Alastair McBeath

More details on the fireball over Germany at $20^h25^m33^s$ UT on November 5, 1995 are given, along with some further radio results, one a set from August–October, 1995, but most from November 1995, and covering the α-Monocerotid outburst, are discussed. The August–October data were found to be of especial interest, and represent a type of monitoring of this period that has been rarely reported in recent years.

1. Introduction

Following the publication of results received by the *SPA Meteor Section* for November and December 1995 [1], several communications were received containing further information on two main events mentioned there, the about magnitude −10 possible Taurid fireball over Germany from November 5, and the α-Monocerotid outburst on November 22. Some further information on both is presented here as a result, along with a particularly interesting set of radio data from August–October.

2. Fireball over Germany, November 5, 1995

Dieter Heinlein sent a copy of a paper recently published in the German journal *Sternschnuppe* [2] concerning this bright fireball, which was photographed by four stations of the *European Fireball Network* of cameras, apart from being seen by many eye-witnesses. The photographs have enabled a good trajectory to be established for the event. The meteor's track passed over Göttingen in Germany, with start and end heights of around 92 km and 50 km respectively. The maximum light was around magnitude −14, and the meteor was discovered to have a radiant and velocity indicating it to have definitely been a Northern Taurid (initial atmospheric velocity about 30 km/s; apparent radiant $\alpha \approx 51°$, $\delta \approx +23°$, both latter parameters within 2° of the predicted Northern Taurid radiant center for November 5 from [3], itself known to be a horizontally-extended area, not a point). An accurate orbit has been established for the meteoroid as well, providing information on another Taurid Complex body for analysts. Congratulations are naturally due to all concerned, particularly the four lucky photographers!

3. Radio results

Christian Steyaert has provided sets of forward-scatter radio data produced by several observers listed below. This information was earlier published in tabular form only in an e-mail item *Radio Meteor Observation Bulletin* 28 [4], which should be consulted for details on the specific radio equipment set-ups. The observers who contributed to this were as follows:

> Maurice De Meyere (Belgium), Werfried Kuneth (Austria), James W. Riggs (California, USA), Ton Schoenmaker (the Netherlands), Ilkka Yrjölä (Finland), and W.T. Zanstra (the Netherlands).

The majority of the results were from 1995 November, covering the Taurids, Leonids, and α-Monocerotids, including Ilkka Yrjölä's, which were discussed previously in [1] and are not repeated here, but some of the most fascinating data was produced by James Riggs, who operated his radio equipment virtually continuously throughout August, September and October, and which we here deal with first.

4. August–October radio data

Figure 1 shows James Riggs's raw daily echo counts throughout the three months of his observations. A large number of peaks are very clear, and an attempt has been made to correlate these radio echo count maxima with known meteor shower maxima and other detected radio events during the period in question, as given in Table 1.

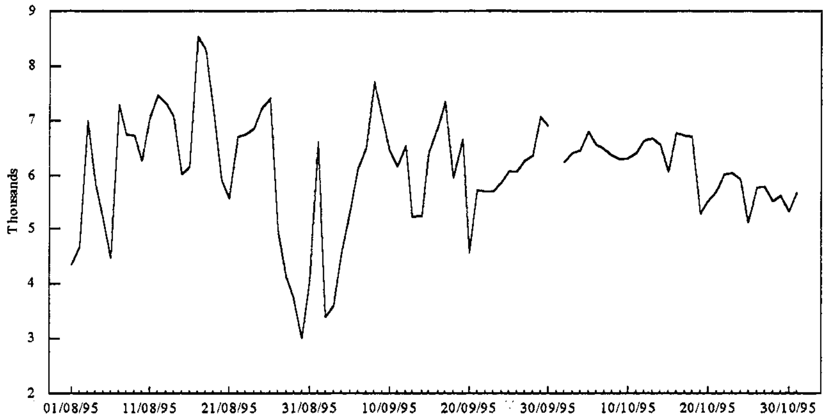

Figure 1 – Raw daily echo count totals during August–October, 1995, as produced by James W. Riggs. The data is continuous except for a one-day break on October 1. For other details, see text.

Table 1 – Peak dates in the raw forward-scatter echo counts obtained by James W. Riggs, August–October, 1995 correlated with known meteor shower maxima (from [5] except where stated) and other radio events.

Peak date	Event is probably associated with
Aug 03	Southern ι-Aquarid maximum (August 4)?
Aug 07	Northern δ-Aquarid maximum (August 8, $\lambda_\odot \approx 136°$ (2000.0) from [4] corrected for 1995)?
Aug 12	Perseid maximum (August 12)
Aug 16	κ-Cygnid maximum (August 19)?
Aug 26	γ-Leonid maximum (August 25); early part of this peak perhaps correlates with Northern ι-Aquarid maximum (August 20)?
Sep 01	α-Aurigid maximum (September 1)
Sep 08	δ-Aurigid maximum (September 9)?
Sep 12	δ-Aurigid maximum (September 9)?
Sep 17	Piscid or κ-Aquarid maxima (September 20 and 21, resp.)
Sep 19	Piscid or κ-Aquarid maxima (September 20 and 21, resp.)
Sep 29	Sextantid maximum (September 27)
Oct 05	October Capricornid or σ-Orionid maxima (October 3 and 5, resp.)?
Oct 13	Unknown—unlikely to be Draconid maximum (October 10), as no unusual activity detected by other means from them in 1995
Oct 16	Radio aurorae detected around October 16–18 (notably 18 from UK [6])
Oct 23	Orionid maxima (centered on October 22)

Interestingly, all the major showers during this period and most of the minor ones seem to have been detected, or at least enhancements in radio activity close to such times were noted. Only the October 13 peak remains without a possible correlated shower or event. It is curious that the radio peak strengths potentially associated with known meteor showers should all be of such relative apparent uniformity. This is particularly odd considering the various favorable factors concerned with the likelihood of, for instance, Perseid and Orionid meteors being detected by radio (good visual rates of swift, often persistently-trained meteors), compared to the much lower activity showers of slower meteors (e.g. the ι-Aquarids or Piscids).

It is difficult to be certain exactly what is being detected in some cases, however, particularly since these are raw results only, and make no allowance for radiant elevation with respect to the radio antenna being used, and so forth. The variability in the background echo-rate was particularly marked around the August-September boundary, with exceptionally low activity being detected right over the period of the α-Aurigid maximum, barring that shower's peak date itself. The problems associated with the radio aurorae in mid-October have already been commented on elsewhere (e.g., [6]).

If many minor showers were being detected, at least near their maxima, as well as the major showers, as these results tend to suggest was the case, that should give all forward-scatter observers fresh heart to continue their observations, but more reports using different set-ups would be needed to properly define whether this is really what was happening or not. It is possible that some sort of atmospheric effects were also playing a role, for instance, and it is notable that the peak-trough echo-count difference during late September and throughout October was generally much less than during August and most of September. September is normally regarded as the end of the Sporadic-E (Es) propagation "season" for the northern hemisphere (cfr. [7]), and it may be that the ion-sheets that allow Es to occur also play a role in enhancing the normal day-to-day fluctuations in radio-detected meteor activity during this time. The "spiky" nature of the radio activity graph during August and September is very reminiscent of both the noctilucent cloud and Es occurrence probabilities found in [7], certainly, an effect which seems to disappear by late September, and was not significantly present during October.

5. November radio data

As stated, the majority of data from [4] concentrated on November, with the most extensive data set being that from Maurice De Meyere. His data are illustrated in Figures 2 and 3. His equipment was operated only between 20^h00^m–8^h00^m UT on most dates, except November 14-15 (to 9^h00^m UT), 15-16, 16-17 and 18-19 (to 10^h00^m UT on each date), whence the gaps.

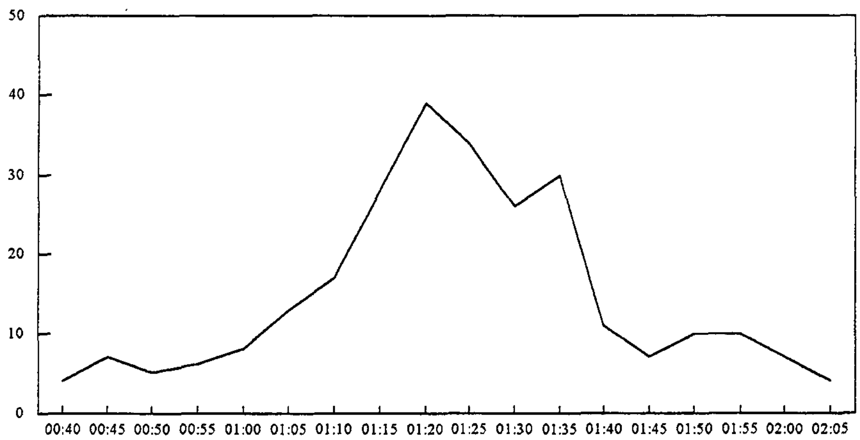

Figure 2 – Raw hourly echo counts during November, 1995. Data from Maurice De Meyere.

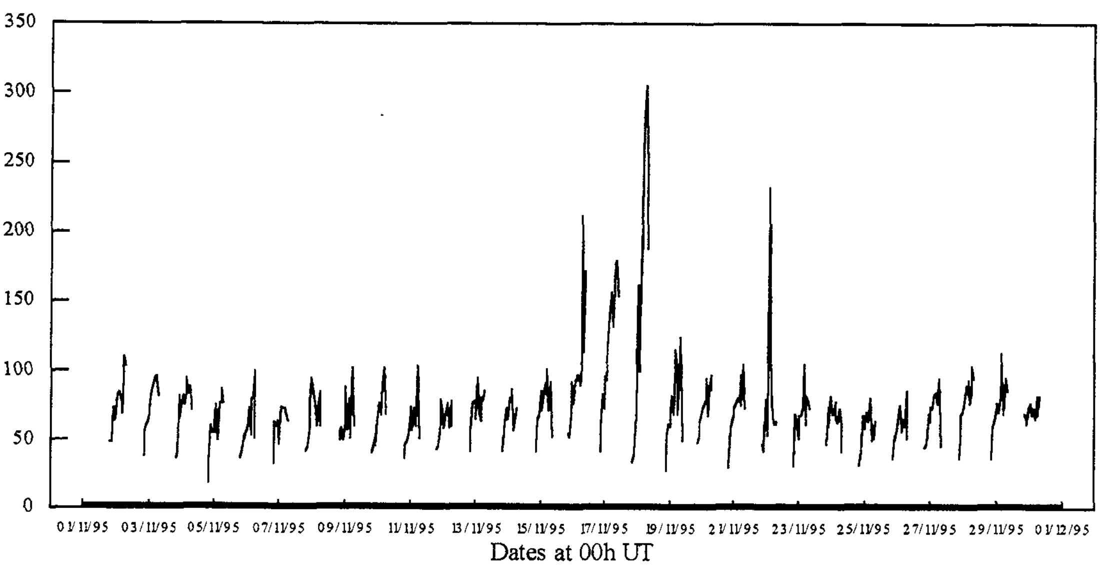

Figure 3 – Raw five-minute echo counts for the period from 0^h40^m–2^h05^m UT on November 22, 1995. Data from Maurice De Meyere.

There are only slight signs of any enhancement from the Taurids in early November from this data, although activity does seem to have been marginally higher than later in the month, when most shower activity had died away generally. Spikes due to the Leonid peak are especially obvious from November 15-16 to 17-18, but November 18-19 still shows some enhancement, and smaller levels of increased meteor activity were noted on November 14-15 and 19-20 as well. The maximum echo rates occurred on November 17-18 from 4^h to 7^h UT, but observing could not be carried out beyond 8^h00^m UT then. However, Maurice comments that the best geometrical conditions for the Leonids with his set-up were calculated to occur between 7^h and 8^h UT daily in mid-November, by which time activity was lower than in the three preceding hours in any case on November 17-18. This peak time fits well with that obtained by other radio operators already discussed in [1] and elsewhere, certainly.

Another clear peak in Figure 2 occurs on November 21-22, its brevity and strength particularly noticeable, as a result of the α-Monocerotids. Figure 3 provides a closer view of this particular maximum, and a possible duality of the best radio rates suggesting peaks around 1^h20^m and 1^h35^m UT. The timing of the "second" peak is well in-line with other radio results published from elsewhere (e.g., [1]), while the "first" maximum fits quite well with some of the visual data, although the mean peak visual time of approximately 1^h30^m UT appears to coincide with a slight lessening in radio rates from Maurice's results.

None of the other observers recorded as continuously as Maurice, but even so, still provided useful data, confirming a radio peak due to the Leonids sometime between 3^h and 8^h UT on November 17-18, the timing variations largely due to the antenna-radiant geometries. Both Ton Schoenmaker and W.T. Zanstra reported enhanced rates during the α-Monocerotids on November 21-22, Ton's data showing a peak rate around 01^h30^m UT, but with higher rates persisting from about 1^h10^m to 1^h40^m UT. Werfried Kuneth was unlucky in using the TV carrier signal from Bucharest as his transmitter station, since it closed down overnight, so he missed the α-Monocerotid outburst, unfortunately.

Acknowledgment

It is good to find more people submitting radio data to us, and hopefully the people named above, and others, will also contribute such work in future. For now, I wish to record my heartiest thanks to all the observers for their efforts, both the radio and photographic ones, represented by this present article, and also the correspondents who so thoughtfully provided the information in the first place.

Good luck with your next observations, and (at least for the visual and photographic watchers) clear skies!

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Visual Observations of the α-Monocerotid Outburst in Slovakia on November 22, 1995

Pavol Rapavý and Jaroslav Gerboš

The results of the observation of the peak activity of the α-Monocerotids (AMO) obtained at two observing sites are presented. A comparison with other observers' results is made.

1. Introduction

Information about a possible α-Monocerotid outburst was published in [1–3]. Previous high activity of the shower was recorded in 1925, 1935, and 1985 [1]. The observing conditions were favorable in Europe in 1995, so the richest collection of observations of this shower so far was obtained.

2. Observations

The first monitoring of α-Monocerotid activity occurred as early as November 18-19, 1995, during standard observations of the Leonids. During 9.85 hours of effective time, only 10 meteors from the area of the α-Monocerotid were recorded by 5 observers. On condition that they effectively belonged to the α-Monocerotid meteor shower, their average ZHR was 3.6.

The peak itself was observed in Kojšovská hoľa ($\lambda = 20°59'39''$ E, $\varphi = 48°47'00''$ N, $h = 1246$ m, observers: Vladimír Hrušovský, Jaroslav Gerboš, Pavol Rapavý; limiting magnitude 6.3) and in Rimavská Sobota ($\lambda = 20°00'24''$ E, $\varphi = 48°22'28''$ N, $h = 210$ m, observers: Katarína Kerekešová, Miloš Socháň, limiting magnitude 5.9).

The frequency in the first half of the night was low: as few as 4 α-Monocerotids were registered at Kojšovská hoľa during 4.5 hours of effective time; until 1^h00 UT, none had been registered in Rimavská Sobota. However, soon after 1^h00^m UT the situation began to change.

A big increase in activity was recorded from 1^h11^m UT (the beginning of an observing interval in Kojšovská hoľa) (Figure 1). There were 498 α-Monocerotids recorded till 01^h49^m UT. During the next 20 minutes the activity gradually decreased to the standard level, 25 α-Monocerotids were recorded. Three observers saw only 11 meteors altogether in the next 4.41 hours' interval, which almost corresponds to the usual value.

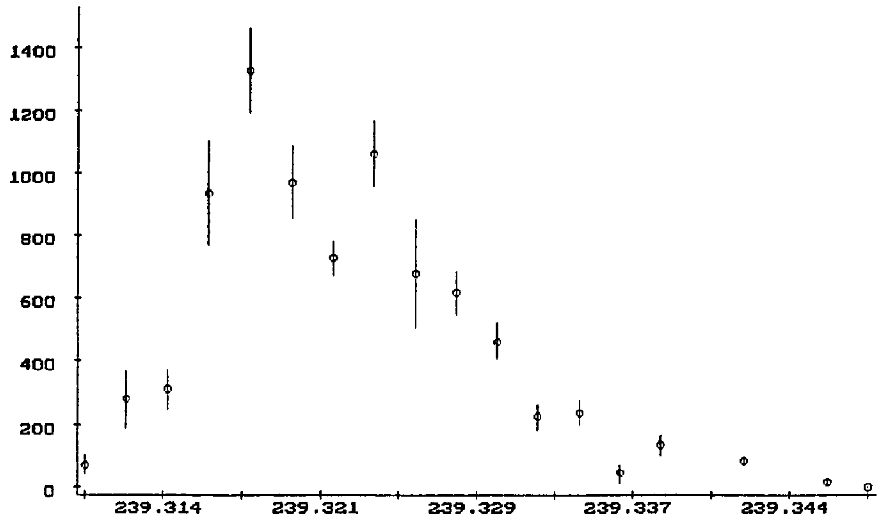

Figure 1 – ZHR during the α-Monocerotid peak. In order to smooth the curve, a step of 0°002 of solar longitude was used.

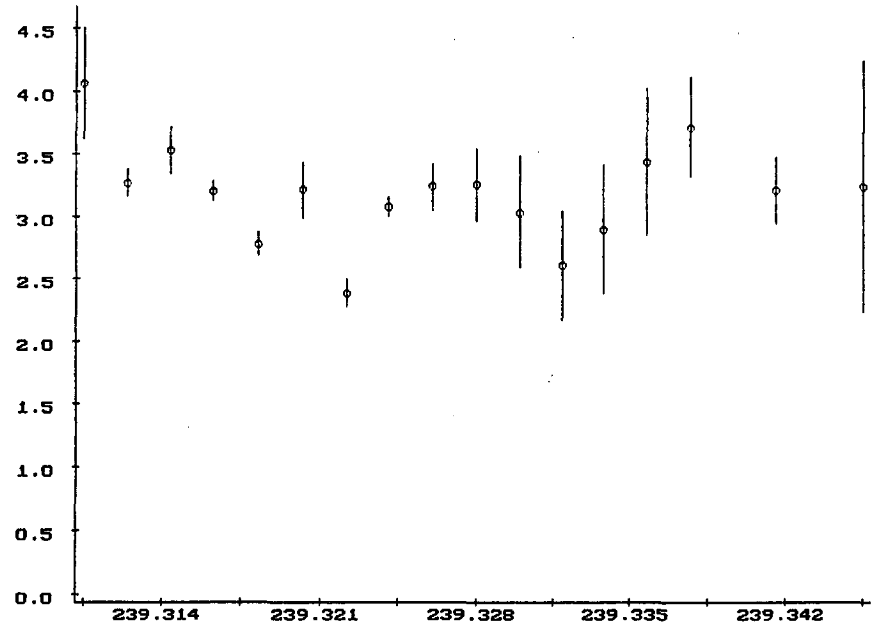

Figure 2 – The profile of the reduced mean magnitude during the α-Monocerotid peak in 1995.

There were 156 α-Monocerotids recorded in Rimavská Sobota between $1^{h}10^{m}$ UT and $1^{h}40^{m}$ UT. The rest of the time (till the end of the observation, 4.43 hours of effective time) only 4 α-Monocerotids were recorded. Despite the small number of observed meteors the results confirm the observations from Kojšovská hoľa.

The meteors were mostly faint (Figure 2), fast, and colorless. According to the meteors observed in the vicinity of the radiant, its location was determined to be at $\alpha = 113°$, $\delta = -3°$, just northwest of the position given by the *IMO*, the radiant being relatively compact.

The observations in Kojšovská hoľa were recorded on a small portable cassette recorder with an external microphone, using a "talking" clock. The subsequent processing enabled the times that the meteors had fallen in the sky to be specified with better than 5-second accuracy. The specification of the times that the meteors had fallen in the sky was used for study of the non-random distribution of the particles in a stream. The record in Rimavská Sobota was made on a small portable cassette recorder, using a light clock. The Leonids and the Northern and the Southern Taurids were recorded too, besides the α-Monocerotids.

Conclusions

The observed numbers of α-Monocerotids and the reduced frequency for both groups are stated in Table 1. The ZHR of the group in Rimavská Sobota is affected more strongly by the lower limiting magnitude. Our observations correspond with observations in the Czech Republic pretty well, but they do not correspond with results [8,9], where the ZHRs are significantly lower.

The comparison of the results with a sufficient number of records does not point to significant fluctuations in frequency with geographic longitude [9,10].

The overall result (for 3-minute intervals and population index $r = 2.7$) is as follows: the primary peak took place at $1^{h}22^{m}$ UT (solar longitude $\lambda_{\odot} = 239\overset{\circ}{.}317$, eq. 2000.0) with a reduced frequency of 1326 ± 132 and the secondary peak at $1^{h}34^{m}$ UT with a reduced frequency of 1063 ± 102 (solar longitude $\lambda_{\odot} = 239\overset{\circ}{.}324$, eq. 2000). The activity of the shower was characterized by an intense increase, a significant double peak and a slower decrease to the level of the sporadic background (Figure 1).

Table 1 – Numbers of meteors, ZHR, and number of observers (after 1^h00^m UT).

Min	Kojšovská hoľa			Rimavská Sobota		
	N	ZHR	Obs	N	ZHR	Obs
11	1	47	3	1	102	2
12	2	93	3	0	0	2
13	0	0	3	0	0	2
14	12	557	3	6	607	2
15	6	278	3	6	606	2
16	3	139	3	4	403	2
17	11	508	3	1	101	2
18	6	275	3	0	0	2
19	34	1565	3	0	0	2
20	11	505	3	2	200	2
21	16	734	3	4	400	2
22	40	1832	3	10	998	2
23	25	1143	3	8	797	2
24	22	1005	3	6	597	2
25	14	638	3	18	1788	2
26	21	956	3	0	0	2
27	29	1319	3	8	792	2
28	15	681	3	4	396	2
29	19	861	3	8	790	2
30	14	634	3	8	789	2
31	26	1176	3	12	1182	2
32	21	949	3	10	983	2
33	13	586	3	6	589	2
34	29	1307	3	14	1373	2
35	3	135	3	0	0	2
36	13	584	3	1	98	2
37	18	808	3	7	684	2
38	10	449	3	5	488	2
39	11	493	3	6	585	2
40	11	492	3	1	195	1
41	9	402	3	0	0	1
42	6	268	3	0	0	1
43	3	139	3	0	0	1
44	6	267	3	0	0	1
45	6	267	3	0	0	1
46	7	311	3	0	0	1
47	3	133	3	0	0	1
48	2	87	3	0	0	2
49	0	0	3	0	0	2

Table 2 – Magnitude distribution (Kojšovská hoľa) between 1^h11^m and 1^h50^m UT.

Magnitude	−2	−1	0	+1	+2	+3	+4	+5	Tot	$\overline{m}$
α-Monocerotids	3	9.5	21.5	53.5	95	173	169.5	17	542	2.79

The profile of the mean magnitude (Figure 2) points to fluctuations in brightness around the peak which correlate with the ZHR profile: the brighter meteors were observed in the peaks. However, our mean magnitude results do not correspond with the results of other observers who state a higher share of brighter meteors [9]. The magnitude distribution for the group in Kojšovská hoľa is in Table 2.

As a final remark, we mention that a few meteors from the area around the star ζ Orionis ($\alpha = 87°$ and $\delta = 0°$) were recorded, too.

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SPA Meteor Section Results: January–February 1996

Alastair McBeath

A very brief report on the visual, photographic, and radio data submitted to the *SPA Meteor Section* during January and February is presented. With European sites enduring one of their cloudiest winters on record from recent times, mainly due to a large blocking area of high pressure over Scandinavia, observing totals were generally low, but the Quadrantid maximum was confirmed as occurring around January 4, 4^h–5^h UT ($\lambda_\odot = 283.^\circ16$, eq. 2000.0) by radio observations.

1. Introduction

Overall, 125 hours of visual observations were reported to the Section during January and February, with 708 meteors seen, the vast majority of these being sporadics. In addition, 564.7 photographic hours were recorded by the *Arbeitskreis Meteore* (*AKM*) all-sky camera operations in Germany, with one trail detected to date, and 96 hours of continuous radio monitoring between January 2 to 6 was received from Illka Yrjölä in Finland (data supplied by Norman Fitch of the *Radio Society of Great Britain*).

The visual observers included (UK, where not stated):

> *AKM* members (Germany, data summaries provided by Jürgen Rendtel), Shelagh Godwin, Jonathan Horner, Marin Plater, Graham Wolf (New Zealand, including data from the *NZ Fireball Network*).

2. January

No visual Quadrantids were observed at all, thanks to the combined effects of poor weather and Full Moon on January 5, but Illka Yrjölä's radio results showed a marked enhancement in echo counts and durations at 4^h–5^h UT on January 4, a near-perfect coincidence with the *IMO*'s predicted visual peak based on the 1992 return at $\lambda_\odot = 283.^\circ 16$ (eq. 2000.0). This tends to support the view that the possible mass sorting of Qusdrantids within the shower thought to make the radio peak fall up to 14 hours ahead of the visual one, did not occur in 1996. Lessening activity was detected until about 14^h UT on January 4, although there is a very marked drop in echo counts between 7^h and 9^h UT, which gives the impression of a double peak, but is probably just the result of the antenna's direction. A similar effect during the minor enhancement of the strengthening Quadrantid activity the previous day at this time is also seen, for instance.

Weak δ-Cancrid activity was noted in late month by several watchers, along with relatively substantial rates of α-Crucids by Graham Wolf, around January 18-19 (observed activity averaging 3–5 meteors per hour in limiting magnitude +6.5 skies). Graham enjoyed some excellent skies by contrast to his European colleagues, and made 32.5 hours of visual observations as a result. By comparison, many UK observers reported only one partly clear night all month!

3. February

The main showers of the month, albeit none with observed activity much above 2–4 meteors per hour, were the Virginids (49 meteors seen), δ-Leonids, and α-Centaurids, most of the latter two sources represented primarily in Graham Wolf's data, with a magnificent 78 visual hours during February, although even he often struggled with poor sky limiting magnitudes. Sky conditions over Europe improved marginally, with several observers enjoying one or two better nights, but observing tallies north of the equator were kept generally low.

4. Acknowledgment

With such unhelpful weather, which, along with moonlight, can be beaten for the major showers at least by radio observations, as shown for the Quadrantids, I am especially grateful to the observers who have supported the Section during this lean spell, including the unnamed casual witnesses who managed to spot most of the nine fireballs notified to us during the session. The better skies are clearly saving themselves for later in the year!

SPA Meteor Section Results: March–April 1996

Alastair McBeath

Some notes based on data presented to the *SPA Meteor Section* from March and April, 1996, are given and discussed. The most notable events occurred during April, with an interesting Lyrid return that seems to have produced a somewhat longer maximum than normal, albeit with perhaps rather variable rates from hour to hour, on April 21-22, and two further spectacular fireballs, one occurring during daylight on April 25, both seen from North Island, New Zealand.

1. Introduction

March produced very poor sky conditions across the UK, and even elsewhere in Europe, many observers reported a lack of observing opportunities. This was a particular problem for those trying to spot Comet Hyakutake, at its best towards the end of March, and several correspondents have commented on not even seeing the comet, let alone any meteors! April brought generally better conditions, although British watchers again found few observing opportunities, even with the added incentive of a Moon-free Lyrid peak in the second half of the month. Table 1 has details of the observing totals achieved.

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

Month	Visual	VIR	LYR	GNO	ETA	Meteors	Photo	Trails
March	$110^h.06$	111	–	111	–	660	$236^h.17$	0
April	$138^h.61$	42	361	–	25	1334	$334^h.69$	2

April also brought further contributions from two radio observers, Robert S. White in England and Illka Yrjölä in Finland (his data reported by Norman Fitch of the *RSBG*), a combined total of 479.5 hours of monitoring, Illka operating his system for 96 hours across the Lyrid peak, Robert running continuously from April 15 to May 1.

Most of the photographic work was carried out by the all-sky cameras of the *Arbeitskreis Meteore* (*AKM*) team in Germany, but the only trail captures reported so far are two meteors, one a Lyrid, by Vasile Micu in Romania.

The visual observers included

> members of the *AKM*, notably Jürgen Rendtel and Janko Richter (Germany), Eva Bojurova (Bulgaria), Jay Brausch (North Dakota, USA), Trevor Law (England), Alastair McBeath (England), Vasile Micu (Romania), Gelu-Claudiu Radu (Romania), Valentin Velkov (Bulgaria), and Graham Wolf (New Zealand).

2. March

The majority of data for this month came from one observer, Graham Wolf in Wellington, New Zealand, who reported 107 hours of visual watching to us. He detected rates from several showers invisible to northern hemisphere viewers as well as noting a healthy level of Virginid activity. The best minor shower rates he saw were from the γ-Normids, which produced a peak around March 13-14. Unfortunately, few plotted trails could be added to the Section's project on the Virginid showers, thanks mainly to the conditions, with only 15 possible Virginid meteors to be combined with those few recorded earlier in 1996. Past experience shows this is to be expected from time to time, partly why an extended monitoring program over several years is necessary for covering minor shower complexes like this.

3. April

With the struggle against unhelpful sky conditions continuing, it is not surprising that most results centered on the Lyrid maximum. Visual observers fortunate in getting some clearer skies recorded rather variable Lyrid activity on April 21-22, with mean peak ZHRs for the night as a whole of about 17 ± 3. This is marginally above their usual level, but the spread of ZHR values from reliable observers under better skies (limiting magnitude at least $+5.5$, less than 20% cloud cover) was significantly greater than expected, between about 30 ± 6 and about 10 ± 2. There are moreover indications that the ZHR level was also varying from hour to hour, at times quite surprisingly, a facet of this year's Lyrid return first highlighted by Rainer Arlt and Jürgen Rendtel [1,2].

Both radio observers detected good activity from the Lyrids for rather longer than normal too, between 0^h and 8^h UT (Illka) or 2^h and 10^h UT (Robert—his results from near the Lyrid peak are shown in Figure 1) on April 22. This impression is borne out in comparing Lyrid rates European observers obtained from Bulgaria and Romania in the east (ZHRs around 15–20 at 22^h–23^h UT on April 21) right across to those from the USA (ZHRs still around 15–20 by 9^h–11^h UT on April 22).

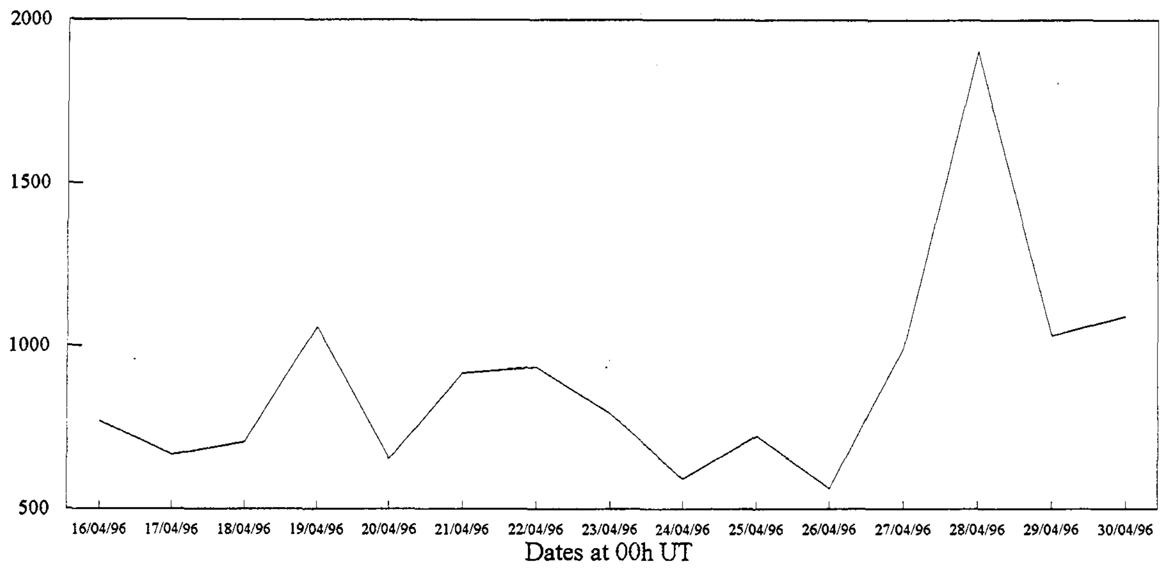

Figure 1 – Raw hourly radio meteor echo counts around the 1996 Lyrid maximum. Data obtained by Robert S. White. The unusually sharp "spike" around 10^h30^m UT on April 21 resulted from a burst of echoes of unknown origin primarily in one ten-minute period from 10^h30^m to 10^h40^m UT, and may possibly be interference of some kind. However, Illka Yrjölä's results show an identical "spike" at about 10^h–11^h UT on this date, so a meteoric event of some kind may be more likely. The "spike" at around 8^h00^m UT on April 23 also shows up in both sets of data.

Magnitude distributions for the Lyrids and April sporadics seen under better skies are given in Table 2. Too few observers reported full details of all the trains seen to make a sensible analysis of them too, but the train proportions for the Lyrids and sporadics respectively were 47% and 9%.

Table 2 – Global magnitude distributions, including mean limiting magnitude and corrected mean magnitudes for the Lyrids and April sporadics seen in good sky conditions.

Shower	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$	Tot	$\overline{\mathrm{Lm}}$	$\overline{m}_{6.5}$
Lyrids	11	12	15.5	43	48	44	38	26.5	11	249	6.32	1.5
Sporadics	4	3	6.5	23	36.5	57.5	78	86.5	158	453	6.25	3.74

As already mentioned, Robert White's radio coverage spanned the entire second half of the month, and a graph showing his raw daily counts for this period can be found as Figure 2. The Lyrid activity's effects on the graph can be seen primarily from April 21–23, but the peak on April 19, and especially that around April 28, are of unknown origin. Two daylight meteor streams, the April Piscids (peak April 20) and δ-Piscids (peak April 24) are both active around these times, but neither is noted for its rates. The April 28 "event" lasted from 05^h30^m to 12^h20^m UT, with the very highest activity from 11^h50^m to 12^h20^m UT, though it is interesting that activity often showed a peak around 09^h–10^h UT on many days around this time, perhaps suggesting an artificial source, or, potentially, a previously undetected shower. A third possibility is that the activity may have been an early Sporadic-E event. April usually sees the start of the Sporadic-E "season" from Britain, for instance. Other radio data from around this period would naturally be very welcome in examining this aspect further.

A number of reasonably bright fireballs, magnitudes from -3 to -7, were reported to the Section during April, especially near the Lyrid peak, but two events over New Zealand outstripped all of these.

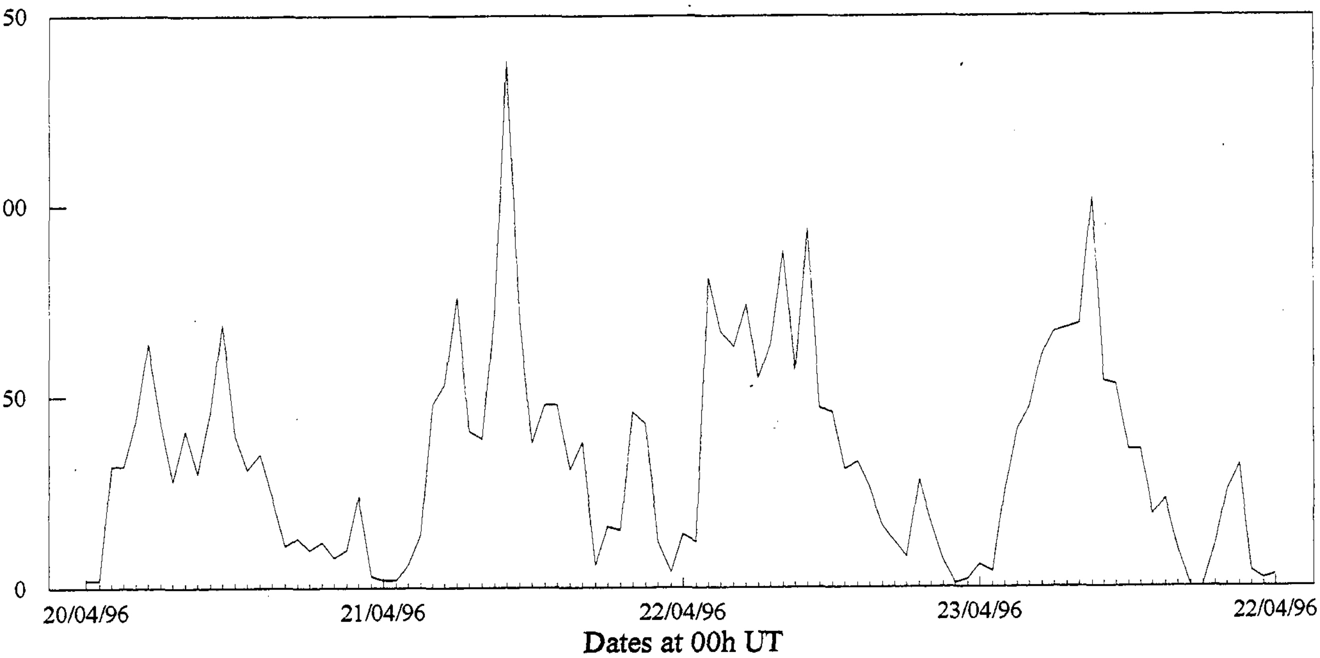

Figure 2 – Raw daily radio meteor echo counts from data produced by Robert S. White during April, 1996. For discussion, see text.

The most spectacular was seen in daylight over North Island at $2^h20^m12^s$ UT on April 25. Graham Wolf was one of the few people lucky enough to see the meteor.

Most of the ten sightings received so far have been of its persistent train (which may have been a dust train, bearing in mind when the event occurred and the train's persistence in the daylit sky), which lasted for 28 minutes, distorting and drifting across the First Quarter Moon while it lasted.

The event itself was of about magnitude −20, comparable to the superb fireball that ended near Sunderland, north-east England, on July 28, 1995 [3], and like that event, the New Zealand fireball produced acoustic shock waves over Wellington and elsewhere within a few minutes of its occurrence. No simultaneous sounds were detected from it, however.

Graham managed to secure some photographs of the object's train, and he has now been able to confirm that splashdown of any meteorites would have been about 20 km out to sea in the Cook Strait.

The second major New Zealand fireball was a magnitude −10 to −14 meteor, that was seen from around 20 locations again on North Island. It took place in the evening sky between 6^h40^m and 6^h50^m UT on April 27.

Acknowledgment

As usual, my heartiest thanks go to all contributors and correspondents for their efforts in viewing and reporting the meteor activity represented here, and to wish them all the very best, and clearer skies, for their future endeavors.

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The International Meteor Organization

Council

President: Jürgen Rendtel, Gontardstraße 11, D-14471 Potsdam, *Germany*,
tel. 49 (331) 960 727, e-mail: jrendtel@.aip.de

Vice-Pres.: Alastair McBeath, 12A Prior's Walk, Morpeth, Northumberld. NE61 2RF, *Engl.*,
tel. 44 (1670) 518 487

Secretary-General: Paul Roggemans, Pijnboomstraat 25, B-2800 Mechelen, *Belgium*,
tel. 32 (15) 41 12 25

Treasurer: Ina Rendtel, Gontardstraße 11, D-14471 Potsdam, *Germany*,
tel. 49 (331) 960 727, e-mail: jrendtel@aip.de
postal (giro) account number: 5472 34-107
post office code: 100 100 10 Postbank D-10916 Berlin
(post office code and postbank to be mentioned together with account number!)

Other council members:
Godfrey Baldacchino, "Sirius," Triq-Il-Migbha, ZBR 10 Marsascala, *Malta*
Peter Brown, Dept. of Physics, Univ. of Western Ontario, London, *Ont., N6A 3K7, Canada*
Marc Gyssens, Heerbaan 74, B-2530 Boechout, *Belgium*
Ralf Koschack, Innere Oybiner Straße 12, D-02763 Zittau, *Germany*
Graham Wolf, Capital City Lodge, 82-88 Hanson St., Newtown, Wellington, *New Zealand*

Commission Directors

Visual Commission: Rainer Arlt, Brandenburger Straße 7, D-14467 Potsdam, *Germany*,
e-mail: 100114.1361@compuserve.com

Telescopic Commission: M. Currie, 25 Collett Way, Grove, Wantage, Oxon. OX12 0NT, *Engl.*,
e-mail: mjc@ast.star.rl.ac.uk

FIreball DAta Center: André Knöfel, Saarbrücker Straße 8, D-40476 Düsseldorf, *Germany*,
e-mail: starex@tron.gun.de

Photographic Commission: Marc de Lignie, Prins Hendrikplein 42, NL-2264 SN Leidschendam
the Netherlands, e-mail: M.C.deLignie@research.kpn.com

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Editor-in-chief: Marc Gyssens, tel. 32 (3) 455 68 18, e-mail: gyssens@wins.uia.ac.be
fax: 32 (11) 26 82 48 (mention "for Marc Gyssens")

Addresses of authors not mentioned above

S. Molau, Straße 246 nr. 16, D-13086 Berlin, *Germany*
C. Verbeeck, Kontichstraat 3, B-2650 Edegem, *Belgium*
D. Koschny, Auf der Klappe 2, D-37154, Northeim-Bühle, *Germany*
V. Lukic, Save Vujanovica 39, YU-14000 Valjevo, *Yugoslavia*
M. Davis, 7304 Doar Road, Awendaw, *SC 29429, USA*
A. Olech, Warsaw Univ. Astr. Obs., Al. Ujazdowskie 4, PL-00-478 Warszawa, *Poland*
Jordanian Astr. Society, P.O. Box 35022, Amman, *Jordan*
M. Weber, Verdunská 19, CZ-16 000 Praha 6, *Czech Republic*
M. Beech, Astronomy Dept., Univ. of Western Ontario, London, *Ont. N6A 3K7, Canada*
T. Cooper, P.O. Box 14740, Brendell 1623, Kempton Park, it South Africa
Y. Shigeno, 2024 Kizukisumiyoshi-cho,Nakahara-ku, Kawasaki-shi, Kanagawa-ken, 211, *Japan*
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