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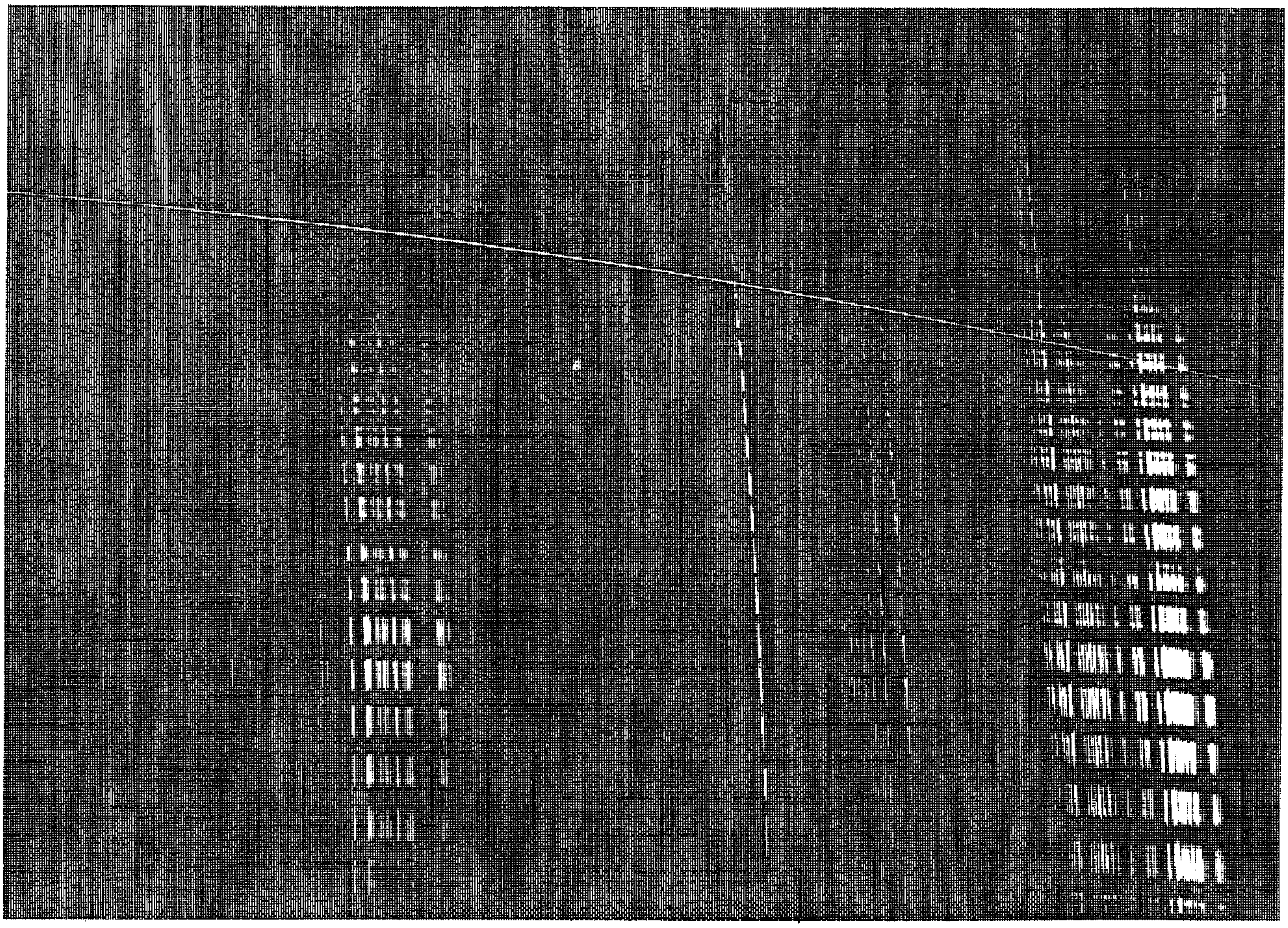

Grating spectrum of more than half of the trajectory of the EN220495 "Kouřim" fireball as photographed at Ondřejov Observatory ($f = 360$ mm, $f/4.5$, 15 shutter break per second). The entire first order spectrum and part of the second order spectrum are visible.

In this issue:
- Practical information for all observers
- A small meteor outburst on June 15-16?
- Computer-based meteor search
- The zodiacal light

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Contents

Useful Information

The October Issue *(WGN 24:5)*

The *October issue* will be mailed in the beginning of October. Contributions are due on September *6* 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

Hopefully, this (northern hemisphere) summer provides you with plenty of opportunity to observe! Contrary to previous years, we have chosen not to wait for the Perseids to complete the August issue in order to stay on schedule as promised, so we cannot tell you yet what has happened in 1996; actually, some of you will receive this issue even before the Perseid maximum. As we anticipate a lot of articles on your summer observations, we decided it was a better idea to make the October issue rather than the August issue a thick one. If you want your contribution to be included in this thick October issue, please make sure it reaches us by Friday, September 6, at the very latest! Meanwhile, enjoy this issue!

Letters to WGN

compiled by Marc Gyssens

On the magnitude of the 1996 Leonid outburst and the role of the IMO

We received two letters by Marco Langbroek in reply to Jürgen Rendtel's and Paul Roggemans's answers to Marco's initial letter in the February-April issue. As these new letters are very long, we have taken the liberty to shorten them.

My letter on the 1996 Leonid rates [1] seems to have sparked some controversy [2,3], as did Peter Jenniskens's original statements [4].

Rendtel goes into depths with his arguments. His reply is quite "matter of fact" and—though it focuses on the wrong topic!—thorough. Roggemans, however, takes an emotional approach. Nevertheless, both fail to address the *central point* in Jenniskens's argument: the 1996 Kitt Peak observations by Milon c.s., which are the primary source of the idea that the 1996 Leonids showed peak ZHRs in the order of 150 000, show an odd jump in the ascending and descending slopes (see Figure 1 in my original letter) which is *not present in the radar data* (regardless of how one interprets them in terms of absolute levels) and which *coincides with a change in observational techniques*! This certainly warrants doubt on the reported peak levels, and I would have preferred Rendtel and Roggemans to address *this* issue instead of circumnavigating it and drowning it in a host of other, less relevant, arguments.

Rendtel adds a lot of arguments which might seem impressive, but which are in fact no more than what Lewis Binford once called "post-accommodative arguments." The question he *should* have addressed is the following: *why* should photographic and other data result in corroborative evidence for the "high" figures if the *original source* of those "high" figures shows *inconsistencies* which are certainly *suspicious* (the jumps in rates coincide with changes in observational techniques!) and not easy to overcome. Said differently: how is it possible that other studies confirm the high rates reported by Milon c.s., while there is significant reason to believe that the Milon results are not correct... It is the fact that scholars for years have so vividly *agreed* on the 150 000 figure (and continue to vividly support it) despite the inconsistencies present in the study that is the basis for these high figures, which makes the whole issue of the 150 000 rates mythical.

The problem with "post-accommodative arguments" like those presented by Rendtel is that they usually are of little value unless the central issue is dealt with first. The only argument which comes near is Rendtel's allusion to a very steep "α-Monocerotid-like" increase in rates. However, putting aside the point that according to us [5] the increase in α-Monocerotid rates was by far not as "sudden" as either presented by Rendtel [2,6] or the "increase" (I prefer the word "jump") in Leonid Rated as presented in the Milon report, the slope of activity after the "jump" occurred (and before the "jump" back to lower levels) has a character that questions such an explanation. It is a sudden *jump*, not a profound *steepness*, like in the case of the α-Monocerotid profile after a certain moment. In between the two jumps, the profile steepness is actually quite similar to the slope of the "main peak" structure before and after the jumps [4]! In addition, Rendtel's argument does not tackle the fact that the jump to higher levels, and then back, occurs—oh, what a coincidence!—at the moments of a change in observational techniques, which makes it suspicious—the more since it is so unusual [4].

The other arguments put forward by Rendtel are not difficult to dispose of, and are of little relevance, since, let me stress again, they do not dispose of the core problem in the debate. Rendtel's grappling with photographic data, for example, is flawed in several aspects. Photographers, if not magazine editors, tend to come up with their best pictures only. The Kitt Peak photographs were taken with rather short exposure times. We all know that meteor rates follow a Poisson distribution: i.e., short periods with little activity are followed by flurries of meteors, and that is a statistical effect, not real variations in rates. This effect does not stop when rates come near 15 000. Short exposures, or counts in short intervals, suffer from these statistics. For the very same reason, the simple calculation that a ZHR near 15 000 implies "only" 4 meteors per second while observers reportedly saw multiples of this number is flawed. The "4 meteors per second" are an *average*, and in reality amount to many meteors per second followed by short spells of (relative) absence of meteors. Of course, it will be those spells with abundant meteors that will primarily be remembered by the observers. To paraphrase Rendtel, "I guess there are a lot of problems to the question if this can be distinguished," especially if we take into account the general ignorance of people to this fact.

As for Roggemans's comments, I will be clear. I strongly advise him to first read a letter before issuing a reply. The answer to his question "for what scientific reason should 40 meteors per second be excluded," is actually given in my initial letter: accurately noting 40 (moving!) objects within a second is impossible, as attested by research now known for several decades. In addition, it is all but scientific to take every report at face value, especially if research in psychology and physiology suggests that a report ventures into the impossible.

[1] M. Langbroek, *WGN* 24, 1996, pp. 2–4.

[2] J. Rendtel, *WGN* 24, 1996, pp. 4–5.

[3] P. Roggemans, *WGN* 24, 1996, p. 79.

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

[5] P. Jenniskens, H. Betlem, M. de Lignie, and M. Langbroek, "Meteor Bursts as Guides to Long Period Earth-Threatening Comets—The α-Monocerotid Example", *submitted*, 1996.

[6] J. Rendtel, "α-Monocerotid Activity Burst on November 22", *WGN* 23, 1995, pp. 200–203.

Marco Langbroek, June 11, 1996

My letter on the 1996 Leonid rates [1] seems to have sparked controversy [2,3], not only as far as the discussion on the 1996 Leonid rates is concerned, but also my casual remark on the (lack of) incorporation of discussions on other than *IMO* data in the new *IMO* Visual Handbook. In this second and separate reply, I will address the issue of the (lack of) inclusion of other than *IMO* data in comprehensive *IMO* works on meteor stream activity. Unlike in the case of the "Leonid debate," I am a little bit hesitant to do so, because this is a *political* issue with little direct (but considerable indirect!) relevance to the accumulation of knowledge in the field of meteor astronomy.

Rendtel's reply is clear and fair in its content, though I do not agree with all his statements. I was shocked however by the comments of Roggemans, whose attitude I find outrageous.

I accept Rendtel's defense as he assures me that it was not their intention to compare or evaluate results of shower analysis obtained by various groups. Of course, authors are free in deciding what their intentions are. But from my point of view, I just regret that they choose (or rather do not choose) for this particular intention. Incorporating discussions on independent analysis would have made their contribution just more significant and valuable. Incorporating independent analytical results would have strengthened their case, something of which also the "average *IMO* observer" would have benefited: he would have been supplied by a multivoiced body of information.

Contrary to Rendtel, I do not see a serious problem concerning data gathered on a "non-global" scale. By combining data from several years, reliable activity profiles can be constructed, and even single year "non-global" data can fit in well in a comparison. And be honest: even gathered *IMO* data is seldom fully "global" due to an uneven distribution of observers around the world and the very same conditional factors mentioned by Rendtel.

Two years ago, we issued a large comprehensive review of stream activity data gathered over the years by *DMS* and *NAPOMS* [4]. These consist of a discussion and presentation of *continuous* activity profiles of some 50 streams. For some streams, e.g., the December Monocerotids, our article includes the very first activity profiles ever published. And for benefit of the reader of *WGN*: yes, this article *does* include a comparison with and discussion of analytical results of other groups, including the *IMO*. Moreover, for the benefit of Jürgen Rendtel and the reader of *WGN*: this article does include information on the radiants used (and many more). For the benefit of Paul Roggemans: *Astronomy and Astrophysics* is a widely read *professional* (scientific) journal. Therefore this analysis is certainly *available*, in the library of almost every astronomical institute, and in order to be accepted articles in such journals must include an elaboration of the reduction procedures used: contrary to Roggemans's assertions, the analytical results are certainly *verifiable* by the very means of the scientific character of the article and journal in which they are presented.

Contrary to what Rendtel argues, such analysis can certainly be used in a comparative and constructive way. This is actually shown in a contribution to the very same issue of *WGN* that bore my letter and Rendtel's reply: my paper on the 1993 Leonids [5]. The accompanying figure in that paper shows annual Leonid activity taken from an analysis by Jenniskens [6], which consists of combined analytical results of *DMS*, the *IMO* and the *NMS*. In addition, I would like to point out that the used analysis of annual Leonid activity presented by Masahiro Koseki (*NMS*) in *Meteoroids and their parent bodies* [7] is another example of a useful analysis available (at least for comparative purposes) in scientific literature. Furthermore, many analyses have been published in the journals of several "local" organizations like the *BAA*, *NMS*, *NAPOMS*, and *DMS*. Though not so widely distributed as scientific journals—but there are some notable exceptions to this rule!—these *are* available: the survey and activity profiles presented in [8] for example are in many cases based on reports in such journals. Occasionally, "locally" gathered data are even presented in well-available books, like Neil Bone's recent book *Meteors* (published by the Sky Publishing Corporation).

Having addressed some issues raised by Rendtel (I hope he will find my comments constructive: this is the way they should be taken), I would like to reply to the letter of Roggemans [3], a characterization of which I already issued above.

I have been raised in an educational environment with a strong emphasis on the philosophy of science and a firm believe that progress in scientific knowledge benefits most from a multivoiced environment. The *IMO* can (and to some extent does) contribute to such an environment by offering amateurs an international forum to such a multivoiced environment (*WGN*). By bringing together *independent* analyses, contrary to the highly centralizing, or monopolizing, approach as advocated by Roggemans, this will be the way to build a stronger relationship between amateurs and professionals in meteor astronomy, and between different groups of amateurs: the strength and promise in meteor astronomy is in different, independent views being developed through independent analysis and their interactive discussion, often based in *regional* initiatives (like the Leonid/α-Monocerotid campaign organized by the *DMS* in cooperation with *SOMYCE* last year [9–12]. This leads to a "fruitful disagreement," a true scientific climate, at least as long as an exchange of ideas is possible. As far as Paul Roggemans's attitude is concerned, this seems not the case [3].

At this moment, some fascinating new thoughts are being developed, especially on the topic of meteor outbursts, outside the *IMO* context (e.g., [8,9,13]). In the future, I will continue my efforts to contribute to the construction of a multivoiced environment in my contributions to *WGN* by bringing in those "outside views" developed in a *DMS* (and other) context. I am sure *WGN* and its readers will benefit, the *IMO* will benefit, and who knows, maybe even Paul Roggemans might benefit.

[1] M. Langbroek, *WGN* 24, 1996, pp. 2–4.

[2] J. Rendtel, *WGN* 24, 1996, pp 4–5.

[3] P. Roggemans, *WGN* 24, 1996, p. 79.

[4] P. Jenniskens, "Meteor Stream Activity I. The Annual Streams", *Astron. Astroph.* 287, 1994, pp. 990–1013.

[5] M. Langbroek, "On the 1993 Leonid Meteor Activity", *WGN* 24, 1996, pp. 46–50.

[6] P. Jenniskens, "Meteor Stream Activity III. Measurement of the First in a New Series of Leonid Outbursts", *Meteoritics and Planetary Science* 31, 1996, pp. 177–184.

[7] M. Koseki, "Leonid Observations in Japan", in *Meteoroids and their parent bodies*, J. Stohl and I.P. Williams (eds.), 1993, pp. 173–176.

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

[9] P. Jenniskens, H. Betlem, M. de Lignie, and M. Langbroek, "Meteor Bursts as Guides to Long Period Earth-Threatening Comets—The α-Monocerotid Example", *submitted*, 1996.

[10] M. Langbroek, "Visual observations on the 1995 Leonid meteor outburst", *in preparation*, 1996.

[11] H. Betlem, "High Precision Photographic Orbits of the 1995 Leonid Shower", *Asteroids, Comets, and Meteoroids*, Versailles, France, July 8–12, 1996, *proceedings in press.*

[12] *Radiant* 17, 1995, pp. 123-155.

[13] P. Jenniskens, "Meteor Stream Activity IV. Meteor Outbursts and the Reflex Motion of the Sun", *Astron. Astroph.*, in press.

Marco Langbroek, June 12, 1996

Comment by the Editor-in-Chief: *I do not wish to comment on whether or not the* IMO *Visual Handbook should have contained comparative analyses, but as principal author of the* IMO *Constitution, I feel the necessity to clarify a few points.*

A lot of valuable amateur work on meteors in the past has either been lost or cannot be used to its full potential because of lack of standardization or globalization. It is this simple fact that lays at the foundation of the IMO. *Thus, the main goals of the* IMO *are central archiving and dissemination of data, achieving standardization and global (i.e., around-the clock) coverage of meteor activity, and, of course, providing feed-back to observers. It was the founders' conviction that this tasks could not be executed by any of the existing organizations, because of national strive.*

From the perspective I just sketched, it must be clear that the IMO *has no intention whatsoever—and never had—to take over tasks of, let alone replace, existing national organizations with or without international contacts. Neither has there ever been any intention to duplicate work that was already done in these organizations. Therefore I find the perception expressed in the above letter incorrect: the* IMO, *by its very nature, cannot just be put on the same line as organizations such as the DMS, BAA, NMS, NAPOMS, etc.*

This last statement does not *entail a value judgment: I do not see the* IMO *"above" these organizations, but as a service to these organizations as well as to individual observers and the international meteor community at large, without any hierarchical links.*

The IMO *seeks to collect as many data as possible from around the globe, and, of course, also to analyze them to provide the feed-back the meteor community is entitled to in return. However, the* IMO *does* not *seek to "monopolize" analyzing data and makes its data available for other people or groups in the meteor community who wish to undertake such analysis, as Paul Roggemans clearly pointed out in his letter in the previous issue. Whether or not it would have been better to include comparative analyses in the* IMO Visual Handbook *is a matter of debate—it is definitely* not *an indication that the* IMO *takes analyses other than its own in lesser regard.*

In the past, there have been organizations that saw the IMO, *a multi-voiced environment by conception, as a "threat" they had to compete with rather than a service they could take advantage of. The fact that, today, most of these feelings have gone to me is proof that my perception of the* IMO *outlined above is the correct one. I can only hope that any resentments towards it that might still be left will soon fade away.*

NAMN announces Internet mailing list

The *North American Meteor Network* (*NAMN*) is now maintaining an Internet mailing list devoted to meteor observing. Any topic related to meteors or meteor observing such as call for observations, individual observational summaries, and general questions are welcome.

This is an excellent place for both beginning observers to ask questions and veteran observers to help others or add their own thoughts to the discussions. Members of the *IMO* are invited to join and participate in the list by sending e-mail to `majordomo@latrade.com`. In the text area of the message, type the text `subscribe meteorobs`.

If you have any questions or problems in subscribing, please contact the list administrator, Lew Gramer, at `owner-meteorobs@latrade.com`.

Hope to see you there!

Mark Davis, July 19, 1996

Observing with mosquitos

Whether you are observing meteors or glued to a telescope, an all-night observing run can be ruined by the presence of a few mosquitos. Sometimes, I contemplated guzzling down bottles of various repellents in a desperate attempt to rid myself of these pests... but this could prove fatal on my part. Insect repellents have varying degrees of success and I do recommend their usage. Often, somebody will recommend one brand over the other, but these are usually acquired preferences. One thing to remember about store-bought repellents is that their effect will wear off after several hours. Sometimes, we will inadvertently wash our hands and the repellent is no longer there to do its job. I have done this on camping trips in the Sierras and found myself only bitten on the hands.

Another popular item is the insect repellent coils that emit a protective vapor as they do a slow burn. With these, I think their effectiveness is mostly psychological on our part, since we are doing something active in resolving the problem.

I have recently talked to some people who are quite active campers out in the wilderness. They have given me some novel ideas that I would like to pass on.

One of them is to eat lots of garlic over a two-week period prior to any scheduled outing. You can either buy garlic tablets from a health store or just eat them raw. The advice I was given is that if you do not smell like garlic, it will not work. For those who are concerned about offending their loved ones... namely husbands/wives or boyfriends/girlfriends, you might want to get them hooked on garlic as well. Just tell them that it is good for the heart or something... I think this is true, but lie if you have to. Now, if you are a guy and have been married for some while, chances are the wife will just think it is a guy thing and let it go at that. You might want to explain it is just a temporary thing. But apparently, garlic works: after all, it has been known to ward off vampires over the ages. It is only natural that they might effect their little blood sucking cousins as well.

Another trick I was told about is the use of "dryer sheets" that you throw in with your clothes as they are dried in a dryer. There are various brands. We use "Bounce." Anyhow, these come in several square inch sheets. The idea is to pin them on your shoulders, shirt sleeves, pant legs etc. The odor in them is said to repel mosquitos. Two other bits of advice was to avoid blue and black clothing since these resemble water that attracts mosquitos.

I do not know how scientific all this stuff is, but to enjoy my observing nights, I will try anything. I am one who personally believes that the more methods used the better off one will be. So..., during the Perseids, I will probably consume a daily ration of garlic, wear sheets of "Bounce" on my red and yellow clothes, splash on copious amounts of my favorite insect repellent while I observe within a circle of burning insect coils.

George Zay, June 19, 1996

International Meteor Conference

Apeldoorn, the Netherlands, September 19–22, 1996

Registration Form

Each individual participant should fill out a form and return it to *Ina Rendtel, Gontardstraße 11, D-14471 Potsdam, Germany*, as soon as possible.

Your registration will be guaranteed only after Ina Rendtel has received the minimum pre-payment of 100 DEM. If you wish to participate, but cannot yet decide, simply return this form with the proper option checked to stay on the mailing list for further circulars.

Name: ______________________________ Birth date: ____________

Address: ____

____

____

Phone: ______________ Fax: ______________ E-Mail: ______________

- ○ wishes to register for the 1996 *IMC* from September 19 to 22;
- ○ intends to participate, cannot yet register, but wishes to stay on the mailing list.

I intend to travel by ________, together with ______________________

Additional requests:

- ○ I need to be picked up at the Apeldoorn railroad station;
- ○ I need travel information from ______________ to Apeldoorn.

For participants wishing to contribute to the program:

Lecture: ____

Duration: ________min. Required equipment: ______________________

Workshop or discussion: ______________________________________

Poster presentation: ______________________________ Space: ________ m^2

Either the entire fee of 195 DEM or a pre-payment of at least 100 DEM should be sent to the Treasurer, *Ina Rendtel*. Follow the payment instructions below. Participants paying only 100 DEM have to pay the remaining 95 DEM upon arrival in Apeldoorn.

Date and signature: ______________________________________

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

- in Europe (except the Netherlands): pay in DEM to Ina Rendtel, postal giro account number 547234107 at Postgiroamt Berlin, bank code 10010010. No bank checks, please! (Bank checks can only be sent to Peter Brown, see below).
- in the UK: proceed as above or pay to Alastair McBeath, 12A Prior's Walk, Morpeth, Northumberland NE61 2RF, England.
- in Japan: pay to Masahiro Koseki, 4-3-5 Annaka, Annaka-shi, 379-01 Gunma-ken, Japan.
- in the Netherlands: pay to the Werkgroep Meteoren NVWS, postal giro account number 4466085.
- all others pay in USD to Peter Brown, Dept. of Physics, Univ. of Western Ontario, London, Ont., N6A 3K7, Canada. In case you pay by bank check, make it payable to Peter Brown, *not* the IMO!

People wishing to pay in other currencies should contact the appropriate IMO contact person for exchange rates.

The 1996 International Meteor Conference

Apeldoorn, the Netherlands, September 19–22, 1996

Urijan Poerink

This year, the *International Meteor Conference* will be held in the city of Apeldoorn in the Netherlands.

The conference is held at a local hostel named "De Grote Beer," i.e., the "Great Bear." The organization is done by members of the Meteor Section of the *Dutch Association for Meteorology and Astronomy*, abbreviated *NVWS*.

As usual, the meeting starts on Thursday evening September 19, 1996. The conference lasts until Sunday (September 22). Details about the registration procedure can be found on the Registration Form. As usual, the fee includes lodging and a copy of the Proceedings.

Practical Meteor Photography Part III: The Rotating Shutter

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

Visual observers who plot meteors, not only determine the position of the meteor, but also estimate the (angular) speed of the meteor. The latter information facilitates the stream association and increases the reliability of radiant area diagrams obtained from plottings.

Photographic meteor trails from single station observations are used in the same way as visual meteor plots. This is why meteor photographs obtained with a camera with a rotating shutter are more valuable than meteor trails without shutter breaks. From the number of breaks, the speed of the rotating shutter and the (angular) length of the meteor trail, the angular speed of the meteor can be calculated.

For double-station photography, the use of a rotating shutter is even more important. In this case, the actual motion of the meteoroid through space and through the atmosphere is determined. The radiant is the direction of this movement; the rotating shutter information yields the speed of the meteoroid.

Finding a suitable electromotor for a rotating shutter is not so easy because there are many types of motors. The following types are useful:

- AC synchronous motors;
- bicycle dynamos; and
- DC motors.

In the sections below, the construction of a rotating shutter for meteor photography is shortly described. The *IMO Photographic Handbook* provides additional information which is worthwhile looking at.

1. AC synchronous motors

AC synchronous motors are particularly useful, because their rotation frequency is directly linked to the frequency of the AC power supply. If the 115/230 V mains voltage is used, no frequency stabilization of the motor is required, because the frequency of the mains voltage (50/60 Hz) is sufficiently stable to serve as a reliable frequency reference (of course, this does not hold if you have your own 115/230 V generator). The actual rotation frequency of the synchronous motor is then 50 (or 60) Hz, divided by some integer number. The most useful rotation frequencies are 12.5 or 25 Hz (750 or 1500 rounds per minute, RPM), but such motors are either expensive or hard to find. One exception is a synchronous motor with a frequency of 250 RPM, which has been widely used in record players. However, due to its low rotation speed, this motor is only useful for all-sky patrol cameras.

A disadvantage of AC synchronous motors is that they are directly fed from the mains voltage; see the section on safety. If you want to power a 115 V motor but your local mains voltage is 230 V, you can put a power resistor in series with the motor (see Figure 1). The resistor should have a resistance value of about 1000 to 10 000 Ω (e.g., 4700 Ω), check with your Volt meter whether the voltage drop is 115 Volt) and be able to dissipate 5 or 10 Watts of electrical power.

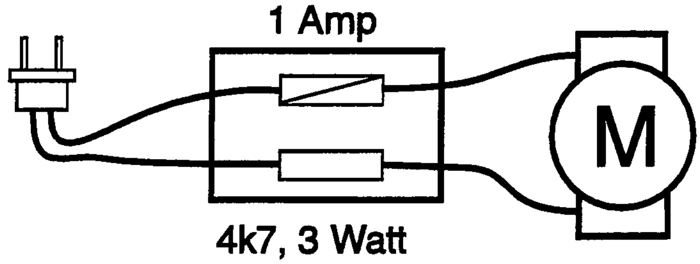


Figure 1 – Connecting a 115 V synchronous motor to the 230 V mains voltage via a resistor and a fuse in series with the motor.

Some AC motors have four power leads. In that case you should put a capacitor in series with the motor at one of the power leads (see Figure 2). The capacitor should be rated for 230 V AC or 630 V DC. The higher the capacitance value the better, but a few 100 nF (nanoFarad) may be sufficient already.

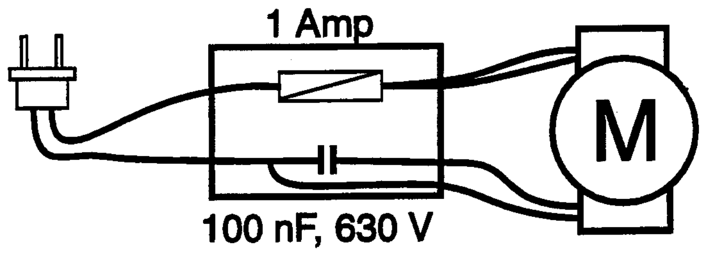


Figure 2 – Connecting a two-phase synchronous motor to the mains voltage using a fuse and a high voltage capacitor.

Be warned that many AC motors are not synchronous motors. Their rotation frequency depends on the mechanical power delivered by the motor (as in a drilling machine), so these motors are not useful for constructing a rotating shutter.

2. The bicycle dynamo

The bicycle dynamo is actually a special type of AC synchronous motor, but it is not designed to be a motor. Therefore it has some disadvantages, such as mechanical instability, low mechanical power and the fact that it does not start by itself when switched on. However, its advantages, low price, wide availability and safety, certainly outweigh the disadvantages. Therefore, if you are going to construct a rotating shutter for the first time and you have the AC mains voltage available at your observing site, I definitely advise you to use a bicycle dynamo.

The usual rotation frequency of a dynamo is 12.5 Hz, but other frequencies have been reported (see Photographic Handbook). Although many people have expressed doubts about the accuracy of dynamos, measurements have proved that they are actually very stable. If the dynamo runs noiseless, the frequency error is negligible. If the dynamo produces a lot of noise, there may be some error, but even then the contribution to the error in calculated angular speeds of meteors is always less than 1%. Causes for noise from dynamos are mechanical wear of the dynamo, an unbalanced shutter blade, or strong wind. A drop of oil, some filing of the shutter blade, or placing of a wind screen may improve the operation of the dynamo.

For powering the dynamo, you need a small transformer from 115/230 V to a lower voltage between 6 and 8 Volt. You can also use this voltage for the lens heating so that you only need one power supply. An ideal solution is a single transformer that supplies both 6–8 V and 12 V, so that the 6-8 V part can be used for the dynamo and the 12 V part for the lens heating.

3. The DC motor

The third type of motor is the DC motor. Since this motor receives no frequency reference from the power supply, this type of motor needs stabilizing electronics. Some DC motors have a large number of internal position sensors that together produce an AC signal with a frequency proportional to the rotation frequency of the motor. The stabilizing electronics can use this signal to apply the right driving voltage to the motor via some control loop.

Since DC motors suitable for meteor photography are either expensive or not generally available, no circuits for the driving electronics are provided here. You may want to consider using a DC motor if you already have a rotating shutter for your camera(s) and want to improve on the design. Within the *Dutch Meteor Society*, most camera batteries are equipped with rotating shutters using a regulated DC motor.

4. The shutter blade

The Photographic Handbook describes very well how to produce a shutter blade. Figure 3 shows the typical shape of the shutter blade. The main considerations are to use thin aluminum plate (0.5 mm) and to limit the diameter of the blade to 30 cm, if you want to have a reasonable chance to get your bicycle dynamo running. Also for more powerful motors, it is wise to limit the weight of the shutter blade, so that your fingers survive when accidentally hit by the blade.

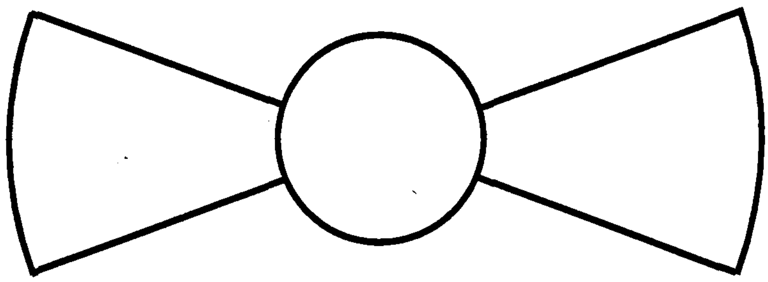


Figure 3 – Typical shape of the blade of a rotating shutter.

5. Safety

For the electrical power supply of rotating shutters, the same safety considerations apply as for the lens heating. However, it may not always be possible to avoid using the 115/230 V mains voltage for AC synchronous motors. Then be sure that it is not possible to touch any electrical contacts and that all high voltage wires are able to withstand a large pulling force.

Apart from electrocution hazards, you can also get hurt from the moving shutter blade (I can guarantee you that you cannot avoid getting hit once or twice). Therefore, be sure that the shutter blade has no sharp edges and do not make the shutter blade too heavy. When using a bicycle dynamo, the shutter blade will normally not hurt you when it hits your finger.

Acknowledgments

Much of the information presented in this article is based on work by Hildo Mostert and Hans Betlem.

Meteor Shower Calendar: October 1996–March 1997

compiled by Alastair McBeath

1. October to December

Ecliptical minor shower activity reaches what might be regarded as a peak in early to mid November, with the Taurid streams in action, but before then we have the Orionids (quite badly affected by a waxing gibbous Moon in 1996, as are the minor ε-Geminids). Of greater interest are the Leonids in November and the Geminids in December, but there are plenty of other low activity showers active, both north and south of the equator which will benefit from December's New Moon - such as the December Phoenicids, Puppids-Velids, December Monocerotids and σ-Hydrids. By contrast, the Coma Berenicids and Ursids later in December lose out to the increasingly Full Moon.

Leonids

Active: November 14–21; Maximum: November 17, 17^{h} UT ($\lambda_{\odot} = 235.^{\circ}7$);
ZHR: periodic—up to storm level, recently 15–20;
Radiant: $\alpha = 153°$, $\delta = +22°$, $\Delta\alpha = +0.^{\circ}7$, $\Delta\delta = -0.^{\circ}4$; radius: 5°; $V_{\infty} = 71$ km/s; $r = 2.5$
TFC: $\alpha = 140°$, $\delta = +35°$ and $\alpha = 129°$, $\delta = +06°$ ($\beta > 35°$ N);
$\alpha = 156°$, $\delta = -03°$ and $\alpha = 129°$, $\delta = +06°$ ($\beta < 35°$ N).
PFC: $\alpha = 120°$, $\delta = +40°$ before 0^{h} local time ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = +20°$ before 4^{h} local time;
$\alpha = 160°$, $\delta = 00°$ after 4^{h} local time ($\beta > 0°$ N);
$\alpha = 120°$, $\delta = +10°$ before 0^{h} local time;
$\alpha = 160°$, $\delta = -10°$ after 0^{h} local time ($\beta < 0°$ N)

The Leonid stream is perhaps most famous for its periodic storms occurring at roughly 33-year intervals when its associated comet, P/Tempel-Tuttle, returns to perihelion. This situation is due to happen again in the years 1998–2000, and Leonid activity showed the first signs of an increase in 1994. Bright moonlight prevented the computation of accurate ZHRs, but best estimates imply rates of around 60+ per hour. A repeat of this activity at the same time in 1996 should be best-seen by observers in the Far East and Australia. Clearly, we have the best opportunity ever to follow what further changes in the Leonids occur in the coming years more fully than has been previously possible, and to take advantage of these circumstances a special *International Leonid Watch* project has been set up with *IMO* help to coordinate world-wide professional and amateur Leonid studies. All observing methods should be pursued to ensure that no detail is missed. Data collection began in 1991, and is intended to continue into the next century.

In 1996, circumstances are very good, since the waxing crescent Moon will have set from most places well before the Leonid radiant rises (at around local midnight for most locations north or south of the equator). Data by all observing methods is required.

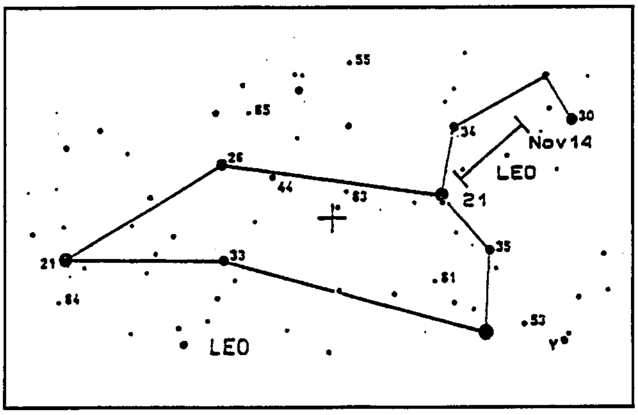


Figure 1 – Radiant positions of the Leonids.

σ-Hydrids

Active: December 3–15; Maximum: December 11 ($\lambda_{\odot} = 260°$); ZHR = 2;
Radiant: $\alpha = 127°$, $\delta = +02°$, $\Delta\alpha = +0.^{\circ}7$, $\Delta\delta = -0.^{\circ}2$; radius: 5°; $V_{\infty} = 58$ km/s; $r = 3$
TFC: $\alpha = 095°$, $\delta = 00°$ and $\alpha = 160°$, $\delta = 00°$ (all sites, after midnight only)

Although first detected in the 1960s by photography, σ-Hydrids are typically swift and faint, and rates generally low, often close to the visual detection limit. Since their radiant, just to the south-west of the "head" asterism of Hydra, a little over 10° east of Procyon (α Canis Minoris), is near the equator, all observers can cover this shower, whose peak this year is only a day after New Moon. Although the radiant rises in the late evening hours from most sites, it is best viewed after local midnight right up until dawn. All observations would be welcomed, especially those made well before the Geminids' peak, since our knowledge of the shower's early activity is very poor.

Geminids

Active: December 7–17; Maximum: December 13, 16^{h} UT ($\lambda_{\odot} = 262.^{\circ}0$); ZHR = 110;
Radiant: $\alpha = 112^{\circ}$, $\delta = +33^{\circ}$, $\Delta\alpha = +1.^{\circ}0$, $\Delta\delta = -0.^{\circ}1$; radius: 5°; $V_{\infty} = 35$ km/s; $r = 2.6$
TFC: $\alpha = 087^{\circ}$, $\delta = +20^{\circ}$ and $\alpha = 135^{\circ}$, $\delta = +49^{\circ}$ before 23^{h} local time;
$\alpha = 087^{\circ}$, $\delta = +20^{\circ}$ and $\alpha = 129^{\circ}$, $\delta = +20^{\circ}$ after 23^{h} local time ($\beta > 40^{\circ}$ N);
$\alpha = 120^{\circ}$, $\delta = -03^{\circ}$ and $\alpha = 084^{\circ}$, $\delta = +10^{\circ}$ ($\beta < 40^{\circ}$ N).
PFC: $\alpha = 150^{\circ}$, $\delta = +20^{\circ}$ and $\alpha = 060^{\circ}$, $\delta = +40^{\circ}$ ($\beta > 20^{\circ}$ N);
$\alpha = 135^{\circ}$, $\delta = -05^{\circ}$ and $\alpha = 080^{\circ}$, $\delta =$ 00°

The entire activity period is virtually free from lunar interference this year, providing a splendid opportunity to observe throughout the shower. Southern hemisphere observers suffer to a degree, as the radiant is low or below the horizon before midnight, but this is a splendid stream of often bright, medium-speed meteors, and well-rewards even these watchers. The peak has shown slight signs of variability in time and maximum rates, and the true maximum may fall a few hours before or after the time noted above. It is likely that Asian and European sites will be the better locations to view the 1996 maximum from. In terms of ZHRs, in 1993 the peak level was around 140, whereas in the late 1980s, 100 was more common. Some mass-sorting across the stream means that fainter telescopic meteor rates are at their highest almost 1° of solar longitude ahead of the visual peaks mentioned earlier, and telescopic results show these meteors radiate from an elongated region, with up to three possible sub-centers.

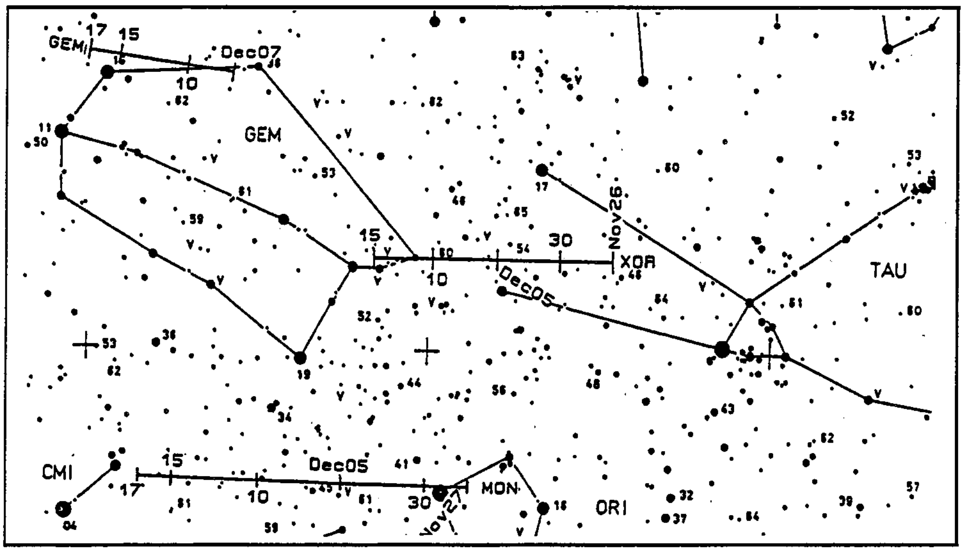


Figure 2 – Radiant positions of the Geminids and some minor showers.

2. January to March

The first quarter of the year brings primarily low activity showers, including the first of the year's main diffuse ecliptical stream complexes, the Virginids, active from late January to mid-April. The two better showers, the Quadrantids, visible from the northern hemisphere in early January, and the α-Centaurids, a sometimes good southern hemisphere shower in early February, are both free from moonlight in 1997, along with the minor δ-Cancrids in mid-January and the γ-Normids in mid-March. Two daylight radio peaks are due from the Capricornids/Sagittarids around 7^{h} UT on February 1, and the χ-Capricornids on February 13, probably around 8^{h} UT. Neither radio shower has been well-observed in recent times, and as both have radiants under 10°–15° west of the Sun at maximum, they cannot be regarded as visual targets, even from the southern hemisphere.

Quadrantids

Active: January 1–5; Maximum: January 3, 11^{h} UT ($\lambda_{\odot} = 283.^{\circ}16$);
ZHR = 120 (can vary $\sim$ 60–200);
Radiant: $\alpha = 230^{\circ}$, $\delta = +49^{\circ}$; Radiant drift: see Table 2; radius: $\sim 5^{\circ}$ at maximum;
$V_{\infty} = 41$ km/s; $r = 2.1$ at maximum, but variable
TFC: $\alpha = 242^{\circ}$, $\delta = +75^{\circ}$ and $\alpha = 198^{\circ}$, $\delta = +40^{\circ}$ ($\beta > 40^{\circ}$ N);
PFC: $\alpha = 150^{\circ}$, $\delta = +70^{\circ}$ before 0^{h} local time;
$\alpha = 180^{\circ}$, $\delta = +40^{\circ}$ and $\alpha = 240^{\circ}$, $\delta = +70^{\circ}$ after 0^{h} local time ($\beta > 40^{\circ}$ N).

The year starts well for northern hemisphere watchers, with a reasonably good return of the Quadrantids, since the Moon will be a waning crescent in eastern Virgo and western Libra on January 3-4, and will give its worst problems only late in the night. The shower's radiant lies in northern Bootes, which makes it circumpolar for many northern locations, but it attains a useful elevation for observations only after local midnight or so, and is at its highest towards morning twilight. It is an interesting challenge to try spotting the occasional long-pathed shower member from the southern hemisphere around dawn, but sensible watching cannot be carried out from such locations. The maximum time given above is based on the best-observed return of the shower ever analyzed, from *IMO* 1992 data, a repeat of which time in 1997 would be excellent news for North American watchers. The peak itself is short-lived, and can be easily missed in just a few hours of poor winter weather in the north, which may be why the ZHR level apparently fluctuates from year to year, but some genuine variability is probably present too. An added level of complexity comes from the fact that mass-sorting of particles across the meteoroid stream makes fainter objects (radio and telescopic meteors) reach maximum up to 14 hours before the brighter (visual and photographic) ones, so observers should be alert throughout the shower! Past observations have suggested the radiant is very diffuse away from the maximum, contracting notably during the peak itself, although this may be a result of the very low activity normally seen away from the hours near maximum. Photographic observations from January 1-6 would be particularly welcomed by those investigating this topic, using the PFCs given above, along with telescopic, video and visual plotting results.

δ-Cancrids

Active: January 1–24; Maximum: January 17 ($\lambda_\odot = 297°$); ZHR = 4;
Radiant: $\alpha = 130°$, $\delta = +20°$; Radiant drift: see Table 2; size: $\alpha = 20° \times \delta = 10°$; $V_\infty = 28$ km/s; $r = 3.0$
TFC: $\alpha = 115°$, $\delta = +24°$ and $\alpha = 140°$, $\delta = +35°$ ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = -03°$ and $\alpha = 140°$, $\delta = -03°$ ($\beta < 40°$ N)

This minor stream is especially suited to telescopic observations, with its large, complex radiant area that may consist of several sub-centers, and many of its meteors are faint. It is likely that this shower is an early part of the Virginid activity, which generally becomes more obvious in March and April. The δ-Cancrid ZHR is unlikely to rise much above 3–4, but the long winter nights in the northern hemisphere provide a good opportunity to see what occurs, particularly this year, with the Moon at first quarter for the shower's peak. The radiant is above the horizon for almost the entire night, whether your site is north or south of the equator, with moonset around local midnight.

α-Centaurids

Active: January 28–February 21; Maximum: February 7, 10^h UT ($\lambda_\odot = 318.^\circ7$);
ZHR is variable, usually ~ 6, but may reach 25+;
Radiant: $\alpha = 210°$, $\delta = -59°$; Radiant drift: see Table 2; radius: 4°; $V_\infty = 56$ km/s; $r = 2.0$

The α-Centaurids are one of the main southern hemisphere high points in the opening months of the year, producing many very bright, even fireball-class objects (meteors of at least magnitude -3). Their peak ZHR is normally around 5–10, but in 1974 and again in 1980, bursts of only a few hours duration that yielded activity closer to 20–30 were detected. As we have no means of telling when another such event might happen, photographic, video and visual observers are urged to be alert, especially this year, since the New Moon on February 7 perfectly favors the maximum. Thanks to their brilliance, even a normal α-Centaurid return is worth looking out for, and almost one-third routinely leave fine persistent trains after them. The radiant is nearly circumpolar for much of the sub-equatorial Earth, and is at a useful elevation from late evening onwards.

γ-Normids

Active: February 25–March 22; Maximum: March 13 ($\lambda_\odot = 353°$); ZHR = 8;
Radiant: $\alpha = 249°$, $\delta = -51°$; Radiant drift: see Table 2; radius: 5°; $V_\infty = 56$ km/s; $r = 2.4$
TFC: $\alpha = 225°$, $\delta = -26°$ and $\alpha = 215°$, $\delta = -45°$ ($\beta < 15°$ S)

The γ-Normid meteors are very similar to the sporadics in appearance, and for most of their activity period, their ZHR is virtually undetectable above this background rate. The peak itself is normally quite sharp, with ZHRs of 3+ noted for only a day or two to either side of the maximum. There are suggestions that the activity may vary somewhat at times, with occasional broader, or less obvious, maxima having been reported in the past.

Post-midnight watching yields best results, when the radiant is rising to a reasonable elevation from southern hemisphere sites, which is good news in 1997, as the Moon is a waxing crescent that will have set long before this time on March 13. All forms of observation can be carried out for them, although most northern observers will see nothing from the shower.

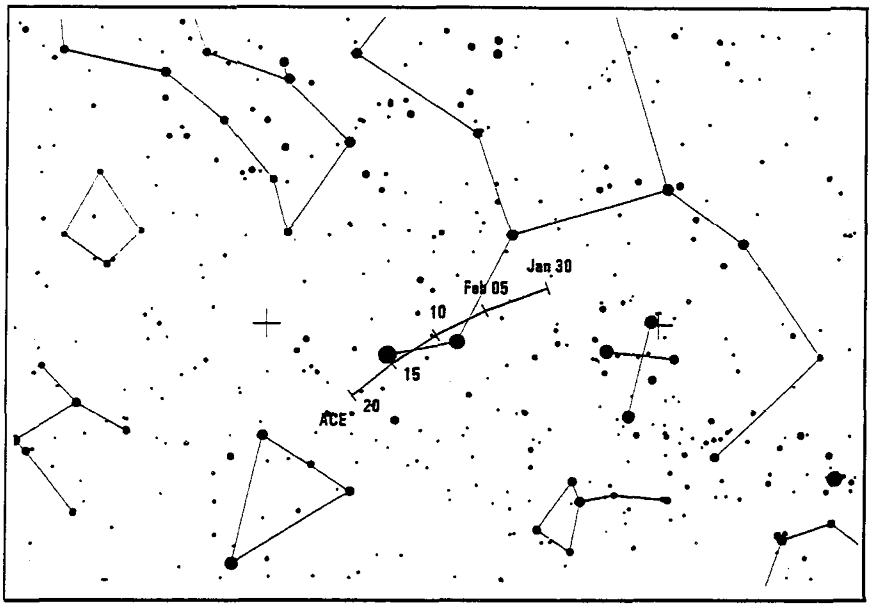


Figure 3 – Radiant positions and drift of the α-Centaurids on Atlas Brno Chart 11.

3. Working list of meteor showers

Table 1 – Working list of meteor showers for the period October 1996–March 1997. Streams marked with an asterisk are periodically or occasionally active, and therefore no ZHR is cited. The "maximum" dates cited for the Virginids and the Puppid/Velids should be seen as reference dates rather than true maxima.

Shower	Activity	Maximum		Radiant			V_∞	r	ZHR
		Date	$\lambda_\odot$	α	δ	Radius	(km/s)		
δ-Aurigids (DAU)	Sep 05–Oct 10	Sep 09	166°	60°	+47°	5°	64	3.0	6
Piscids (SPI)	Sep 01–Sep 30	Sep 20	177°	5°	−01°	5°	26	3.0	3
Draconids* (GIA)	Oct 06–Oct 10	Oct 10	196°.5	262°	+54°	2°	20	2.6	
ε-Geminids (EGE)	Oct 14–Oct 27	Oct 20	207°	102°	+27°	5°	71	3.0	3
Orionids (ORI)	Oct 02–Nov 07	Oct 21	208°	95°	+16°	10°	66	2.9	25
Southern Taurids (STA)	Oct 01–Nov 25	Nov 03	220°	50°	+13°	10°/5°	27	2.3	5
Northern Taurids (NTA)	Oct 01–Nov 25	Nov 13	230°	58°	+22°	10°/5°	29	2.3	5
Leonids (LEO)	Nov 14–Nov 21	Nov 18	235°.2	153°	+22°	5°	71	2.5	var
α-Monocerotids (AMO)	Nov 15–Nov 25	Nov 20	237°	117°	−06°	5°	60	2.7	5
χ-Orionids (XOR)	Nov 26–Dec 15	Dec 02	250°	82°	+23°	8°	28	3.0	3
Dec Phoenicids (PHO)	Nov 28–Dec 09	Dec 05	253°	18°	−53°	5°	22	2.8	var
Puppid/Velids (PUP)	Dec 01–Dec 15	Dec 06	255°	123°	−45°	10°	40	2.9	10
Dec Monocerotids (MON)	Nov 27–Dec 17	Dec 10	259°	102°	+08°	5°	42	3.0	3
σ-Hydrids (HYD)	Dec 03–Dec 15	Dec 11	260°	127°	+02°	5°	58	3.0	2
Geminids (GEM)	Dec 07–Dec 17	Dec 14	262°.0	112°	+33°	5°	35	2.6	110
Coma Berenicids (COM)	Dec 12–Jan 23	Dec 19	268°	175°	+25°	5°	65	3.0	5
Ursids (URS)	Dec 17–Dec 26	Dec 22	270°.7	217°	+76°	5°	33	3.0	10
Quadrantids (QUA)	Jan 01–Jan 05	Jan 03	283°.2	230°	+49°	5°	41	2.1	120
δ-Cancrids (DCA)	Jan 01–Jan 24	Jan 17	297°	130°	+20°	10°/5°	28	3.0	4
α-Centaurids (ACE)	Jan 28–Feb 21	Feb 07	318°.7	210°	−59°	4°	56	2.0	6
δ-Leonids (DLE)	Feb 15–Mar 10	Feb 24	336°	168°	+16°	5°	23	3.0	2
γ-Normids (GNO)	Feb 25–Mar 22	Mar 13	353°	249°	−51°	5°	56	2.4	8
Virginids (VIR)	Jan 25–Apr 15	Mar 24	4°	195°	−04°	15°/10°	30	3.0	5

Table 2 – Radiant positions from October 1996 to March 1997 in α and δ.

	NTA	**STA**	**ORI**	**DAU**				
Oct 5	25° +12°	27° +7°	85° +14°	89° +49°		**GIA**		
Oct 10	29° +14°	31° +8°	88° +15°	95° +49°		262° +54°		
Oct 15	34° +16°	35° +9°	91° +15°		**EGE**			
Oct 20	38° +17°	39° +11°	94° +16°		99° +27°			
Oct 25	43° +18°	43° +12°	98° +16°		104° +27°			
Oct 30	47° +20°	47° +13°	101° +16°		109° +27°			
Nov 5	53° +21°	52° +14°	105° +17°					
Nov 10	58° +22°	56° +15°		**LEO**	**AMO**			
Nov 15	62° +23°	60° +16°		150° +23°	113° −5°			
Nov 20	67° +24°	64° +16°	**XOR**	153° +21°	117° −6°			
Nov 25	72° +24°	69° +17°	75° +23°		121° −7°	**MON**	**PUP**	**PHO**
Nov 30			80° +23°	**HYD**		91° +8°	120° −45°	14° −52°
Dec 5	**COM**	**GEM**	85° +23°	122° +3°		96° +8°	122° −45°	18° −53°
Dec 10	169° +27°	108° +33°	90° +23°	126° +2°		100° +8°	125° −45°	22° −53°
Dec 15	173° +26°	113° +33°	94° +23°	130° +1°	**URS**	104° +8°	128° −45°	
Dec 20	177° +24°	118° +32°	**DCA**		217° +75°			
Jan 0	186° +20°	**QUA**	112° +22°					
Jan 5	190° +18°	231° +49°	116° +22°					
Jan 10	194° +17°		121° +21°					
Jan 20	202° +13°		130° +19°	**ACE**	**VIR**			
Jan 30				200° −57°	157° +16°	**DLE**		
Feb 10				214° −60°	165° +10°	155° +20°	**GNO**	
Feb 20				225° −63°	172° +6°	164° +18°	225° −53°	
Feb 28					178° +3°	171° +15°	234° −52°	
Mar 10					186° 0°	180° +12°	245° −51°	
Mar 20					192° −3°		256° −50°	
Mar 20					198° −5°			

4. Daytime radio meteor streams

Table 3 – Working list of daytime radio meteor streams. The "Best Observed" columns give the approximate local mean times between which a four-element antenna at an elevation of 45° receiving a signal from a 30 kW transmitter 1000 km away should record at least 85% of any suitably positioned radio-reflecting meteor trails for the appropriate latitudes. Note that this is often heavily dependent on the compass direction in which the antenna is pointing, however, and applies only to dates near the shower's maximum.

Shower	Activity	Max	$\lambda_\odot$	Radiant		Best Observed		Rate
		Date	2000.0	α	δ	50° N	35° S	
Sextantids	Sep 09–Oct 09	Sep 27	184°3	152°	00°	06^h–12^h	06^h–13^h	medium
Cap/Sagittarids	Jan 13–Feb 04	Feb 02	312°5	299°	−15°	11^h–14^h	09^h–14^h	medium
χ-Capricornids	Jan 29–Feb 28	Feb 14	324°7	315°	−24°	10^h–13^h	08^h–15^h	low

5. Lunar phases

Table 4 – Lunar phases for September 1996–March 1997.

New Moon	Oct 12	Nov 11	Dec 10	Jan 09	Feb 07	Mar 06	Apr 07
First Quarter	Oct 19	Nov 18	Dec 17	Jan 15	Feb 14	Mar 16	Apr 14
Full Moon	Sep 27	Oct 26	Nov 25	Dec 24	Jan 23	Feb 22	Mar 24
Last Quarter	Oct 04	Nov 03	Dec 03	Jan 02	Jan 31	Mar 02	Mar 31

Errata
The 1995 α-Monocerotids from Radar Observation at Ondřejov

Miloš Šimek

Due to an oversight by the Editor-in-Chief, the figure that should have accompanied the above article in the June issue (WGN 24:3, June 1996, pp. 88–89) *was omitted. We publish the figure below, with our apologies.* (Ed.)

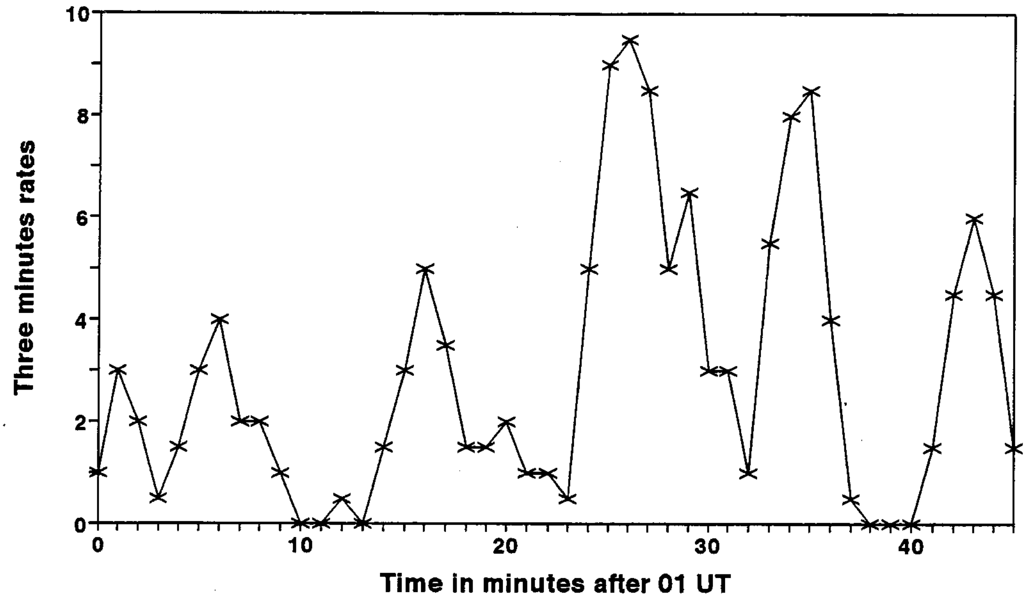


Figure 1 – Three-minutes sliding shower echo rates with duration $T \geq 0.4$ s. Time is given in minutes after 1^h UT, November 22.

SPA Meteor Section Results: November–December 1995

Alastair McBeath

An unfortunate number of errors appeared in the above article in the June issue (WGN 24:3, June 1996, pp. 96–100.) *Alastair asks to amend the text as follows:*

- Reference [1] noted in paragraph 2 of p. 96 was omitted from the reference list on p. 100 and should be as follows: A. McBeath, "SPA Meteor Section Results: September–October 1995," *WGN* 24:1/2, 1996, pp. 73–76. However, all the remaining references in the paper are numbered correctly with the list as printed in *WGN*.
- Illka Yrjölä's name is spelled incorrectly as as "Yrjulle" on p. 98, paragraph 2, and on p. 100, paragraph 2.
- Table 2, p. 98, has had the corrected mean magnitude column omitted from it. The values for the three listed sources are as follows: Leonids (`LEO`) +2.16, α-Monocerotids (`AMO`) +1.91, sporadics (`SPO`) +3.57.
- Table 3, p. 98, should have the abbreviated shower name "`ORI`" changed to "`LEO`" for the top two rows only. The sporadic rows are labeled correctly.

Finally, the author observes that the concluding paragraphs in the above article, as well as in the previous one in the series on the September–October results, containing the author's thanks to the contributing observers and correspondents, were omitted. Occasionally, it may be necessary to shorten an article for lay-out reasons, and chance had it that this was twice the case, for two articles of the same series. Of course, this does not mean that suddenly the input from observers has become less important to us. Actually, it is quite the contrary, as this whole journal is a tribute to the meteor workers on the field without whom meteor astronomy would simply not exist. (Ed.)

Ongoing Meteor Work

A Small Meteor Outburst on June 15-16, 1996

Marco Langbroek

A possible small meteor outburst was observed by the author during the night of June 15-16, 1996. In 1.9 hours effective observing time between 22^h40^m and 00^h50^m UT (limiting magnitude +6.1), 38 meteors were observed: 25 of these were sporadics, but in addition 13 meteors on the edge of medium fast to fast velocity (comparable to the Lyrids, i.e., around 50 km/s) dispersed from a radiant at $\alpha = 18^h40^m$, $\delta = +55°$ (1950.0). Peak rates occurred around 23^h35^m UT with peak ZHR in the order of about 20. The slopes of the activity profile have a B-value of about 50. The population index of these ξ-Draconids was established at about 2.7.

1. Observation of a possible outburst

In the evening of June 15, 1996, I prepared for a night of observations on the sporadic background. Unlike the year before (when I observed one or more nights during every month except February and March) I had, due to a very heavy workload from my studies and some health problems, only a very limited amount of observational nights spent so far; actually, this would be my third night this year (the other two nights being the Lyrid maximum [1]). I love observing in June [2,3]: the nights are gentle and the early summer starry skies have an air of mysticism, frogs fill the air with their pleasant symphonical sounds, bats occupy airspace and amaze with their acrobatic flight and many small intriguing streams hide in the low sporadic background. In 1995, I spent several nights observing in May, June, and July [3] and greatly enjoyed it.

Around 22^h40^m UT, when the sky had darkened, I started observations from my home at Voorschoten, the Netherlands ($\varphi = 52°10'$ N, $\lambda = 4°30'$ E) under good, though not optimal conditions. The sky limiting magnitude was near +6.1, and occasionally a small streak of cirrus came drifting by. Soon, the first sporadic meteors were seen and plotted on a gnomonic map.

At 22^h53^m UT, a nice magnitude 0 meteor appeared (nr. 199 in Figure 1). The meteor had a velocity on the edge of medium fast to fast (comparable to Lyrid meteors, i.e., about 50 km/s), a distinct yellowish color and a short persistent train. Three minutes later, a +3 with the same characteristics appeared from a similar direction. After yet another +4 meteor from the same direction and some sporadics, a beautiful −1 meteor (nr. 205), again with a velocity of about 50 km/s and a yellowish color and short persistent train, appeared at $23^h13^m54^s$ UT at virtually the same location as the previously observed magnitude 0 meteor and coming from the same direction.

At that moment, I still did not think of anything unusual. The realization that something unusual might be going on came after 23^h30^m UT when a flurry of meteors appeared, again with that very characteristic velocity, all seemingly dispersing from a radiant near the head of Draco, like their four predecessors: as much as 5 in the +2 to +5 range appeared in succession (nrs. 210–214) in the ten minutes between 23^h32^m UT and 23^h42^m UT. This was remarkable, and (still a little bit in doubt) I stopped for a few minutes to take a better look at my plottings.

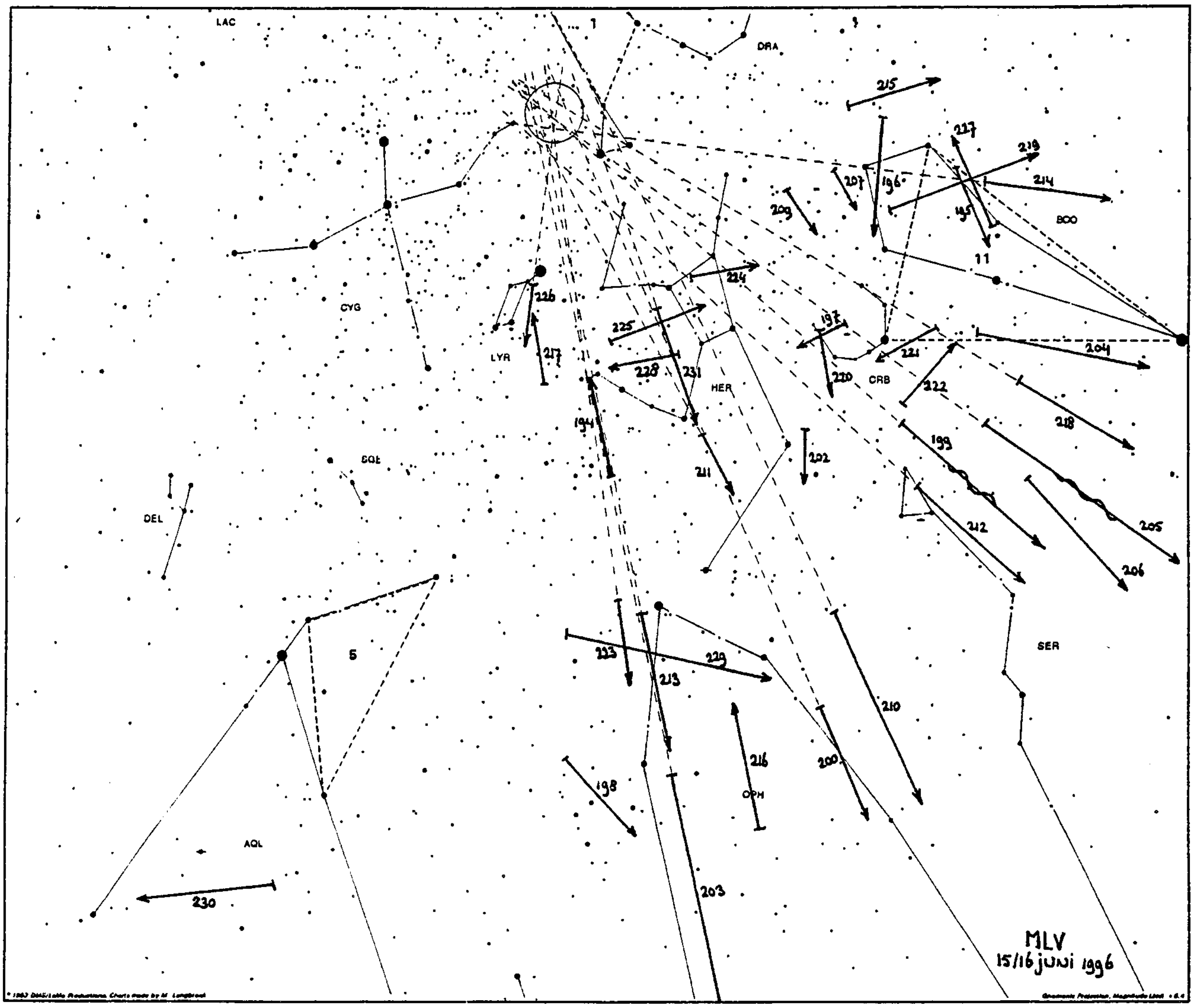


Figure 1 – Meteor plottings from the night of June 15-16, 1996. 13 meteors (velocity about 50 km/s) disperse from a radiant at $\alpha = 18^h40^m$, $\delta = +55°$ (1950.0). The illustration is an excerpt from chart nr. 1 of [4].

Realizing that there seemingly was an outburst in progress, I made a sky limiting magnitude estimate and continued observing, trembling in my chair from excitement. Rates seemed to decline, however. Beside a number of sporadics, another 4 meteors from the radiant in Draco appeared in the hour between 23^h48^m UT and 0^h50^m UT, when advancing twilight caused me to stop.

2. Analytical results

In total, I observed 38 meteors in $1^h\!.9$ effective observing time that night. Figure 1 shows my plottings. Beside 25 sporadic meteors, 13 meteors with a very characteristic Lyrid-like velocity can be seen to disperse from a radiant at $\alpha = 18^h40^m$, $\delta = +55°$ (1950.0), about halfway between κ Cygni and ξ Draconis. Since the radiant is located within the official borders of Draco, I have decided to call the stream the "ξ-Draconids." It should be emphasized that the number of observed sporadics is comparable to the numbers I observed in June and July 1995 [3]: the 13 "ξ-Draconids" truly come in *addition* to the normal sporadic rates for this time of the year.

Figure 2 shows the activity profile for these ξ-Draconids as I have calculated them from my observations. The ZHR-dots have been calculated for 20 minute intervals (using the reduction method outlined in [5] and [6], with $\gamma = 1.4$ in radiant altitude dilution and my C_p of 1.2 as calculated from recent observational campaigns).

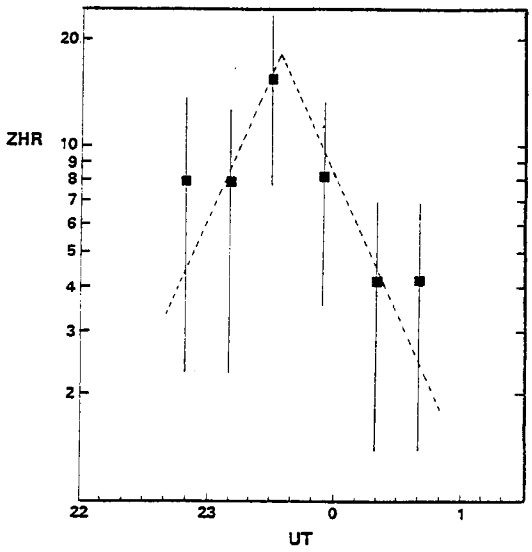


Figure 2 – Activity curve calculated from the observations, using the method described in [7] with $\gamma = 1.4$, $\chi = 2.7$ (as derived from the magnitude estimates) and my C_p of 1.2.

The profile shows a distinct peak-like structure, with slopes having a B-value of about 50 [5,7]. Highest rates occurred around 23^h35^m UT ($\lambda_\odot = 84\overset{\circ}{.}473$ (1950.0)), when the ZHR reached values of about 15–20. The numbers of meteors per bin are quite low: a profile in 10 minute intervals is more ambiguous, features more rugged slopes, and might suggest a higher peak ZHR (near 40). The observational data are given in Table 1.

From the observed magnitude distributions (Table 2), I obtained the population index r by applying a probability function. (I used the observability function from [7], allowing for a shift proportional to the deviating sky limiting magnitude, since these work quite well for my observations on regular annual streams.)

For the ξ-Draconids, I find a population index of 2.7 compared to 3.8 for the observed sporadic meteors. For both the ξ-Draconids and the sporadics the slopes of the corrected magnitude distributions are quite well linear (Figure 3).

3. Discussion

The results are highly suggestive of a small meteor outburst. The characteristics of this possible outburst are similar to those of a number of reported outbursts from other "outburst streams" [5,6].

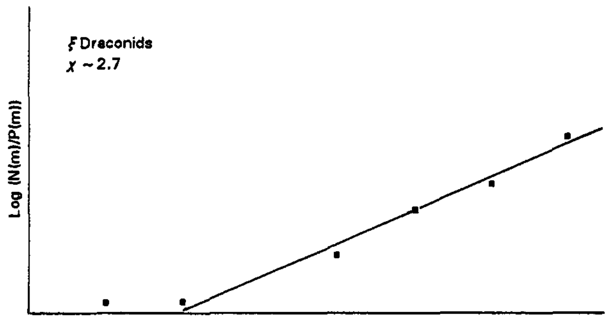
No earlier record of the stream is present in the survey of meteor outbursts in [5] and later extensions [6].

Table 1 – Observational data (observer M. Langbroek, location $\varphi = 52°10'$ N, $\lambda = 4°30'$ E).

UT	T_{eff}	Lm	N_{Dra}	N_{Spor}	h_{rad}	C_p
22^h40^m–23^h00^m	$0\overset{h}{.}33$	+6.1	2	5	74°	1.2
23^h00^m–23^h20^m	$0\overset{h}{.}33$	+6.1	2	5	76°	1.2
23^h20^m–23^h40^m	$0\overset{h}{.}33$	+6.1	4	3	79°	1.2
23^h40^m–00^h10^m	$0\overset{h}{.}45$	+6.1	3	7	82°	1.2
00^h10^m–00^h30^m	$0\overset{h}{.}33$	+6.0	1	5	84°	1.2
00^h30^m–00^h50^m	$0\overset{h}{.}33$	+6.0	1	1	85°	1.2
Total	1.90	~ 6.1	13	25		

Table 2 – Magnitude distributions.

	−1	0	+1	+2	+3	+4	+5	+6
ξ-Draconids	1	1	0	3	5	2	1	0
Sporadics	0	0	1	4	10	7	3	0



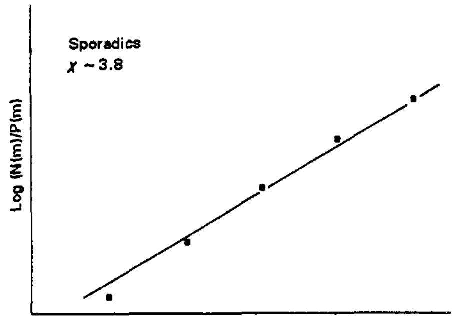


Figure 3 – Plots of $\log(N(m)/P(m))$ of the observed ξ-Draconids (left) and sporadics (right).

If recently developed ideas are correct, "far comet type" outbursts originate from gravitational influences of the major planets on the "IRAS" dust trails in the orbits of high inclination long period comets [5,6,8]. A correlation with the solar reflex motion (the solar system barycentric shift) has been recently suggested [6], and if this is correct the ξ-Draconid outburst might reoccur in the year 2020 (provided that it was indeed a "far cometary type" outburst. For a definition of outburst phenomena and a catalogue, see [5] and [6]).

After some preliminary reporting on the internet, George Zay provided me with his observational results from the USA carried out a few hours later [9]. Between 4^h55^m UT and 11^h27^m UT (June 16), George observed 37 meteors in 5.39 hours of effective observing time: 3 of these might have been possible ξ-Draconids (there is however some ambiguity in the velocity of these meteors [10]). clearly, the small outburst was over by the time Zay started observations. Interestingly, George informed me that he and Robert Lunsford had independently issued a report on low level activity from the radiant (located by them at $\alpha = 274°$, $\delta = +54°$ (Lunsford) and $\alpha = 280°$, $\delta = +53°$ (Zay)) a few days before [9] (It should be emphasized however that I was not aware of this report at the time of my observations)! Taking a look at the evidence, my opinion is that there has indeed been activity from a previously unknown stream.

This was the fifth outburst I observed since I started serious meteor work in 1989. I observed the Perseid outbursts of 1992 and 1993 and the Leonid outburst of 1995 (which were all of "near comet type") and the α-Monocerotid "far comet type" outburst of 1995. The unexpected nature of the ξ-Draconid outburst however makes it into one of the most remarkable events in my observational career, even though rates did not get that high. I am very curious to know if anyone can *confirm* the observed possible outburst around 23^h35^m UT (June 15) by either independent visual or radio observations.

Acknowledgments

I wish to thank Hans Betlem and Casper ter Kuile for helping me with issuing a preliminary report at the Internet on June 16. I thank George Zay and Lew Gramer for communicating their USA observations.

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Computer-Based Meteor Search: a New Dimension in Video Meteor Observation

Sirko Molau and Mirko Nitschke

Several aspects of computer-based meteor search are discussed. In particular, the article deals with cheap, high-quality video meteor cameras, a computer-based meteor search system, and effective measurement and analysis software for the captured meteors.

1. Introduction

The abilities and power of video meteor systems have recently been discussed in detail by several authors [1–3]. The number of observers using this method to obtain high-quality meteor data is increasing. They extend the results of meteor photography to fainter magnitudes and smaller meteor showers. However, three main problems have to be solved before video work can become as usual and frequently performed as photographic or even visual observations. We need

1. cheap, high-quality video meteor cameras;
2. a computer-based meteor search system; and
3. an effective measurement and analysis software for the captured meteors.

2. Meteor cameras

Until recently, the main problem developing suitable video systems for meteor astronomy was the price. Thus, most currently operated cameras are individual developments and stand-alone systems. Basically all of them consist of an image intensifier coupled to some type of optics and a CCD imaging sensor. However, especially in the last few years image intensifiers have become less expensive. Even second generation devices (MCPs), which show much better characteristics for our purposes, can now be purchased at reasonable prices well below 500 USD, which makes the operation of more amateur owned video systems only a question of time.

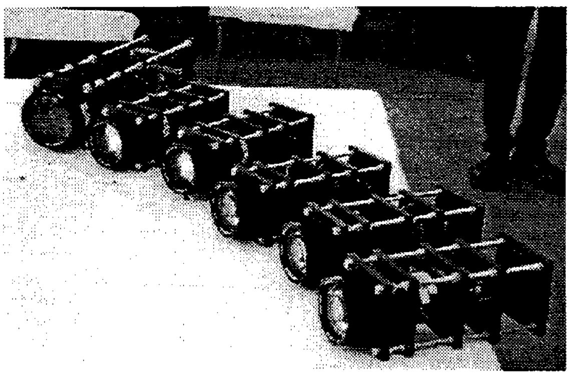

Figure 1 – The camera series before its distribution among German meteor observers during the annual *AKM* meeting in April 1996.

Recently, we have designed and built a video meteor camera series (Figure 1). The six cameras consist of 0.75/50 mm ultra-fast lenses, second hand MCP image intensifiers and simple CCD video modules for recording the MCP's output screen. The systems are able to record stars down to magnitude 8.5 and have an apparent field of view of 20 degrees in diameter. Their design is very compact (approx. $100 \times 100 \times 300$ mm) and robust. This makes them especially suitable for field operation which is often the case in meteor astronomy.

To our knowledge, this is the first camera series with several cameras having the same structure and therefore the same recording properties. This will be a considerable advantage when combining data from different stations. In addition it was proven, that meteor cameras can nowadays be built at prices below 800 USD. The optical bench like mechanic design is open for future hardware extensions. It can easily be modified and adapted to other components.

3. Automated meteor search

One of the currently most difficult problems is the search for meteors. So far there is no system that is able to automatically detect meteors on video tapes in real time. Until now all tapes have been manually inspected by the different observer teams and only first attempts of automation were to be found in the literature [3].

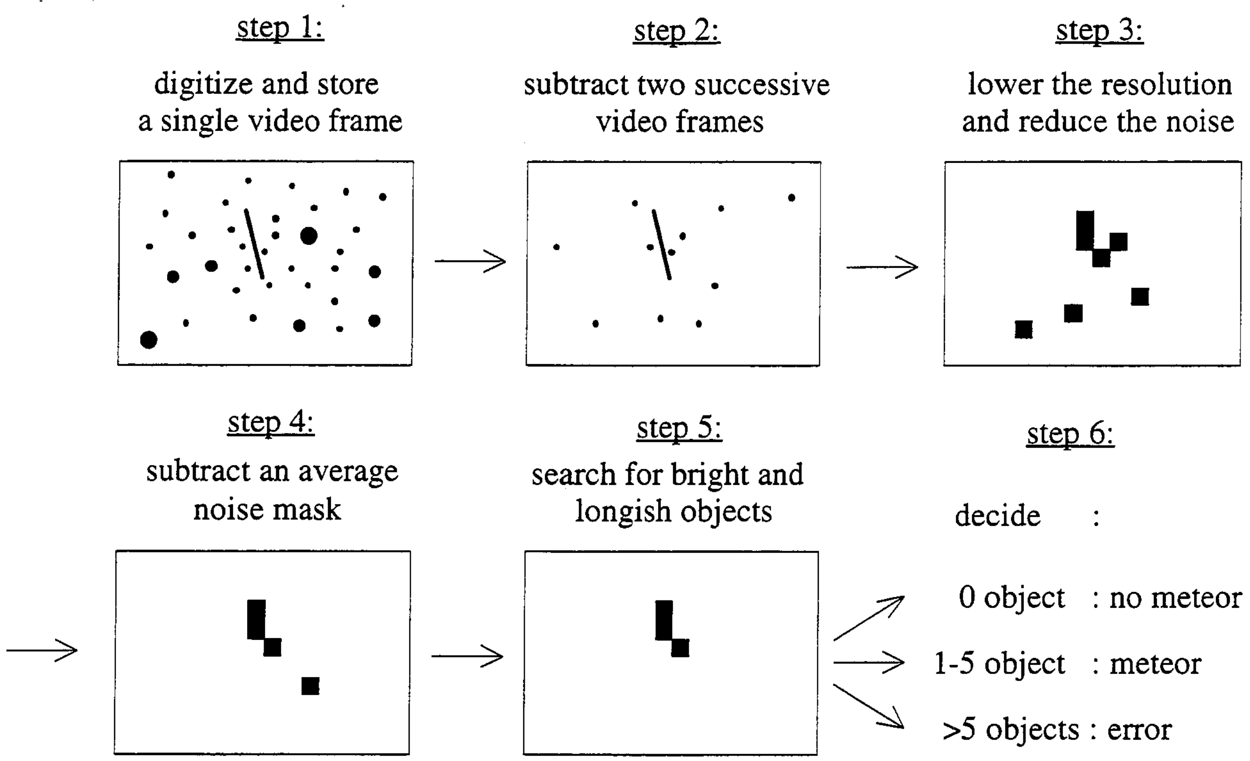

Figure 2 – Meteor search algorithm.

It is obvious that effective large scale video observation depends on the availability of automatic search systems, since the efficiency of manual inspections is limited. There is no sense in developing large camera series and doing regular observations if the video tapes cannot be analyzed in reasonable times.

So far, the limited computing speed of available PCs together with noise problems of first generation image intensifiers made the automated search infeasible. However, with the development of new micro processor generations, price reductions for frame grabber cards in the multimedia era and the availability of essentially noise-free MCPs, on-line image processing has finally become possible.

In the last few months we developed and tested a prototype for a meteor recognition system which proved to work fine with the hardware currently available. The principle of the search algorithm was proposed earlier in [3] and is described in Figure 2.

A frame grabber digitizes video frames at a rate of approximately 10 frames per second and subtracts successive images from one another. As the result only changes in the image (i.e., appearing and disappearing meteors) and noise remain visible. All persistent (i.e., stars) or slow moving (i.e., satellites) objects will disappear and do not influence the following steps. To reduce the noise, the resolution of the image is lowered by a factor of four in both axes. So every new pixel is averaged from 16 raw pixels and the noise is reduced by 75%.

The next step involves a mask which is subtracted from the low resolution difference image. This mask accounts for different sensitivity and noise within the intensifiers field of view. It is dynamically generated from the average or maximum noise of the last n video frames ($n \approx$ 102–103). By subtracting the mask from the difference image, constant probabilities for meteor detection in the entire field of view independent of camera properties and sky conditions are ensured.

Finally, the procedure looks for longish objects in the resulting image. That is, for every pixel the maximum sum of five neighbors aligned in different directions is calculated as shown in Figure 3.

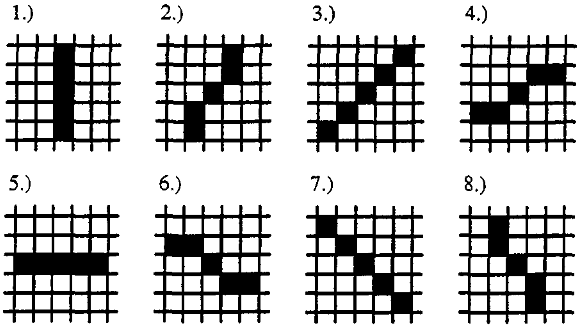

Figure 3 – For each pixel, 8 sums of 5 neighbors are calculated to find longish objects.

This sum has to be bigger than a certain threshold to be counted as a meteor. The threshold itself is similar to the mask dynamically computed from the average or maximum noise of the last n meteor-free frames, multiplied by a detection rate factor r. The r-factor tunes the sensitivity of the detection algorithm: Being only slightly bigger than 1, it makes the procedure very sensitive to detect even faint meteors. However, the number of misidentifications (i.e., the algorithms identifies noise as a meteor) increases dramatically. On the other hand there will be almost no misidentification with higher r-values, but some of the fainter meteors will also be missed. If there is no pixel sum exceeding the threshold, no meteor is detected. If such pixel sums exist, the computer counts them and stores the position of the brightest spot together with its time of appearance. If the number of pixel sums exceeding the threshold becomes too big, something "strange" happened (a change of the camera's field of view, for example). In this case the procedure restarts calculating the noise mask, since general observing conditions may have changed.

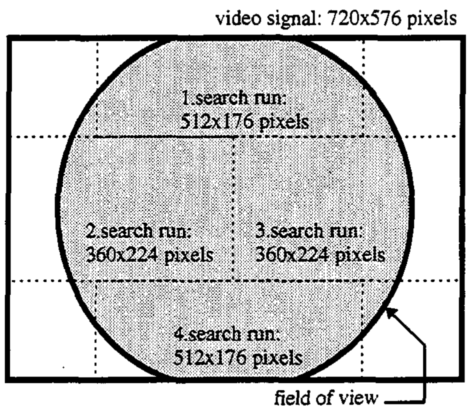

Figure 4 – The search program runs 4 times inspecting different parts of the field of view.

The described algorithm was implemented in Borland PASCAL including inline assembler routines for all time critical sections. It drives a 512×512 pixel AT-bus frame grabber card with 256 grey levels. The program was tested on a 486/DX2 66 MHz and a Pentium 90 MHz machine respectively, using the recordings from the α-Monocerotid outburst in 1995. This shower was recorded with the prototype of the new cameras series, thus, a video system using an MCP intensifier. That is why the main problem we faced when we analyzed MOVIE's video tapes in 1993 [3], the strong electron noise of first generation intensifiers, did not occur.

In order to achieve an appropriate number of inspected video frames per second, the search program needs to run four times, each time inspecting another part of the field of view (Figure 4). Every frame contains about 90 000 pixels.

With this technique, the program was able to analyze every third non-interlaced video frame (8.3 frames/s) running at the 486 PC, and every second frame (12.5 frames/s) when started at the Pentium machine, respectively. The 30 minute test section of the α-Monocerotid tape contained 28 meteors, 25 of which had been found by visual inspection. The computer detected 20 meteors during the four necessary test runs achieving a detection rate of almost 75%. The r-factor was set to 2.5 leading to only one misidentification. This low number is as important as the ratio of detected to recorded meteors. Normally the meteor activity is much smaller than on the test tape. The number of misidentifications should therefore not exceed 5 per hour to make the search procedure effective.

It can be concluded, that automatic meteor detection is possible with today's computer technology. The remaining 25% of undetected meteors occurred either in the small corners of the field of view remaining uninspected, or they were just too faint. In both cases they are not suited for further analysis anyway, since their positions are inaccurate due to the proximity to the border, or they would be lost in the noise.

It turned out, that the CPU speed is not anymore the main problem. The real bottleneck is the transfer speed from the frame grabber card to the computer's main memory, i.e., the bus system.

It is important to have a frame grabber that allows the transfer of raw images to the main memory: currently, more common MPEG-compression boards are not suitable for meteor detection. The suggested inspection rate of 10 frames per second is appropriate for meteor detection. Since even faint video meteors last in average at least 0.2 seconds, all of them will be visible on at least one inspected video frame. It would be even critical to further increase the frame rate, since especially slow moving meteors near a shower radiant would be missed due to their almost stationary appearance.

We expect, that the detection rate and the number of test runs can still be improved. On the one hand, the data transfer speed within the PC can at least be doubled using PCI frame grabber cards. This implies a reduction down to two or even one test run necessary for each video tape. In addition, there are still improvements in the back end of the algorithm thinkable. They do not significantly increase the computing time due to the reduced size of the image, but might still improve the detection rate. Currently, the software has prototype status to study the properties and abilities of the suggested algorithm. In the future it is planned to do a market analysis. We intend to find a cheap frame grabber that matches the needs of video meteor observers, and to implement the search program for that hardware.

4. Computer-based measurement and analysis

The problem of measuring video meteors was the first to be solved by several video observers. Almost every team developed its own analysis software for different hardware and different computer generations [4–6]. Recently, Marc de Lignie has expanded his "AstroRecord" measurement program to video observations. The program is a hardware independent solution. It requires Video for Windows AVI animation files as data input and does all the necessary calculations to obtain the meteor's data. The software was introduced at the last IMC and received much attention. We suggest to decide for one software package for each of the described problems (AstroRecord for the meteor measurement, for example) to avoid that all the programming work is done again and again. This strategy ensures, that all meteor data are obtained with the same procedure allowing us to directly compare results of different observers. In addition, there has only one program to be maintained and improved with further progress in meteor science and computer hardware.

5. Future prospects

From the current point of view, the analogue recording of the sky using a VCR and video tapes seems to be an appropriate solution. Real time image compression hardware, which allows the storage of several hours of video signal on a computer's hard disc, as well as digital video are currently under development. It is to expect, that it will take some more years until the prices for such components have reached a suitable level for amateurs. Due to digital broadcasting and the multimedia age as such there exists a mass market for such equipment, so we would like to claim that as the next generation of video systems.

There have been discussions whether or not CCD cameras could be used to transfer the information directly from the imaging sensor to the computer. This would make the optics and electronics of the video camera as well as the frame grabber card redundant. There would be no signal conversion from the CCD output via gain control to analogue video signals and back to digital computer images. Hence, the noise and the computing overhead should reduce significantly. However, currently in amateur astronomy available CCD cameras serve other purposes and do not reach the frame rate needed for meteor observation. This leads automatically to longer integration times, and two of the main advantages of video systems are lost: the ability to directly record the development of a meteor and the measurement of its velocity without a shutter. In addition, integrated video cameras belong to the mass market and are therefore relatively cheap. Stand-alone CCD cameras, however, are only used in some small areas and will always be more expensive.

6. Conclusions

With the availability of cheap meteor cameras on the one hand, and the possibility to automate the meteor search on the other hand, two remaining problems for the large scale usage of video systems in meteor astronomy have been solved. It is expected, that a complete hardware and software solution will be available by the end of the year, which makes extensive scientific studies based on amateur video recordings possible. To achieve that aim it is essential, that every video observer does not only record the sky, but also inspects and measures his own video tapes. This will be possible due to smaller hardware costs and centrally available analysis software.

Acknowledgments

We wish to thank Felix Bettonvil from the *NVWS*, who found those amazing ultra-fast lenses for our meteor camera series at an optical flee market in the Netherlands. So far we didn't even know, that such fast lenses do exist. We would also like to thank Detlef Koschny, who helped purchasing the image intensifiers and contributed to the mechanic components of the cameras.

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The Zodiacal Light

Alastair McBeath

A brief description of the zodiacal light phenomena visible from dark-sky sites on Earth is given, together with some practical observing suggestions. Some recent zodiacal light results submitted to the *SPA Meteor Section* from Romania are presented.

1. Introduction

The abstract of an earlier *SPA Meteor Section* results article [1] commented on some photographs of the morning zodiacal light taken from Romania on several dates in 1995 October. Unfortunately, space considerations in that issue of *WGN* resulted in the omission of those observations, which are presented, along with some more recent notes, later in this paper. However, this does give us the opportunity to examine in some more detail the zodiacal light complex of phenomena we can sometimes see from the Earth, and why it is of interest to us as meteoricists.

2. The "False Dawn," the "Afterglow," and the "Counterglow"

Humans have been aware for some millennia that, from good, dark sites, an approximately conical glow precedes the true light of dawn and apparently prolongs the evening twilight too, and the names "False Dawn" and "Afterglow," or similarly poetic titles, have long been used to describe what is seen. An alternative title, the "Zodiacal Light," has become accepted in scientific parlance, since these crepuscular cones of light have their long axes lying roughly along the line of the ecliptic, and are thus primarily seen over stars in the zodiacal constellations. The light cones can usually be seen extending for around 60° to either side of the Sun along the ecliptic, and for roughly 10°–20° to either side of the ecliptic itself, although the zone within about 30°–40° of the Sun is usually impossible to observe from Earth because of the solar glare or bright twilight.

Although the brightest regions of the zodiacal light cones can be significantly brighter than the average Milky Way for a visual observer, a secondary condensation, which is rather less obvious, perhaps being no more bright than the mean galactic light, has been recorded frequently too. This is the Counterglow, more commonly referred to now by its German title of *Gegenschein*, a word of comparable meaning. This is a generally elliptical area, again with its long axis lying on the ecliptic, that is found centered around 180° away from the Sun. It is usually seen as being at maximum about 40° × 20° in size.

From a very good, dark-sky site, it is sometimes possible to detect a faint, thin strip of light that links the apex of the zodiacal light cones with the outer edges of the Gegenschein. This is called the zodiacal band, for obvious reasons, and it is usually described as being significantly fainter than the average area of Milky Way.

3. Zodiacal dust

Space-borne and Earth-based instruments have shown that the bulk of this zodiacal glow is due to sunlight scattered by interplanetary dust, concentrated near the ecliptic plane, and mostly within the outer asteroid belt. Spacecraft which have traveled away from the Sun beyond this region have recorded virtually no trace of the zodiacal light closer to Jupiter, for example. The dust particles are generally very small, about 0.0001–0.0002 mm in diameter, although a proportion are larger than this, more than about 0.02 mm, and extremely dark, with albedos of order about 0.07 (the Moon's albedo is about 0.12, that of Venus about 0.65). They probably represent the final collisional and disrupted debris of once-larger cometary and asteroidal dust particles of the sporadic meteor complex, including meteoroids that have been expelled from streams. Much of the sunlight-scattering is in a forwards direction, hence the brightest part of the zodiacal light is in the direction of the Sun, and decreases rapidly with increasing ecliptic longitude from the Sun, but back-scattering is important too, and produces the enhancement directly opposite the Sun on the ecliptic, which we see as the Gegenschein.

The zodiacal dust grains are of a size where the various perturbing influences within the inner Solar System can most readily act, which will operate to mean the particles are removed from the Solar System entirely, for instance spiraling in to the Sun, and destruction, under Poynting-Robertson drag, or being expelled from the Solar System by solar radiation pressure. Consequently, the zodiacal light complex needs continual renewal to maintain its status, or it would fade away entirely. Indeed, some recent discussions have suggested (e.g., [2] and references there) that the zodiacal complex has varied in its strength over recorded human history quite markedly, although more recent observations have suggested only subtle variations are to be noted today (as found in several papers in, for instance, [3]). The light is thus of interest to meteor scientists and observers because of its origins, and because its appearance may change over time, albeit this may only be detectable instrumentally in the present epoch.

4. Making observations

An observer's location on Earth determines when to look out for the zodiacal light, and how likely it is to be seen. From dark sky sites within or near the Tropics, the zodiacal light complex can be seen on almost any night of the year, and it is here that routine monitoring of the light's appearance and intensity can most usefully be made on a day-by-day basis. Moving significantly north or south of these zones makes the zodiacal light a more elusive target, while those living in light-polluted regions are at a significant disadvantage, and may never be able to see it at all.

The best chance of seeing the zodiacal light from the less suitable temperate sites many meteor observers work from is when the ecliptic makes its steepest angle with the horizon, and the upper regions of the evening or morning zodiacal light cones are furthest from the horizons. This occurs between roughly mid-February to early-April in the northern hemisphere's evening sky (southern hemisphere's morning sky) and late-August to mid-October in the northern hemisphere's morning sky (southern hemisphere's evening sky).

For detecting the Gegenschein, picking a time when the ecliptic is highest above the horizon around local midnight is sensible, albeit there are problems at such times because these periods modernly also coincide with the times when the Gegenschein will be seen over the Milky Way. This is a particular problem for southern hemisphere observers, due to the brightness of the Scorpius-Sagittarius Milky Way compared with the relative faintness of that in Taurus-Gemini, the north's favored region for Gegenschein sightings. The theoretical "best seasons" for looking out for the Gegenschein are thus late-November to mid-January north of the equator, or late-May to mid-July to the south, but southern observers would be advised to try picking the Counterglow up against the stars of Libra in April–May, or Capricornus in July–August, especially at the first attempt.

The standard items to record on making a sighting are much as usual, including the observer's name, correspondence address and site location, and the dates and times in UTC of the observation. A sketch of what could be detected, along with any brighter stars, planets or notable horizon landmarks, should be made for the evening and morning light cones, and angular estimates should be made of the cone's widest point (usually near the horizon) and greatest vertical extent, in degrees. Use true azimuths, correcting appropriately if using a magnetic compass for these, where 000° is due north, 090° due east, 270° due west, and so forth, and give the vertical extent from the true, not apparent, horizon. Measurements can readily be made using a 15 cm rule, which when held at arm's length subtends about 20 degrees of arc at the eye for most people. An alternative is to use the hand, again held at arm's length from the eye. The clenched knuckles represent about 9–10 degrees of arc across, while the outer edges of thumb and fourth finger held widespread give an angle of about 20°–22° for most observers. Then, estimate the light's brightness by comparing it to the Milky Way. It will very rarely be bright enough to compare it with even thin moonlit cirrus clouds, for example.

With the Gegenschein, a sketch showing its position against the stars on a pre-prepared star chart is useful. The projection of the chart is largely irrelevant, but it should show enough faint stars to enable the accurate drawing of the glow's approximate edge (or the edge of the brighter part of the glow, if that will be easier). Remember that the shape drawn onto the chart will almost certainly be distorted compared to what is seen in the sky, however. Any unusual features—such as color, brightness variations or apparent distortions of the light's outlines—should also be noted down carefully.

On most occasions, naked-eye observations are the only visual sort practical, since even low-power binoculars are liable to render the faint light virtually unnoticeable, and are unlikely to show up unexpected features, but photographic (or indeed low-light-level video) observations are more practical alternatives to making sketches. A standard 35 mm camera will suffice for photography, with a 400 ISO or faster film, and the lens set to around $f/4$. A more widely-opened camera iris can produce unwanted vigneting around the edges of the frame, which will make the zodiacal light lose definition in the final result. A normal or wide-angle lens can be used, and with a set-up driven to follow the sky, a 10–15 minute exposure should work quite well. Undriven exposures will lose definition of the edges of the light, and will generally need to be longer in any case, perhaps 15–30 minutes. Color films will generally produce a pale pink or yellow-orange color to the light, depending on their color balance. The light is reflected and scattered sunlight, thus yellow or orange are certainly more probable as "real" colors.

5. Recent observations

Zodiacal light observations during the past twelve months have been received by the *SPA Meteor Section* from Vasile Micu at Bunila in Romania. Vasile made a fine set of visual and photographic observations of the morning zodiacal light on October 5 and 25, 1995. His photography was carried out using Kodak PJB Color film (400 ISO) with a standard 35 mm camera, using a 40 mm lens at $f/4$, and employing various exposure lengths from 5–15 minutes using a driven camera mount. The cone-shaped light in the pre-dawn sky was very well captured on the four prints Vasile provided, the color a pale yellow on two of the shots. His good fortune is largely down to having access to an excellent dark sky site. His meteor watches made on the same nights had limiting magnitudes of +7.05 (October 5) and +7.5 (October 25), for instance. These shots are particularly notable as they were the first photographic observations of the zodiacal light submitted to the Section.

In addition, Vasile picked up an unexpected bonus in two of his three October 5 photos: Comet de Vico, which was in Leo in early October. At the time, the comet was not far from γ Leonis, and in yet another of the coincidences 1995 seemed to be notable for, the author made his first observation of Comet de Vico on October 5 within 30 minutes of Vasile's end time for his second photo that night! Unfortunately, artificial light pollution meant the zodiacal light went unrecorded at the author's location.

Vasile made further zodiacal light sightings in the evening sky of 1996 March too, and has submitted a very impressive black-and-white photograph taken on March 8. This was a 10 minute exposure on 400 ISO Kodak film with a 58 mm lens at f/2, which clearly shows the zodiacal light cone in Pisces and Aries, and has the superbly brilliant planet Venus embedded in the light cone's upper section.

6. Conclusion

Any other observers of the zodiacal light are encouraged to submit their data to the author, for analysis and future results' articles on this topic. Although not strictly meteoric, the zodiacal light complex is of importance to all with an interest in meteor science, and the observing guidelines here are equally valid for making observations of rare sightings of the glow scattered from meteoroid swarms in space, which have occasionally been suspected when very high meteor activity has manifested. Although many workshops and meetings on comets, asteroids, and meteors now regularly deal with interplanetary dust too, those interested in starting to investigate the topic further for themselves should particularly see [3–5]. An expanded version of this current article, with diagrams and charts appropriate for the northern hemisphere, appeared as [6].

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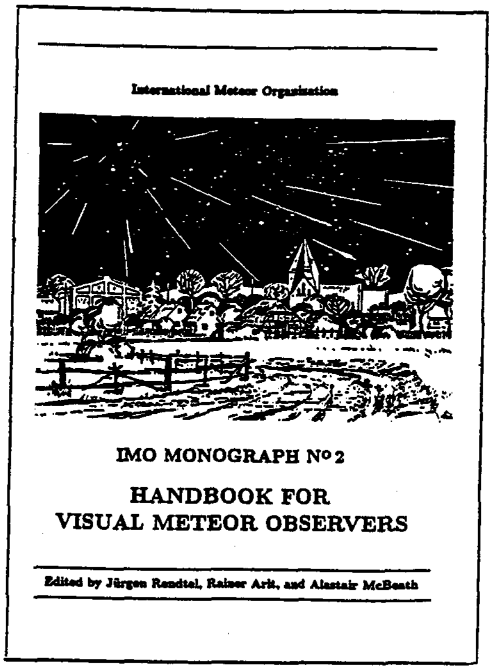

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