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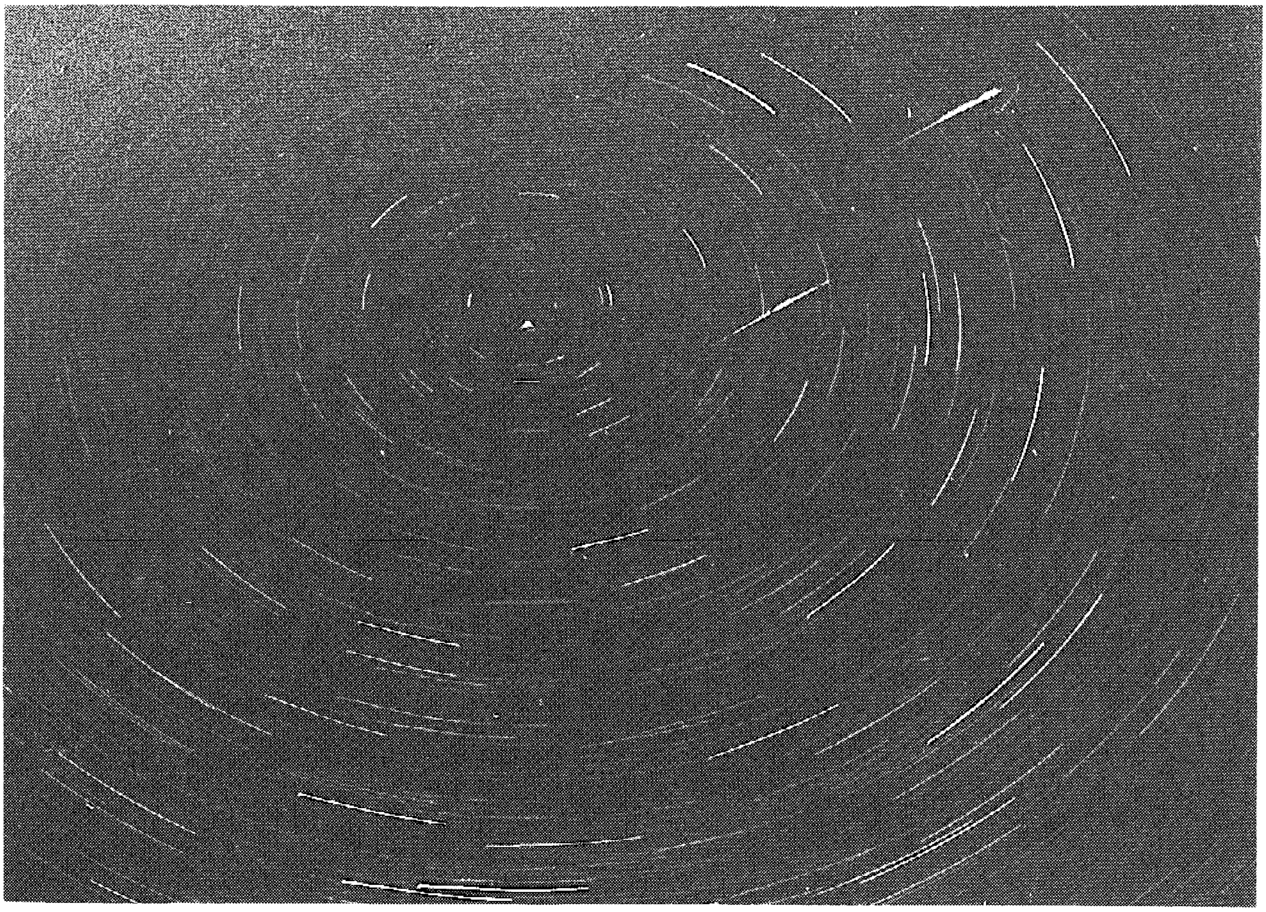

Two −4−−5 Perseid fireballs captured by Jürgen Rendtel on a photograph exposed on August 14, 1991, between $1^h10^m45^s$ and $2^h15^m17^s$ UT at the Bulgarian National Observatory on Mount Rozhen. The first meteor (nearer to α UMi) appeared at $1^h12^m25^s$ UT and the second one (nearer to the edge of the print) at $1^h35^m35^s$. A fish-eye lens Zodiak 8 $f/3.5$, $f = 30$ mm, was used, in combination with an ISO 400/27° film.

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

Afgiftekantoor: 2540 Hove

WGN, volume 20, nr 1, February 1992, pp. 1–54

Contents

Useful Information

The April Issue *(WGN 20:2)*

The *April issue* is expected to be mailed during the first week of April 1992. Therefore, contributions are due *March 6*. They should be sent to *Marc Gyssens* or to any member of the editorial board (addresses: inside of back cover).

From the President

Jürgen Rendtel

Once again, we lived to see a very successful year for our International Meteor Organization. *This concerns observational results as well as official consequences.*

Data derived from our observations are of interest for professional astronomers not only because we all together gather a large sample, but also because there are methods developed which allow the calculation of physical quantities. Thus IMO *is able to present well developed methods for observation and analysis, and to give serious information about accuracy and limits of the methods.* IMO *as well as a few other experienced amateur meteor groups of the world now present consultants to the* IAU Commission 22. *Furthermore, we are going to meet professional meteor astronomers at the 1992* IMC *to be held in Czechoslovakia in July.*

Thinking about IMO*, one has to bear in mind that many of our members never meet personally. We are in contact with each other through correspondence or via publications only. Thus also the procedures of voting and finding common points of view are different from other, especially national or local organizations. Therefore I would like to encourage all members to express their opinion to the Council (or a Council member) or to contribute to our journal* WGN *with either results or reports about campaigns, your local group, etc., in order to let other people know who else is there in* IMO *and how meteor work does happen elsewhere.*

Although the astronomical conditions for observations of the major showers are unfavorable in 1992—except the Quadrantids which have already passed when you read this text—we should make every effort possible to monitor the meteor activity. The Perseid outburst of 1991 impressively demonstrated that even the so-called "well-known" showers may surprise the observers with unexpected features.

Still the major amount of information gathered in IMO *is contributed by the visual branch. We should spend more attention to other fields, such as photographic, video, radio, and telescopic work in the near future!*

I wish you a healthy, peaceful and successful New Year, allowing that your intentions can be fulfilled, and that meteor work within IMO *may develop further on—with stimulating surprises from the interplanetary matter the Earth meets along its orbit.*

From the Editor-in-Chief

Marc Gyssens

Following our President, I too would like to offer you my best wishes for a good and satisfactory 1992. In the same spirit, I would also like to encourage you to use WGN *to improve the communication between subscribers and members. A suggestion in that direction was recently made by one of or senior members, Mr. Noel White. In answer to his (and probably also other readers') wishes, I particularly wish to encourage you to use WGN's Letter Section more frequently. My feeling is that this medium of communication is not used to the extent it should be. Please let me know any comments or issues you want to communicate to the other readers of* your *journal!*

Notes from the IMO Treasurer

Ina Rendtel

1. Gifts from members and subscribers

The following people paid more than required for their 1991 membership or subscription. Their financial contribution helped a lot to finance the production of *WGN* in 1991. Gifts are welcome and help to keep the subscription low for those who cannot afford to pay more than 25 DEM. The donators were:

> Robert Burnham, Erwin Van Ballegoy, Malcolm Currie, Werner Depoorter, Vincent Devore, Ivo Dielen, Paolo Di Marcantonio, David Hughes, Edward Hamers, Daniel Glomski, Luc Gobin, Roberto Gorelli, Susanna Grigori, Marc Gyssens, Marc Hamilton, Teemu Hankamäki, Werner Hasibuck, Lars Trygve Heen, Jost Jahn, Klaas Jobse, Andre Knöfel, Ralf Koschack, Detlef Koschny, Gotfred Kristensen, Jean Christophe Lernould, Alastair McBeath, Pekka Parviainen, Ghislain Plesier, Ina and Jürgen Rendtel, Janko Richter, Paul Roggemans, Hans-Georg Schmidt, Duncan Steel, Richard Taibi, Casper ter Kuile, Leonard Tomko, José Maria Trigo Rodriguez, Didier Van Hellemont, Jeroen Van Wassenhove, Cis Verbeeck.

Thank you very much!

2. Exchange of publications with currency-controlled countries

Last year, several members paid an exchange subscription to *IMO*. We hope that everybody received the publications he or she expected. If you have not received what you ordered, please report such facts to the treasurer.

For 1992 the following arrangements are possible:

- *Czechoslovakia:* Order the gnomonic *Atlas Brno 2000.0* for 5 DEM from *IMO*, every five copies sold cover the subscription of a Czech reader. Orders are booked by *IMO* and copies have to be sent from Brno; this procedure may take up to 3 months. If you ordered an atlas and did not receive it within 3 months, please inform the treasurer.
- *Hungary:* Order the *1989 IMC Proceedings* from *IMO* (12 DEM) and help our Hungarian friends to cover their subscription. Copies can be supplied by the *IMO* treasurer.
- *Other currency-controlled countries*, such Russia, the Ukraine, the Slovakian part of the CSFR, Bulgaria, etc.: You can make donations for the *IMO* fund "Assistance to members from currency-controlled countries" (for a subscription or for a publication), or you can help by paying for a specific person with whom you made an agreement for some exchange. If you want to obtain a specific publication, for instance Russian astronomical journals, the Minor Planets' Ephemerids 1991, 1992, etc., contact the Secretary-General who will try to arrange this exchange.

3. Complaints about not receiving ordered publications

In general, we receive very few complaints, but every now and then it may happen that parcels disappear or are destroyed in mail. If you do not receive what you ordered from or through *IMO* in, say 4 months after your order was placed, do not hesitate to contact the treasurer.

It may happen that something goes wrong in our administration, due to misunderstandings, or because of unclear orders, ... Sometimes we receive money without any indication what it is for or whom it is from!

Letters to WGN

compiled by Marc Gyssens

1. Non-Linear Meteor Trails

In response to Ralf Koschack's letter in WGN 19:5 (October 1991), p. 170, we received the following interesting note by Dr. Martin Beech, University of Western Ontario.

The problems relating to the appearance of non-linear meteor trails has recently been discussed in two letters to *WGN* [1,2]. These letters raised several interesting points, a few of which might bear some further analysis. In particular the frequency of, and mechanism responsible for such events are better constrained than might at first be acknowledged.

Non-linear meteor trails have been observed on many occasions, and the statistics that are available suggest that their appearance might be as common as one per two or three hundred meteors observed [3]. This estimate is derived on the basis of observations collected by several dedicated observers. For example, C.P. Olivier (1884–1975) and W.F. Denning (1848–1931), who clashed on many occasions concerning the interpretation of meteoric data, both found from their collected observations that about 0.5% of their trails were denoted as non-linear. Likewise several photographic surveys have found a similar percentage for non-linear effects [3]. These later results, however, have to be taken with some caution since as Fred Whipple warned in 1938, the oscillations he had found in some meteor trails were in reality due to a tracking motor [4]. An apparently genuine photograph of a non-linear meteor trail, however, was captured by Mr. Roy Gephart in 1988 [5]. Having made these points, however, the comments of Ralf Koschack [2] must still be borne in mind, and that many apparently non-linear meteor trails that are visually observed probably result from physiological and head-turning reflex effects.

One important point that the historical record has shown is that the non-linear meteor trails appear in essentially two forms: those that gently curve and those that follow a sinuous path [6] (see also Figure 1). It has been argued that these different trail types result from the action of two distinct physical processes [3]. As Ralf Koschack [2] clearly demonstrated, the path of a meteoroid is unlikely to be changed through an impulsive force. An important factor, however, as suggested by Gotfred Kristensen [1], is meteoroid spin. That meteoroids do spin, and spin rapidly has been inferred from several studies [7]. This spin combined with meteoroid geometry may explain the two non-linear forms.

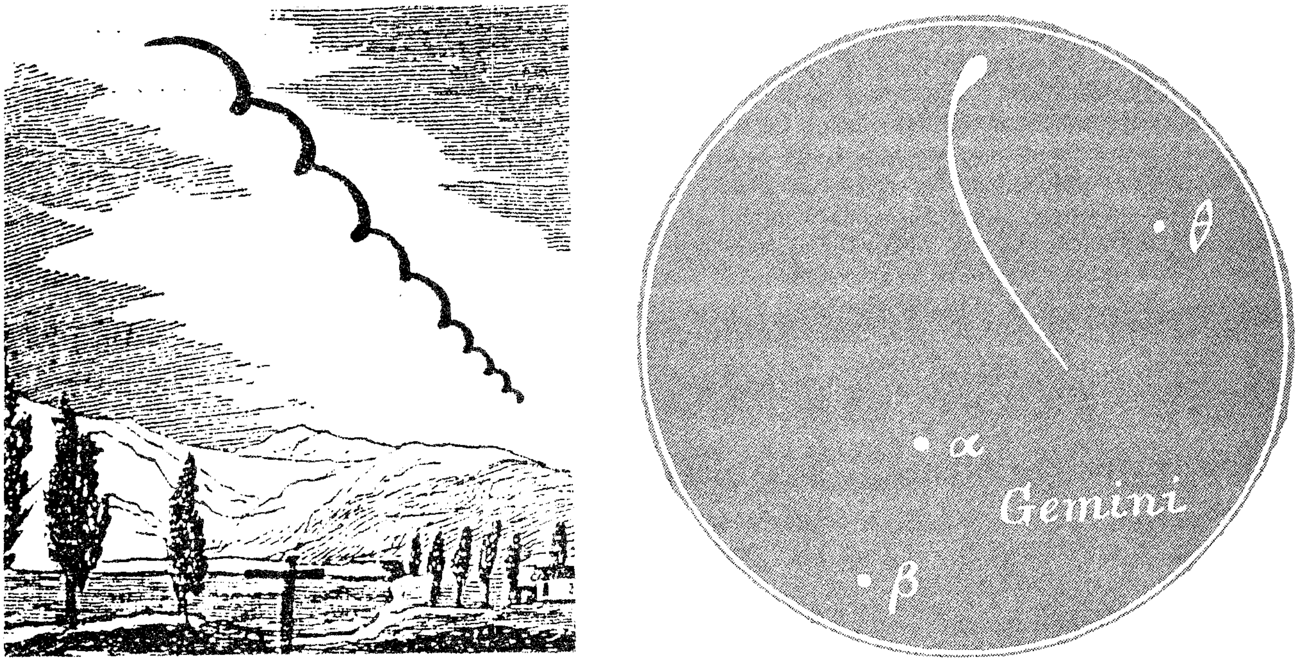

Figure 1 – *Left:* Sinuous meteor trail observed by Prof. Montigny of the University of Namur in the province of Namur, on October 5, 1852, at 19^h40^m local time. Note that this drawing shows the meteors' path across the sky, and should not be confused with a long-duration train.*Right:* This gently curving meteor trail was seen by W.F. Denning on the night of December 25, 1886. Denning believed that most observations of non-linear meteor trails were illusory, but attested that this trail was well observed and did indeed curve.

The gently curving trails are possibly due to the Magnus effect acting on spherically symmetric spinning meteoroids, while the sinuous trails may be due to torque-free precession on non-symmetrical spinning meteoroids [3]. These two effects have every-day counterparts in contemporary sports. It is the Magnus effect that causes the ball to curve from a tennis backhand shot, and it is torque-free precession that causes a thrown American football to follow a spiral path.

The workings of these mechanisms are not entirely clear. The conditions of meteoroid ablation are severe, and the detailed fluid mechanical interaction of the hyper-sonic meteoroid with the atmosphere is completely unknown. These are, however, areas of continued research.

To finish off, I am not entirely sure that the mechanism described above can explain the very abrupt changes, such as those described by Gotfred Kristensen [1], in a meteoroids path, but the phenomena as a whole deserves further study. The author of this letter, for example, would very much like hear of any observations relating to non-linear meteor trails.

[1] G.M. Kristensen, "Unusual Meteor Track", *WGN* 19:4, August 1991, p. 136.

[2] R. Koschack, "Letters to WGN", *WGN* 19:5, October 1991, p. 170.

[3] M. Beech, "Non-Linear Meteor Trails", *Earth, Moon and Planets* 42, 1988, pp. 185–199.

[4] F. Whipple, *The Sky Magazine* 3, 1938, p. 18.

[5] *Sky and Telescope*, January 1989, p. 11.

[6] M. Beech, "Meteors Off The Straight And Narrow", *Astronomy Now*, August 1989, pp. 18–20.

[7] W. Jones, "Rotational Damping of Small Interplanetary Particles", *Mon. Not. Roy. Astron. Soc.* 247, 1990, pp. 257–259.

Martin Beech, November 18, 1991

2. On telescopic meteor observations

We received a letter from Telescopic Commission Director Malcolm Currie commenting the article by I. Tepliczky and P. Spányi on telescopic 1991 April Lyrid observations in Hungary, in WGN 19:5 (October 1991, p. 217)

I was pleased to see Zoltán Antal Nagy's 1991 April Lyrid telescopic plots in *WGN*. It shows that observations are possible even from cities. There is one aspect of Zoltán's observations that I should like to comment upon. Zoltán selected field centers only 5° from the radiant, which according to the *IMO* radiant list has a diameter of 5°, meaning that part of each binocular field encroached on the radiant. I can appreciate that Zoltán wished to improve the accuracy of the radiant position, since the effect of orientation error is reduced, and to counteract the magnified angular speed. However, there are disadvantages to this strategy.

Firstly, the radiant subtends 60° at each field center, so a random sporadic has a high probability of being misassigned as a shower meteor. Given the preponderance of sporadic over shower meteors at telescopic magnitudes, the proximity to the radiant could lead to unreliable conclusions. The path length cannot be relied upon to be a good discriminant for shower association because some telescopic observers see most meteors as short trails. Secondly, shower meteors may not necessarily be obvious. For instance you may have shower meteors directed ***towards*** the radiant center, because the meteor's individual radiant is some degrees away from the center. Thirdly, telescopic radiants may have different locations from their visual counterparts, which could mean accidentally looking directly at the radiant, where the cross-section is small, hence reducing rates too. Unless the radiant is compact, I recommend not viewing closer than 10° from the radiant.

Malcolm Currie, January 17, 1992

Notes from the Visual Commission Director

Ralf Koschack

Here I want to discuss two problems of, in my opinion, general interest which occurred during the last months.

The first one deals with the necessary of plotting meteors in minor shower observations. I received the following comments on [1] from an active visual observer and have heard from several other people that they think in a similar way:

> *... [I] cannot help feeling there is less and less reason for actually plotting minor shower meteors. We are now assuming such large radiant areas for these streams that the errors on visual plotting must be equal to or even greater than those from simple back-prolongation of the trail under the sky. I've been routinely making velocity estimates on a simple speed scale (like the 0–5 scale ...) for years, ... So apart from providing a permanent record which can then be checked in future years for new showers, which I admit is a worthwhile exercise in its own right, within the obvious limitations of such plotting, I cannot see any useful purpose being served by using up part of the observing time by plotting the events seen for minor showers. ...*

First of all it should be made clear where the plotting errors reported in [1] come from. The final plotting error results from the two phases of plotting, the first of which is fixing the path of the meteor in the sky and the second is plotting the path fixed in the first phase onto the map. The error occurring in the first phase affects all kinds of recording techniques. The charts of the *Atlas Brno* which should be used for plotting are that accurate that the error of plotting a path once fixed in between the stars is very small. This means the first phase yields the greatest contribution to the final plotting errors.

The second phase of the counting method is the back-prolongation of the path under the sky which causes considerable errors for radiant distances above some 30°. This means the final error should be even bigger than that one of the plotting method.

Furthermore it is impossible to apply the criteria for shower association within their error limits given in [1] directly under the sky. Here the subjective component becomes too strong and may affect the final result considerably. Analyzing the plots at the desk, there is not much space left for subjective decisions: either the meteor meets all criteria within the well-defined error limits or it does not.

In minor shower observations we operate near the limits of visual technique's ability. Therefore we have to take special care of the reliability of our results. In this connection, the possibility of revising observations is an important point. Imagine there are two observers finding quite different results. In case they did counting, there are no data that can be checked. If they have plotted all candidates for shower membership, one can at least revise shower association.

Despite these objective arguments I know that people are lazy by nature. So it is much more comfortable only to record shower and other data on tape rather than to pull one's hands out of a warm sleeping bag into the cold winter air and plot the meteor. All this costs some 30 seconds the effective time must be reduced by. Furthermore the analysis of the plots takes some additional time during the day. But consider: you also make a major effort by getting up at night, reaching the observing site, ... Eventually, you have obtained an intersting result and then somebody comes who does not believe in it. In case you have chosen the comfortable way you have nothing at hand to prove your point. However, if you did take the little additional effort to plot, then you have the necessary documentation at hand.

Now, do not misunderstand this as a plea for plotting in every case. The arguments I gave are valid for minor shower observations when the meteor frequency is low (less than about 20 per hour). During the maximum of a major shower the dead time makes plotting useless for analysis, therefore counting is the most interesting method then. For choosing the most suitable method, please refer to [2].

Now some comments to the velocity estimates. If an observer is able to say which value on the 0–5 scale for instance a Monocerotid at 20° elevation and 50° radiant distance and a σ-Hydrid at 40° elevation and 60° radiant distance must have and which error limits on this scale are permitted he can estimate the velocity in °/s (described in [3]) as well. Sometimes I wonder how difficult it is to make observers try something new even if it is most simple and useful. During the 1990 Orionid campaign in Lardiers for instance, I really had to push an observer to try the method. After only two watches he was quite happy with it and his estimates corresponded quite well with those of the other observers. The point I want to make is that it is not difficult, probably new for the first time, but in doing so an important information is added to each meteor. Of all the observers that switched to this method I know nobody who returned to the 0–5 scale.

The second problem I want to address here also deals to some extent with documentation and reliability of visual results. During the last months an increasing number of observers reports sub-radiants of several showers, in particular of the Perseids. Some people claim that *IMO* officers such as myself do not believe in the reliability of these results. Therefore let me explain my point of view.

Considering the achievable plotting accuracy it is obvious that the detection of sub-radiants lies at the limit of what can be done visually. The closer one comes to that limit the more important the question of the reliability of the results becomes. In recent years, all kinds of visual results had a bad reputation due to their questionable reliability. This was the reason to declare improving the reliability as the prime goal of the Visual Commission [5]. Correspondence with professional astronomers show the reputation of visual results improving, thanks to the efforts of the *IMO*. To maintain this trend, we have to be very careful.

From all sub-radiants I have seen so far only the final result, i.e., the positions. But in order to evaluate the reliability of the results it is necessary to document very carefully the data the results are based on as well as the way the result has been obtained. In concrete terms, the observing method, the charts used for plotting, the participating observers, the quantity of data, the method of analysis, the original results (some kind of density distribution the positions were derived from) from which the significance of the individual radiants can be evaluated, must be given. I am looking forward to publications of this kind. Only on this basis it is possible to discuss the existence or non-existence of the sub-radiants.

Until that time, there is no reason to believe in the existence of sub-radiants as the more accurate techniques (photography [4] and telescopic observations) do not indicate this. To be considered as real, a sub-radiant should be detected independently by different observer groups to exclude possible systematic effects and show a radiant drift similar to that of the main radiant. The latter point is a necessary criterion as the particles forming a sub-stream have orbits similar to the main stream and thus similar intersection conditions with the Earths' orbit, resulting in similar radiant drifts. If the results are then based on a sufficient quantity of data (several hundreds, better thousands of meteors) it can be stated that there is probably a sub-radiant in the visual range. To analyze a sub-radiant in terms of magnitude distributions, rates, etc., it must have an activity comparable to the main radiant and a certain distance to the main radiant. Otherwise we record for the larger part some "pollution" from the main radiant, comparable to the sporadic pollution analyzed in [1]. To any fictive radiant in the vicinity of a major shower radiant it is possible to associate some 20% of the shower meteors. Therefore the activity of an analyzable sub-radiant must be significantly higher.

People planning the analysis of sub-radiants should consider the following too: an observer who plots a considerable number of meteors during the maximum of a major shower is unable to obtain useful ZHR data at the same time due to the dead time. During the maximum one observer can watch either for ZHR data or for sub-radiants.

At this point I must state that the ZHR data have priority for the Visual Commission as they are used in a global analyses to obtain mass distributions and spatial number densities. These quantities are of great interest and can be obtained from the visual observations with good accuracy and reliability. On the contrary, visual sub-radiants will always be somewhat questionable. They are better studied by more accurate techniques such as photography or telescopic observations which are in turn not very useful for mass distributions and spatial number densities. In other words, for each task we should use the right tool, not one tool for each task.

Nevertheless, if there are large observer groups observing at the same site it can be arranged that a few observers try to observe for sub-radiants. Perhaps they find something new which was not found for years by other people watching for ZHR data.

References

[1] R. Koschack, "Analysis of Visual Plotting Accuracy and Sporadic Pollution and Consequences for Shower Association", *WGN* 19:6, December 1991, pp. 225–241.

[2] R. Koschack, "Hints for Visual Observers", IMO INFO 5, 1991.

[3] R. Koschack, "Estimating a Meteor's Angular Velocity", *WGN* 18:4, August 1990, pp. 103–104.

[4] L. Kresák, V. Porubčan, "The Dispersion of Meteors in Meteor Streams: I. Size of Radiant Areas", *Bull. Astr. Inst. Czechosl.* 21, 1970, pp. 153–170.

[5] R. Koschack et al., "Program of the Visual Commission", *WGN* 17:6, December 1989, pp. 204–206.

About the VMDB-Input and the 1991 Deadline

Paul Roggemans

At this moment most data for 1991 should have arrive for input in the *VMDB*. We have, however, a number of repeated shortcomings in the data reporting.

First of all we regret that we receive most data such a long time after the observations took place. We intend to produce the 1991 edition of the *WGN Report Series* in April 1992. This means that **your reports** for 1991 should be ready now and **should reach us not later than March 1992**. Please try to respect this deadline as well as the following advice.

For small amounts of data, use the report form (first side of the sheet), according to the instructions given in the booklet *Hints for Visual Observations*. Despite the fact that every observer got a copy of this publication with the April 1991 issue of *WGN*, we noticed the following shortcomings in the reports:

- A plague among amateurs is their endless inspiration to discover minor streams. Some observers claim the existence of new radiants for which they report one or two meteors... Some reports list more radiants not recognized by the *IMO* than unquestionably existing streams! Moreover, about every national group has its own favorite radiants which differ from one group to the other. Nothing else but sporadics are counted for these phantom radiants and reported as observed streams. The numbers reported for these radiants are unsignificant, but before we can make any input we are forced to rewrite the report forms. We must remove the phantom radiants, add the meteors to the sporadic totals and modify both rate-reports and magnitude distributions: it is a very big waste of time. So please report only the radiants to the *IMO* given in the booklet *Hints for Visual Observers*. Herewith the *IMO* recognizes the limited capabilities of the visual observing technique. On the background of visual minor shower observations and the resulting limitations you could read more in the previous issue of *WGN*.
- You are urged to use intervals of effective observing that are long enough: one hour is a minimum. Moreover, do not split your observing nights up in short intervals: again, intervals of less than one hour should be avoided. In all cases, the center of the field of view has to be given: many observers still forget to report this. It is most important to provide magnitude distributions: for each observer independently, per stream, and per night. If the limiting magnitude varies strongly, or when an extreme high number of meteors is observed (many hundreds), then you should give magnitude distributions for intervals smaller than one night. However, do not make magnitude distributions per hour or per half hour. It is completely unrealistic to make make magnitude distributions with small numbers of meteors seen in intervals that are too short.
- 1991 Observations ready for input in the *VMDB* can be sent straight to Paul Roggemans (address on inside of back cover). If you want to have correspondence about your observing reports, or if you have questions or remarks about visual work in the *IMO*, send your letter and observations to the Director of the Visual Commission: Ralf Koschack. If you send the same observing reports to both Ralf Koschack and Paul Roggemans, please indicate this. Otherwise it may happen that your data are entered twice which can cause problems.

Visual Meteor Data Base Statistics for 1989 and 1990

Paul Roggemans

1. Introduction

The article about the *VMDB* statistics in *WGN* 18:6 (December 1990) provoked many positive responses from active observers. It is indeed interesting to read on who sees what, how much and in how much time. These statistics allow for a comparison of successive years and of the efforts of observers. For active observers these may lead to some competition trying to do the most observations; after all, there is nothing wrong with that.

One main conclusion from three years observing in the *IMO* is certainly that world-wide, there are not enough observers to follow the major streams adequately. As a consequence we are limited to certain streams for annual analysis, in function of the circumstances under which these streams appear. Nothing is to be said about the minor showers. These are endlessly more difficult to study and seem out of reach for any investigations from amateurs if there is not an extreme effort concentrated on one or a couple of such minor streams. Anyhow, the skill and experience necessary to recognize meteors from almost unactive radiants is that rare that there are not enough observers available to do the work. There is a crying need for more regular observers!

2. IMO totals

The *IMO* receives data from many more observers than the organization has members. We appreciate very much that observations are forwarded to the *IMO*. The more data we have, the more perspectives are opened to study the structures of streams. The totals below represent the efforts of many amateurs. One thing is very sure: never before so many observational data have been brought together!

The data below represent the status of the *VMDB* at the end of October 1991. Some other data having arrived very late has been entered since.

Table 1 – *VMDB* grand totals for 1988–1990

	1988–1990	1989	1990
Effective time	$15\,411^{\mathrm{h}}$	5322^{h}	4404^{h}
Meteors	283 377	89 493	78 586
Observers	770	412	339
Countries	26	21	21

For 1990, we did not yet receive the Hungarian and Italian observations, also the Perseids had a maximum spoiled by moonlight. Allowing for these factors, 1990 is a good year. Years with strong moonlight at the Perseid maximum will always turn out to be very less successful in these statistics since so many people observe *only* during the Perseid maximum. Such observers have little training and their observations are of limited value. Their absence will reduce the grand totals considerably, but influence very little the quality of the overall result. Regular observing is recommended.

Table 2 – Total observing time and number of meteors per month

Month	1988–1990		1989		1990	
	T_{eff}	N	T_{eff}	N	T_{eff}	N
January	$924^{\mathrm{h}}.19$	13331	$413^{\mathrm{h}}.70$	6147	$386^{\mathrm{h}}.93$	5775
February	$527^{\mathrm{h}}.47$	4953	$204^{\mathrm{h}}.57$	1925	$173^{\mathrm{h}}.61$	1550
March	$481^{\mathrm{h}}.49$	3283	$199^{\mathrm{h}}.13$	1310	$187^{\mathrm{h}}.62$	1404
April	$840^{\mathrm{h}}.48$	9540	$232^{\mathrm{h}}.44$	2133	$292^{\mathrm{h}}.97$	3622
May	$722^{\mathrm{h}}.46$	12972	$322^{\mathrm{h}}.86$	6800	$216^{\mathrm{h}}.23$	3733
June	$317^{\mathrm{h}}.31$	2814	$126^{\mathrm{h}}.13$	953	$104^{\mathrm{h}}.15$	1161
July	$1617^{\mathrm{h}}.74$	27156	$524^{\mathrm{h}}.23$	8767	$656^{\mathrm{h}}.86$	13531
August	$5642^{\mathrm{h}}.66$	133944	$1937^{\mathrm{h}}.24$	47661	$853^{\mathrm{h}}.53$	14327
September	$597^{\mathrm{h}}.79$	6348	$257^{\mathrm{h}}.41$	2029	$124^{\mathrm{h}}.34$	1330
October	$1333^{\mathrm{h}}.37$	19152	$405^{\mathrm{h}}.88$	4187	$653^{\mathrm{h}}.14$	11934
November	$1140^{\mathrm{h}}.02$	12812	$373^{\mathrm{h}}.32$	3365	$314^{\mathrm{h}}.02$	3599
December	$1265^{\mathrm{h}}.99$	37072	$325^{\mathrm{h}}.41$	4216	$440^{\mathrm{h}}.93$	16620
Total	$15410^{\mathrm{h}}.97$	283377	$5322^{\mathrm{h}}.32$	89493	$4404^{\mathrm{h}}.33$	78586

Looking at the efforts each month separately (Table 2) shows very well how efforts are naturally clustered around meteor shower maxima. The cold month of January gets a lot of attention due to the Quadrantids, but the warm month June on the northern hemisphere is very poorly covered. August 1990 was certainly not poor, compared to the other months, but the moon scared off the maximum watchers, cutting very deep in the 1990 statistics. An uniformed reader may tend to conclude that 1990 was a poorer year and pessimists could even suggest that the global interest in meteor observing is decreasing. Much depends on a very few observers at some strategic locations. When these are hampered by poor weather or moonlight on crucial nights or periods, that results in thousands of meteors and hundreds of hours less. Here also, you may never think somebody else will observe in your place. Remember on most nights only a very few amateurs will be out observing for the *IMO*, so be one of them!

3. The VMDB competition

Which country is the most active in meteor observing? Germany again!

Last year I sketched the evolution of meteor history. When I made the study for the *Bibliographic Meteor Catalogue*, I literary lived through 200 years of meteor history. I read when and how societies got established, how they collapsed and how meteor work passed through a long way of suffering. History is painful for some societies, even after more than 20 years. Referring to failures in the past seems to be unacceptable. Some societies were very disturbed by lasts' years overview of meteor history. While the reasons for failures in the past are crystal clear, some people deem it necessary react when these chapters of meteor history are reminded to the public of today.

The following table is very objective, the results are according to observational reports submitted to *VMDB*. It is not our fault when not all reports are sent to *IMO*. Also some care must be taken with countries that joined only in recent times: some did not yet provide data for 1988 (Japan, China, ...). Notice also that most meteors listed under Belgium are seen by two observers, while the other observers are often occasional participants, changing the observing group every year. The large number of observers is not a quality but a most unfortunate situation in this case, since nearly all observers quit after a single first observation.

I will not say anything more here, since any word too much seems to hurt national feelings easily. Are ashamed of your country? Great, take your flag, sing your national hymn and go out observing to improve your countries' reputation!

Table 3 – Total observing time and number of meteors per month

Country	1988–1990			1989			1990		
	Obs	N	$T_{\rm eff}$	Obs	N	$T_{\rm eff}$	Obs	N	$T_{\rm eff}$
Germany	44	81721	$3689^{h}.58$	32	24329	$1036^{h}.41$	31	23450	$1176^{h}.88$
Australia	137	50827	$2523^{h}.88$	71	17782	$1033^{h}.72$	063	16537	$732^{h}.10$
Belgium	106	27919	$1666^{h}.17$	44	6667	$460^{h}.44$	45	6831	$434^{h}.03$
Hungary	150	23891	$1687^{h}.67$	108	9231	$871^{h}.32$			
Spain	36	17713	$1024^{h}.09$	8	4179	$248^{h}.44$	30	7201	$383^{h}.46$
United States	43	17191	$963^{h}.63$	19	3311	$200^{h}.99$	28	6371	$418^{h}.63$
Japan	71	15190	$1230^{h}.53$	41	7279	$622^{h}.72$	67	7911	$607^{h}.81$
Malta	27	6828	$476^{h}.71$						
Norway	11	6344	$201^{h}.64$	8	1613	$62^{h}.22$	5	244	$13^{h}.96$
Italy	36	5890	$232^{h}.57$	23	2121	$116^{h}.74$	1	9	$1^{h}.48$
Finland	19	5318	$315^{h}.38$	12	1987	$133^{h}.84$	11	2453	$110^{h}.83$
the Netherlands	9	4646	$202^{h}.38$	3	968	$32^{h}.54$	4	1117	$79^{h}.81$
United Kingdom	5	4540	$370^{h}.19$	4	1713	$143^{h}.03$	2	1339	$97^{h}.89$
Yugoslavia	26	4492	$189^{h}.65$	18	3390	$111^{h}.51$	12	1102	$78^{h}.14$
Canada	3	2574	$131^{h}.91$	1	730	$34^{h}.89$	3	879	$66^{h}.29$
Soviet Union	4	2086	$60^{h}.66$	4	2086	$60^{h}.66$			
Brasil	8	1595	$65^{h}.09$	7	915	$26^{h}.13$	7	680	$38^{h}.96$
France	5	1486	$164^{h}.97$	3	715	$76^{h}.17$	5	242	$37^{h}.88$
Czechoslovakia	6	845	$46^{h}.88$				6	845	$46^{h}.88$
New Zealand	6	705	$44^{h}.04$	1	123	$7^{h}.69$	6	447	$26^{h}.69$
China	5	462	$28^{h}.44$	1	35	$3^{h}.00$	4	427	$25^{h}.44$
Taiwan	2	343	$8^{h}.00$				2	343	$8^{h}.00$
Bolivia	6	306	$26^{h}.60$				6	128	$14^{h}.61$
Rumania	2	268	$45^{h}.75$	2	152	$29^{h}.86$			
Hong Kong	2	167	$10^{h}.00$	2	167	$10^{h}.00$			
Ireland	1	30	$4^{h}.56$				1	30	$4^{h}.56$
Total	770	283377	$15410^{h}.97$	412	89493	$5322^{h}.32$	339	78586	$4404^{h}.33$

To stimulate you even more to defend your prestige, we dare to publish the list with the 25 most active observers, taken over the period 1988 to 1990. For some observers we got only data for some years. You can compare the overall top-25 with the activity displayed by the people in 1989 and 1990; the "Nr."-column refers to their place in the top-25 of that year. Some people already quit their activities, others will climb up with the years going by. Despite the few groups who do not find it useful to send data to the *IMO*, the observers in Table 4 are beyond doubt the most active observers in the world.

During three years it was possible to observe various radiants, but you may wonder how much meteors were seen from the different radiants? The list below mentions the total number of meteors seen for each radiant in the period 1988 to 1990, in 1989 and in 1990. We do not mention all radiants from the original *IMO* list. Only the mentioned in the *Hints for Visual Observers* by Ralf Koschack (*IMO Info* 5) of which at least 100 meteors were observed are listed. We may indeed conclude that if the world is not able to record more than 100 meteors of a stream in three years, that the activity was neglectable anyway.

The low numbers show how difficult it is to obtain sufficient information about minor streams. Moreover, not all meteors reported can be used for analyses, since all criteria are not always met. For instance, plotting work is required to identify these minor showers and even that is often not done! So please, if you insist on observing minor shower observer, follow the most rigorous observing procedure!

Table 4 – Total effective observing time ($T_{\rm eff}$) and numbers of meteors seen (Met.) per observer.

1988–1990				1989			1990		
Nr.	Observer	$T_{\rm eff}$	Met.	Nr.	$T_{\rm eff}$	Met.	Nr.	$T_{\rm eff}$	Met.
1	Rendtel Jürgen (Germ.)	$702\overset{h}{.}50$	10925	1	$173\overset{h}{.}44$	2736	1	$207\overset{h}{.}68$	3016
2	Knöfel André (Germ.)	$567\overset{h}{.}18$	8658	4	$137\overset{h}{.}05$	2718	6	$108\overset{h}{.}01$	1096
3	Trigo José (Spain)	$366\overset{h}{.}17$	8264	11	$99\overset{h}{.}12$	2254	7	$105\overset{h}{.}58$	3184
4	Wood Jeff (Austr.)	$360\overset{h}{.}28$	12427	7	$106\overset{h}{.}36$	3321	5	$119\overset{h}{.}34$	4922
5	Roggemans Paul (Belg.)	$350\overset{h}{.}40$	8339	9	$101\overset{h}{.}19$	1497	2	$160\overset{h}{.}74$	4221
6	Koschack Ralf (Germ.)	$340\overset{h}{.}11$	16458	8	$101\overset{h}{.}56$	5067	4	$121\overset{h}{.}83$	5144
7	Marsch Adam (Austr.)	$294\overset{h}{.}74$	2402	3	$142\overset{h}{.}60$	1206	3	$152\overset{h}{.}14$	1196
8	Rendtel Ina (Germ.)	$293\overset{h}{.}82$	9881	15	$74\overset{h}{.}85$	3119	8	$97\overset{h}{.}30$	2378
9	Plesier Ghislain (Belg.)	$287\overset{h}{.}04$	2282	2	$144\overset{h}{.}89$	1245	19	$54\overset{h}{.}22$	242
10	Platt George (Austr.)	$282\overset{h}{.}99$	6372	10	$99\overset{h}{.}16$	1959	26	$45\overset{h}{.}83$	1447
11	Glossop Mark (Austr.)	$281\overset{h}{.}15$	6211	5	$126\overset{h}{.}07$	2680	17	$61\overset{h}{.}08$	1592
12	Arlt Rainer (Germ.)	$268\overset{h}{.}27$	6220	14	$75\overset{h}{.}13$	2152	20	$51\overset{h}{.}99$	1059
13	McBeath Alastair (UK)	$224\overset{h}{.}58$	2198	22	$59\overset{h}{.}17$	517	10	$80\overset{h}{.}00$	968
14	Koch Bernhard (Germ.)	$200\overset{h}{.}91$	4404	19	$65\overset{h}{.}55$	1125	9	$87\overset{h}{.}65$	2442
15	Taibi Richard (USA)	$182\overset{h}{.}67$	1489	17	$66\overset{h}{.}16$	442	31	$40\overset{h}{.}51$	289
16	Rajala Leo (Finland)	$173\overset{h}{.}32$	3465	16	$66\overset{h}{.}65$	1204	12	$63\overset{h}{.}74$	1619
17	Lunsford Robert (USA)	$166\overset{h}{.}44$	5073	36	$38\overset{h}{.}35$	1117	15	$62\overset{h}{.}33$	1590
18	Coroneos Martin (Austr.)	$162\overset{h}{.}24$	4186	18	$65\overset{h}{.}67$	1482	21	$51\overset{h}{.}57$	1558
19	Kuschnik Ralf (Germ.)	$150\overset{h}{.}79$	2960	13	$75\overset{h}{.}40$	1746	41	$27\overset{h}{.}20$	363
20	Plesier Francis (France)	$122\overset{h}{.}91$	1126	20	$61\overset{h}{.}00$	544	86	$10\overset{h}{.}99$	53
21	Blackman Guy (Austr.)	$119\overset{h}{.}83$	2008	29	$45\overset{h}{.}54$	632	48	$22\overset{h}{.}29$	380
22	Mori Gabor (Hungary)	$111\overset{h}{.}04$	648	6	$109\overset{h}{.}10$	641			
23	Mameta Katsuhiko (Jap.)	$108\overset{h}{.}72$	1278	28	$45\overset{h}{.}56$	520	13	$63\overset{h}{.}16$	758
24	Rendtel Petra (Germ.)	$104\overset{h}{.}58$	3536	34	$39\overset{h}{.}77$	1467			
25	Bellot Luis (Spain)	$103\overset{h}{.}07$	749	21	$60\overset{h}{.}74$	434	29	$42\overset{h}{.}33$	315

Table 5 – Total number of meteors observed per shower

Shower	1988–90	1989	1990	Shower	1988–90	1989	1990
α-Bootids (ABO)	276	34	109	Piscids N (NPI)	110	48	19
α-Centaurids (ACE)	196	110	14	Taurids N (NTA)	1611	387	752
Aquarids (AQU)	3158	1568	462	o-Centaurids (OCE)	150	93	3
α-Scorpids (ASC)	691	223	242	Orionids (ORI)	4014	496	3056
Aurigids (AUR)	535	194	331	χ-Orionids N (ORN)	289	42	82
α-Capricornids (CAP)	4235	1546	1042	χ-Orionids S (ORS)	172	8	55
Coma Berenicids (COM)	835	368	379	Piscis Austrinids (PAU)	358	56	295
δ-Aquarids N-S (DAQ)	361	97	193	Perseids (PER)	70283	25305	4242
δ-Aurigids (DAU)	49	3	46	Phoenicids (Jul) (PHE)	179	124	38
δ-Cancrids (DCA)	248	93	57	Quadrantids (QUA)	4704	2470	2202
δ-Leonids (DLE)	187	55	49	δ-Aquarids S(SDA)	4641	1505	1724
ε-Geminids(EGE)	295	10	262	ι-Aquarids S (SIA)	676	271	369
η-Aquarids (ETA)	4906	2808	1399	σ-Orionids (SOR)	95	27	65
Geminids (GEM)	20445	318	11255	Piscids S (SPI)	344	146	64
Giacobinids (GIA)	63	0	12	Taurids S (STA)	1992	433	775
σ-Hydrids (HYD)	501	31	144	Taurids (TAU)	1805	413	412
Lyrids (Jun) (JLY)	149	28	40	θ-Centaurids (TCE)	144	54	69
κ-Cygnids (KCG)	4527	1460	753	θ-Ophiuchids (TOP)	98	35	30
Leonids (LEO)	1013	40	795	Ursids (URS)	107	77	22
λ-Sagittarids (LSA)	281	131	65	Puppid/Velids (VEL)	179	33	0
Lyrids (LYR)	1118	28	675	Virginids (VIR)	855	213	330
Monocerotids (MON)	405	25	161	ζ-Puppids (ZPU)	327	127	0
μ-Virginids (MVI)	111	32	21	Other showers (DIV)	10392	3354	3092
δ-Aquarids N (NDA)	2767	803	604	Sporadics (SPO)	127543	41819	41037
ι-Aquarids N (NIA)	427	9	406	Total	283377	89493	78586

For some streams, however, such as Giacobinids, which is a periodic stream, an exception must be made as here it is very normal that zero rates are reported, taking away doubt whether or not the meteoroids get distributed along large parts of the stream orbit.

4. Conclusion

In 1991 you got some very detailed stream analyses. Now we enter the latest 1991 observing reports into the *VMDB*. Please help us by sending correctly compiled reports for your 1991 data as soon as possible to the *VMDB*. We want to complete the input of all 1991 reports in March 1992, so make sure that your last reports arrive no later! The 1991 Report will be prepared for printing in April 1992. In these reports you find *all* visual observations received in time by the *IMO*. The *IMO* does not only *collect* observing data; *everybody* can get the collected visual observations by simply ordering *WGN*'s *Report Series*! Thank you for your assistance and please observe as much as you can!

Instructions for Reporting 1992 Visual Observations

Paul Roggemans

From the beginning of 1992 onwards, the work within the Visual Commission will be reorganized. In the past, I took care of much of the input of the *VMDB*. This job however takes so many hundreds of hours that it became much more time-consuming than the job of Secretary-General. Moreover, observers also send letters with questions and request along with their reports. These requests are about analyses, literature, programs, etc. concerning visual observing within the *IMO*. Replying to these letters takes even more time. Those letters concerning questions, analyses, etc,, should be addressed to the Director, *Ralf Koschack* (see slightly changed address on inside of back cover). Observing report forms and data should be sent to *Rainer Arlt* (address on inside of back cover) who will be responsible for entering data into the *VMDB*.

However, observational reports regarding 1991 should still be sent to Paul Roggemans, provided they reach him before the end of March 1992.

The 1992 IMO International Meteor Conference

Smolenice Castle, Slovakia, CSFR, July 2–5

Daniel Očenas and Peter Zimnikoval

The 1992 *IMC* will be held at the Smolenice Castle, which is very nice place in the Carpathian Mountains, about 70 km from Bratislava. Participants are expected to arrive on Thursday, July 2, in the afternoon or the evening. An introductory meeting is planned. Friday, July 3, is a full day of lectures, discussions and workshops. On Saturday, July 4, there are more lectures as well as an excursion and the 4th *IMO* General Assembly. On Sunday, July 5, before noon, some more lectures will be given after which the event will be closed.

Participants will be accommodated in the Smolenice Castle in rooms with 2–4 beds. Meals will be provided by the castle's kitchen.

The registration fee is 150 DEM and includes accommodation, full board, the excursion, some little souvenirs and the proceedings. A pre-payment of 100 DEM is due no later than May 1992. Instructions for payment will be sent after receiving the registration form. Participants from currency-restricted countries should contact the local organizers:

Daniel Očenas, M. Razusa Street 5, CS-974 00 Banska Bystrica, CSFR, phone +42-88 542 64, or
Peter Zimnikoval, Hvezdaren, CS-975 90 Banska Bystrica, CSFR, phone +42-88 246 33.

If you did not yet register with the form in last year's October issue of *WGN*, please do so now! For your convenience, the registration form is reprinted in this issue. We already have a lot of participants from Japan, Canada, the former Soviet Union, and many countries of Eastern and Western Europe. Several professionals have already registered and many others are also expected. Do not miss this most international event!

The *IMC*'s final day will parallel the first day of the professional **International Astronomical Symposium (IAS)**, titled **Meteoroids and their Parent Bodies**, in the same building. The *IAS* is held from July 6 till July 12. Amateurs also interested in attending this meeting should contact:

Dr. Anton Hajduk, Astronomical Institute, Slovak Academy of Sciences, Interplanetary Matter Division, CS-842 28 Bratislava, CSFR, phone +42-7 495634, fax +42-7 496849.

International Meteor Conference, July 2–5, 1992
International Astronomical Symposium, July 6–12, 1992

Smolenice Castle, Slovakia, CSFR

Registration form

The undersigned wishes to register for the 1992 *IMC* or to receive further information:

Name: ______________________________

Address: ______________________________

____

Phone: ____________ Fax: ____________ E-Mail: ____________

Interested to attend:	*IMC* only, July 2–5	Yes/No
	IAS only, July 6–12	Yes/No
	IMC and *IAS*, July 2–12	Yes/No

Wishes to present a poster/lecture/workshop, the title of which is:

____

Date and signature: ______________________________

Send this form to *Daniel Očenas, M. Razusa Street 5, CS-974 00 Banska Bystrica, Czechoslovakia*, phone: +42-88 542 64.

Visual Observers' Notes: March and April 1992

Jeff Wood

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

Table 1 lists some of the meteor showers to be seen in March and April 1992. Table 2 shows moonlight and observing conditions. The illuminated part of the Moon is always given for 0^h UT on the date indicated. The dates of the phases of the Moon are also given in UT.

The Visual Commission of the *IMO* although requiring data on all streams realizes practical considerations like work, study, family, Moon and weather prevent people from observing regularly on a day by day basis throughout most of the year. With this in mind, it has been decided to encourage everyone who has time to observe to concentrate on a couple of showers per month rather than the whole lot. This means we should be able to get a good set of data on these few rather than sparse data on many showers. The showers chosen for special investigation for the months of March and April are the Virginids, δ-Leonids, γ-Normids, δ-Pavonids, α-Scorpids, π-Puppids, and the theoretical radiants of 1863 Antinous and 1981 Midas.

1. Virginids

This shower is very complex and is active from February 1 through to May 30. There are many subradiants and submaxima. Observers are encouraged to continue the project outlined in the Visual Observers' Notes for January and February 1992 [1].

Table 1 – A list of some of the meteor showers to be seen in March–April 1992.

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

Table 2 – Moonlight and observing conditions in March–April 1992.

Date	k	Date	k
Friday February 28	0.25−	Friday April 03	0.00+
Friday March 06	0.02−	Friday April 10	0.45+
Friday March 13	0.60+	Friday April 17	1.00−
Friday March 20	0.98−	Friday April 24	0.59−
Friday March 27	0.42−	Friday May 01	0.04−

New Moon:	March 4, April 3, May 2
First Quarter:	March 12, April 10, May 9
Full Moon:	March 18, April 17, May 16
Last Quarter:	February 25, March 26, April 24

2. γ-Normids

This shower is often misnamed the Corona Australids due to a transcription error by the great New Zealand meteor worker R. MacIntosh in 1935. The γ-Normids are active from February 25 through to March 22. A variable maximum of 3 to 15 meteors per hour occurs on March 14. They are fast meteors and are best seen from the southern hemisphere in the pre-dawn hours. With favorable Moon-conditions, the *IMO* urgently requires observations of this stream. Observers should locate their field center no more than 40° away from the radiant and plot all possible γ-Normids seen. If observers wish to monitor both the δ-Pavonids and the γ-Normids, the field center must be located around $\alpha = 270°$ and $\delta = -55°$.

Table 3 – Radiant positions of the γ-Normids.

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

3. δ-Pavonids

The δ-Pavonids are thought to have been formed from the debris of Comet P/Grigg-Mellish (1907 II). Observations to date indicate that the shower produces variable activity with rates at maximum varying in the range of 5 to 15 meteors per hour with the radiant reaching its greatest altitude in the southern hemisphere skies in the pre-dawn hours, the δ-Pavonids should provide moon-free viewing for all of their period of activity except from March 16 to 26. The δ-Pavonids appear to have several maxima during the period March 30 to April 10, apart from the major one that occurs on the moring of April 7. With this in mind, southern hemisphere observers are encouraged to give the δ-Pavonids particular attention in 1992. They should locate their field center no more than 40° away from the radiant and ensure that all meteors seen are plotted.

Table 4 – Radiant positions of the δ-Pavonids (diam.: 10° × 5°).

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

4. April Lyrids

The Lyrids are active from April 16 to 25 reaching a maximum of between 10 and 15 meteors per hour on April 22. On a few occasions, the most recent being in 1982, rates have been much higher almost reaching 100 meteors per hour. The Lyrids' parent body is comet P/Thatcher (1861 I). In 1992, the start of the activity period is heavily affected by the Moon. From April 21 onwards observers in the northern hemisphere can start to watch the shower around 22^h local time when the radiant reaches sufficient elevation and should continue until the Moon reduces the limiting magnitude below 5.5. In the southern hemisphere, the radiant altitude and the Moon make the viewing conditions very difficult. Observations should only be made if the limiting magnitude exceeds 5.5.

With a V_∞ of 49 km/s care need to be taken when identifying meteors as Lyrids. Observers should ensure that the center of their field of view is no more than 40° from the radiant. Also they should plot all meteors seen unless the ZHR exceeds 10 when countings are permitted. Only at maximum is this likely to be the case.

Table 5 – Radiant positions of the Lyrids (diameter: 5°).

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

5. α-Scorpids

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

With a velocity V_∞ of 35 km/s, and several other Scorpio-Sagittarid radiants active in the same region of the sky, especially in May and early June, special care need to be taken when recording and classifying these meteors.

Table 6 – Radiant positions of the α-Scorpids (diameter: 5°).

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

Observers should plot all possible α-Scorpids seen. They should center their field of view no more than 30° from the radiant.

6. π-Puppids

The π-Puppids are a young meteor shower having been recorded only over the last 20 years. Their parent body is comet P/Grigg-Skjellerup. The π-Puppids are a periodic shower occurring in great numbers every five years. Rates therefore range from almost zero up to 40 per hour. The last strong activity was in 1987 and so 1992 should see a return to good rates.

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

With the Full Moon occurring on April 17, observers should be able to get a few hours of dark sky during the evenings on and about maximum (April 23). Unless rates exceed 10 per hour, all possible π-Puppids seen should be plotted. Observers should center their field no more than 40° from the radiant.

Table 7 – Radiant positions of the π-Puppids (diameter: 5°).

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

7. Theoretical radiants of 1863 Antinous and 1981 Midas

The Earth has a closest approach to the orbit of the minor planet *1863 Antinous* on April 6 (distance: 0.178 AU). Possible meteors have a V_∞ of 19.6 km/s and should radiate from $\alpha = 204°$, $\delta = +32°$ (April 6), $\alpha = 212°$, $\delta = +31°$ (April 16) [2].

A closest approach with the orbit of *1981 Midas* occurs on March 20 (distance: 0.001 AU). Possible meteors have a V_∞ of 30.1 km/s and a radiant at $\alpha = 205°$, $\delta = +35°$ (March 10), $\alpha = 213°$, $\delta = +34°$ (March 20) [2].

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

It should be noted that the theoretical radiant positions may differ somewhat from the actual observed ones by some degree. This means that it is impossible to carry out shower associations and obtain ZHRs using standard observing procedures. What needs to be done is to investigate whether or not there is a significant radiant in the vicinity of the predicted one. In order to do this, observers should center their field of view at a distance of less than 20° from the predicted radiant position and plot all meteors seen that radiate from an area of about 25° around the predicted radiant position onto the Atlas Brno gnomonic charts. The X,Y-coordinates of the plots should be measured (see [3]) and reported in the table format described in the Aquarid Project (see [4]). Please of course mention the chart number.

In 1992 the *IMO* requests that observers watch the 1863 Antinous radiant from March 27 (radiant position $\alpha = 195°$, $\delta = +33°$) to April 16 (radiant position $\alpha = 212°$, $\delta = +31°$). The 1981 Midas radiant on March 20 is badly affected by the Moon. However, northern-hemisphere observers can start to watch this radiant around 21^h local time and should continue until the Moon reduces the limiting magnitude too greatly. The radiant should be monitored from March 21 (radiant position $\alpha = 214°$, $\delta = +34°$) to March 30 (radiant position $\alpha = 220°$, $\delta = +33°$).

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Telescopic Observers' Notes: March and April 1992

Malcolm J. Currie

Recently, I was able to complete the data entry and file-format currently being analyzed with *RADIANT* [1,2]. Already, interesting results are emerging, and a full report will appear later in the year. *RADIANT* is proving to be an excellent tool for telescopic-meteor analysis. During December last there were clear skies too in western Europe. I personally, was able to observe throughout the Geminids, though limited by mist before midnight and especially around maximum, the total was 447 meteors during 9 nights. The watches during December 5-6 to 10-11 will complement the 1990 data. Likewise many sites were clear for the Quadrantids, and one report has already arrived.

Mark Vints has submitted his 1991 Perseid data. It was another classic Lardiers campaign, observing every night save one, between August 3-4 and 15-16, totaling 511 meteors in $T_{\text{eff}} = 22\overset{h}{.}22$. Mark used a 10×50 binocular with a $6\overset{\circ}{.}2$ field. This impressive total was despite the fact that sky conditions were poor for Lardiers. The most striking feature of the data is the paucity of Perseids. Even on the nights around visual maximum, less than ten per cent of the meteors were Perseids (on August 11-12 there were 3 Perseids of 33 meteors in total; August 12-13, 5 of 36; and August 13-14, 2 of 85). These data imply a steeper luminosity function than observed in previous years and are surprising given the high number of faint Perseids reported by some visual observers. [3]

Torsten Hansen reports an analysis of his 1991 Taurid observations. This shower has never been a successful target for me, perhaps because of the 127-mm aperture I use, therefore I was delighted to hear of a successful five-night campaign with 50-mm binoculars. Torsten has found that the northern component had a "relatively sharp radiant near the theoretical one." In comparison Torsten "could not find a clear image of the southern component at all" except on October 9-10, 1991, when 5 southern Taurids intersected within a $2\overset{\circ}{.}5$-diameter area at $\alpha = 27\overset{\circ}{.}5$, $\delta = +13\overset{\circ}{.}5$. Generally, the northern component gave higher rates than the southern. Torsten also looked out for Draconids on October 9-10, but with no success.

Forthcoming events

Although activity is at its nadir during the period, this does not mean that there is nothing worth observing. The fact that telescopic observations during the period are few and far between, means that there are excellent prospects for discovering a new radiant and identifying which minor showers are active. There is the pleasure of watching a shower few others have studied. Also the reduction in rates is less pronounced than for the naked-eye observer [4]—the average meteor magnitude is at its faintest [5].

The Lyrids are affected by a waxing gibbous moon, therefore I should urge observers to concentrate their watches during the period on the *Virginids*. The Virginids is the collective name for several irregular- and low-activity radiants that emanate within a small area of sky. For that reason they are best studied by positional data, particularly by telescopic and video techniques. In addition the medium velocity of Virginids increases their probability of being observed telescopically, and the showers have a high population index indicating richness in faint meteors. Visual observations have indicated numerous showers over the years, but many of these are probably spurious because of the difficulty of shower discrimination. For instance, the 1990 telescopic plots only show two main centers.

What I would like to see is *IMO* collect data over a number of years to map the complex, and to determine which radiants are genuine and which are bogus. Since activity persists from mid-February through May the Virginid complex may be studied every year, and the equatorial location of the complex makes it amenable to observers in both hemispheres, thus making it a good target for *IMO*. Given the level of activity I doubt that sufficient data can be collected in a single year. However, plotting will give objective data, which can be analyzed at leisure. Data from different techniques can be combined in *PosDat* to give a more complete picture. Only once a map of the true centers are known can individual years be reviewed to see which components were present in each of them.

Because of the density of radiants it is vitaly important for watchers to concentrate on plotting the meteor trail as carefully as possible. The critical parameter is the orientation of the meteor. Use two pairs of adjacent stars that span the meteors' path, and estimate the fractional position between each pair of stars, e.g., one third from star A to star B. The wider the separation between each stellar pair, the more accurate the orientation will be. Only once the path is fixed should the details be transferred to the chart. Also it is important to select several field centers so that the effect of radiant occlusions is reduced.

Choose at least three field centers around $\alpha = 175°$–$220°$, $\delta = +5°$–$20°$ separated by about 20° moving south-eastward through the shower's duration. See Table 4 of [6] for the radiant drift. Southern-hemisphere observers might prefer centers south of the complex. I am deliberately vague as a variety of centers will help resolve occlusions. Being near the galactic pole the normal criteria for field selection (stars well-distributed both spatially and in brightness) may have to be relaxed, though the spatial criterion is more important for determining accurate paths.

The *δ-Leonids* are slow moving, and active during February to mid-March peaking around February 22 from an average radiant $\alpha = 156°$, $\delta = +19°$. Visually, the rates are low, but this shower is worth checking telescopically as it has a high population index. Since activity is concurrent with the Virginids, field centers need to be selected carefully. In order to determine the location of the radiant it may be beneficial to select an additional center around $\alpha = 160°$, $\delta = 0°$ during March's new-moon period. See Table 5 of [6].

Southern observers might also like to tackle the δ-Pavonids during April's dark time. Their radiant is elongated and may contain distinct sub-centers. Visually, sub-maxima have been recorded, lending weight to that speculation. Careful plotting should resolve major sub-components. One pair of field centers are $\alpha = 268°$, $\delta = -35°$ and $\alpha = 176°$, $\delta = -65°$. If the altitudes of the field centers permit, centers closer to the radiant than these are desirable.

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Erratum and Addendum

The 1991 Perseids from Crimea and Siberia

communicated by A.I. Grishchenyuk

In WGN 19:6, December 1991, pp. 243–244, we published some tables presenting Crimean an Siberian data concerning the 1991 Perseid outburst. Meanwhile, Mr. Grishchenyuk sent us a corrected version of the second table of the above mentioned note. Therefore, we republish the corrected table below.

Table 1 – Uncorrected Perseid rates obtained by A.I. Grishchenyuk (GA), D. Suchov (SD) and O. Semenov (SO) from Malorechenskoe, Crimea, on August 12-13, 1991.

Time (UT)	T_{eff}			Lm			Per		
	SD	GA	SO	SD	GA	SO	SD	GA	SO
19^h00^m	0.75	0.75	0.75	5.9	6.1	6.0	28	36	34
20^h00^m	1.00	1.00	1.00	6.1	6.3	6.1	42	52	44
21^h10^m	0.82	0.82	0.82	6.2	6.2	6.2	84	91	81
22^h20^m	1.12	1.12	1.12	6.2	6.3	6.2	82	92	77
23^h40^m	1.57	1.45	1.58	6.3	6.3	6.3	159	157	168
02^h05^m	0.66	0.66	0.66	6.0	6.0	6.0	56	61	62

Moreover, Mr. Grishchenyuk was so kind to communicate to us Perseid magnitude distributions for the night of August 12-13.

Table 2 – Magnitude distributions for the Perseids on August 12-13, 1991, as observed by A.S. Levina (LA), A. Smetanko (SA) and D. Karkach (KD) from Krasnoyarsk, Siberia, and by A.I. Grishchenyuk (GA), D. Suchov (SD) and O. Semenov (SO) from Malorechenskoe, Crimea.

Obs	−7	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	Tot	$\overline{m}$
LA			0.5	2.5	3	9	11.5	37.5	71	146	94	56.5	4.5	436	1.93
SA			0.5	2.5	3	8	12	42	66	156	103	58.5	11.5	463	2.00
KD			0.5	1.5	2	6	11	42.5	66.5	118	54	50	6	358	1.93
GA	1			1		5	3	14	27.5	96.5	217	118.5	5.5	489	2.75
SD		1		1	1	1	3	12	14.5	84.5	237	92.5	3.5	451	2.80
SO		1		1	2	0.5	3	13.5	21.5	94	241	95.5	3	476	2.75

Given the fact that the circumstances in Krasnoyarsk and Malorechenskoe were comparable (limiting magnitudes of 6.0–6.3 *in both cases, depending on the individual observers), the difference of about* 0.8 *in average meteor magnitude between both sets of observations confirm that the 1991 Perseid outburst was much richer in bright meteors than the "traditional" maximum, as was already reported by Japanese observers [1]. (Ed.)*

[1] P. Roggemans, M. Gyssens, J. Rendtel, "One-Hour Outburst of the 1991 Perseids Surprises Japanese Observers!", *WGN* 19:5, October 1991, pp. 181–184.

The Importance of the Taurids

Duncan Steel, Anglo-Australian Observatory

The Taurid Complex is believed to contain, apart from four meteor showers (the Northern and Southern Taurids, and the Daytime ζ-Perseids and β-Taurids) which represent the four intersections of a broad stream with the Earth, in addition several Apollo-type asteroids (2201 Oljato, 5025 P-L, 1982 TA and 1984 KB) and comet Encke. In the past year two new asteroids have been discovered (1991 GO and 1991 TB2) which also appear to be members of the complex. The implications of this, and the importance of the complex to mankind, are discussed herein. Monitoring of the Taurid meteor shower activity, and the determination of Taurid orbits, are to be encouraged as having the potential to provide important data of use in determining the future activity of the complex.

1. Introduction

The two night-time meteor showers known as the Northern and Southern Taurids are very well known, and have been studied for many years. Some of the first meteor orbits to be determined, as part of the Harvard photographic survey commencing in the 1930's under F.L. Whipple, were Taurids. These showers have a peak activity in November but are active from at least mid-September through to the beginning of December [1], although recently it has been suggested that in fact the showers continue right through to February [2]. Soon after the advent of decameter radars in World War II the daytime intersection of the Taurid stream with the Earth, which had been suggested by Whipple, was observed in the form of the Daytime ζ-Perseid (first half of June) and β-Taurid (last week of June – first week of July) meteor showers. The subdivision of these broad showers into individual components (e.g., Arietids, Piscids, ρ-Geminids) has been discussed in detail by Štohl and Porubčan [2] and will not be repeated here.

The Taurid Complex of meteoroids is of considerable interest since it seems to be the product of the break-up of a very large comet, the decay and spreading being well-advanced in the present epoch. With co-workers at the University of Oxford I have investigated the possible origin and evolution of the Taurid Complex using as a basis the Taurid meteor orbits available from the IAU Meteor Data Center (Lund Observatory, Sweden), and we have shown that the break-up of a giant comet occurring over about the last 20 000 years (a brief time, astronomically) is not inconsistent with the observed spread in orbital elements amongst the meteors [3]. An additional confirmation of this time-scale, which was derived solely on dynamical grounds, we take to be the apparent association with the Farmington meteorite which fell in Kentucky in 1890. Dating of that meteorite indicates a space-exposure age (i.e., a time in heliocentric orbit free from shielding after release from within its larger parent object) of only 7000–25 000 years, which is rather more than an order of magnitude less than for any other meteorite (see [3] and citations therein). However, it is fair to note that although the time of fall (late June) and radiant of Farmington support an association with the Taurid Complex, its physical characteristics does not do so, at least according to present-day ideas on the nature of meteorites.

To summarize the last paragraph: the Taurid Complex is of interest astronomically since it seems to be the product of the comparatively-recent decay of a large comet. Therefore studies of the Taurid meteor showers, which have been reported in the pages of this journal too many times for individual references, are to be encouraged (see also [4]).

However, the Taurid Complex is also of significance since if the hypothesis of Clube and Napier [5] is correct then it has directly affected the human race at many stages of our past history, and will continue to do so with catastrophic consequences. Briefly, the hypothesis says that the Taurid Complex contains a marked concentration of large fragments of the parent comet, with a major portion of the progenitor perhaps awaiting discovery [6]. As the orbit of the Taurid Complex evolves, this concentration cyclically (over millenia) attains a node at 1 AU, and in such epochs (lasting for a century or so) the Earth is subject to multiple impacts by 50–200 meter objects. The last such large impact was the Tunguska event in 1908, although there is evidence for more recent enhancements [3]. Further, not only would such impacts (mostly resulting in airbursts in the atmosphere) result in widespread damage to human activities, but in addition the terrestrial climate would be severely affected; hence the title of the Clube and Napier book [5]. We thus see that the Taurids are indeed of considerable importance, both from the altruistic point of view (the pursuit of scientific understanding) but also from a self-serving aspect: if Clube and Napier are correct then it would benefit us immensely to learn as much as we can about the Taurid Complex before the next epoch of large impacts comes around.

2. The asteroids and comets in the Taurid Complex

One problem with regard to numerical integrations of orbits such as reported in [3] is that individual meteor orbits are not of high precision, nor can they be considering the short time during which the trajectory can be observed. However, macroscopic objects in space (asteroids and comets) can be observed over an extended period and hence their orbits accurately determined. Numerical integrations of such orbits, to see how they are dispersed from each other over periods measured in units of 10^4 years, are therefore possible. To this end it is very useful to have as many individual objects as possible, and thus recent discoveries are of interest.

In the past, following the work of others, I have suggested [7] that the Taurid Complex contains at least four Apollo-type asteroid in addition to periodic comet Encke, whose orbit and its relation to the Taurid meteoroid stream was investigated several decades ago by Whipple. I have also suggested [7] that comet 1967 II Rudnicki might be a member of the Taurid Complex, although Štohl (personal communication) points out to me that there are problems in reconciling its long-period orbit with the short-period nature of the other known Taurid-Complex objects. The orbits of these four Apollos and comet Encke are given in Table 1. The only parameters given are the semi-major axis (a), eccentricity (e), perihelion distance (q), inclination (i) and longitude of perihelion ($\pi = \Omega + \omega$, where Ω is the longitude of the ascending node and ω is the argument of perihelion); π has been seen in the past to be of great utility in defining associated streams (e.g., see [1]), and in the case of such a broad, well-developed stream such as the Taurid Complex the familiar Southworth and Hawkins or Drummond D-criteria are of little use since they rely upon the values of Ω being similar for a stream (i.e., most showers last for only a week at most) whereas this is clearly not the case for the Taurid Complex (see the discussion in [3]).

Table 1 – Some orbital parameters of large Taurid-Complex objects

Object	a	e	q	i	π	Source
P/Comet Encke	2.22 AU	0.846	0.341 AU	11°9	160°	[7]
2201 Oljato	2.17 AU	0.712	0.626 AU	2°5	172°	[7]
1982 TA	2.30 AU	0.773	0.523 AU	12°2	129°	[7]
1984 KB	2.22 AU	0.762	0.528 AU	4°6	146°	[7]
5025 P-L	4.20 AU	0.895	0.439 AU	6°2	146°	[7]
1991 GO	1.96 AU	0.662	0.663 AU	9°7	113°	[8, 9]
1991 TB2	2.40 AU	0.836	0.394 AU	8°6	132°	[10]

One finding of our modeling of the dispersal of the Taurid meteoroids [3] was that any object with a smaller semi-major axis will tend to lag behind the precession in π shown by the others (i.e., the precession rate depends upon a, or the aphelion distance Q, since those with larger values for these parameters come closer to Jupiter and thus suffer larger perturbations). Thus it was of great interest to find that asteroid 1991 GO, discovered by K. Endate and K. Watanabe from Japan in April [8], has an orbit [9] which strongly suggests it to be a Taurid-Complex member, but with a smaller value of a than the other known asteroids (or comet Encke) and with a value for π, as expected from the modeling, that is also smaller than those for these asteroids (see Table 1). The likely membership of 1991 GO in the Taurid Complex was kindly pointed out to me by David Asher (Oxford).

More recently has come the discovery of 1991 TB2, which also appears to be a Taurid-Complex asteroid. This body was discovered independently by J. Mueller and C. Shoemaker from Mount Palomar in California on October 3 and 6 respectively [10]. Again the relevant orbital parameters are listed in Table 1: note that for both 1991 GO and 1991 TB2 the stated orbits may be altered as later astrometric data become available. 1991 TB2 is of interest, apart from being one more member of the TC which therefore adds weight to the significance of this stream or structure, in that it has a larger a and e than the other three Apollos with $2.0 < a < 2.5$ AU (note that 5025 P-L has a very poorly-determined orbit), and a smaller q. It may well, therefore, be one body which is in a different precession cycle than the other asteroids (cfr. modeling by Steel et al. [3]).

3. Why continued observations of the Taurid showers may help our understanding

The fact that the two night-time branches of the Taurid stream do not show equal activities, as is also the case for the daytime showers, is important information which allows constraints upon the orbital evolution (and hence age) of the Taurid Complex to be imposed. It is important to note that the balance between the branches may be expected to vary in time over periods of several years or decades, and such variation may be interpretable in terms of not only the precession of the stream components but also as an indicator of likely future activity (e.g., when the major swarm suggested by Clube and Asher [6] is going to swing around and be in an Earth-intercept orientation, with possible catastrophic consequences). Therefore consistent, continued monitoring of the Taurids over many years may be invaluable.

Our numerical integrations [3] indicate that Taurid-Complex objects often exist in mean-motion commensurabilities (resonances) with Jupiter, which planet controls their orbital evolution. In addition concentrations amongst the observed meteoroid orbits appear near the 9:2, 4:1 and 7:2 resonances; these correspond to semi-major axes of 1.91, 2.06 and 2.26 AU respectively, and the 3:1 resonance relates to a semi-major axis of 2.50 AU (few such meteoroids are observed in the Taurid Complex, apparently, since with such a high eccentricity this sized orbit would have aphelion near Jupiter and thus be lost from the Taurid Complex on a time scale rather shorter than its age). However, the reality or otherwise of such concentrations cannot be proven/disproven until such time as a rather larger set of Taurid meteor orbits becomes available. Again, this is an area in which observations by amateurs may prove to be invaluable, in view of the excellent results gained over the past few years by groups using small cameras to determine meteor orbits. Such work on the Taurids is to be encouraged.

Acknowledgment

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Icarus, 1991 RC and the Daytime Arietids

Duncan Steel, Anglo-Australian Observatory

The Earth-crossing asteroid 1991 RC was discovered in early September 1991 from the Anglo-Australian Observatory. Its orbit has a large eccentricity and a very small perihelion distance. These two orbital parameters, along with its inclination to the ecliptic, very nearly match those of asteroid 1566 Icarus. It is therefore possible that the two asteroids form a "stream", of which the Daytime Arietid meteor shower might also be a member.

A peculiar minor planet has been found as part of the Anglo-Australian Near-Earth Asteroid Survey (AANEAS). Earth-crossing asteroid 1991 RC was discovered by Robert H. McNaught on a plate taken September 3rd using the U.K. Schmidt Telescope at Siding Spring Observatory in New South Wales. 1991 RC is noteworthy because it has a small orbit very similar to that of 1566 Icarus, and thus passes close to the Sun. It is the eleventh Earth-approaching minor planet discovered since AANEAS began in May 1990.

In tracking such fast-moving asteroids, normally discovered when they are close to the Earth, international cooperation is often necessary, and the orbit of 1991 RC was only well-determined when follow-up astrometric positions were determined by Jim Scotti (University of Arizona) using the Spacewatch telescope at Kitt Peak National Observatory. The orbit of 1991 RC was quickly recognized by Brian Marsden (Minor Planet Center and the Central Bureau for Astronomical Telegrams, Cambridge, Massachusetts) to be virtually identical in several ways to that of 1566 Icarus [1]. The latter asteroid was discovered in 1949 soon after the commissioning of the 1.2-meter Schmidt telescope at Mount Palomar in California [2], this being the earlier twin of the UK Schmidt; it is therefore appropriate that 1991 RC, the twin of Icarus, was discovered using the telescope in Australia.

1566 Icarus was so-named due to the fact that at the time of its discovery it had by far the smallest perihelion distance (closest approach to the Sun) of all known asteroids, this fitting in with the Greek legend of Daedalus and his son Icarus, who escaped from their jail in a tower by constructing wings of feathers and wax; but Icarus flew too high, too close to the Sun, and the wax of his wings melted. With a perihelion distance of 0.187 AU Icarus held the record until 1983 when 3200 Phaethon, with perihelion at 0.140 AU, was discovered using data from the Infra-Red Astronomy Satellite; Phaethon is the parent of the Geminid meteor shower. Icarus is also noteworthy on account of its small orbit and concomitant short period (about 1.12 years), and its relatively high inclination to the ecliptic (near 23°). 1991 RC turns out to have almost identical values for these parameters (see Table 1) pointing to its being a twin of Icarus, the two presumably being fragments of a disrupted larger body.

Table 1 – Orbits of 1566 Icarus and 1991 RC (Epoch 1950.0).

Object	a	e	q	i	ω	Ω	Source
1566 Icarus	1.078 AU	0.8268	0.1867 AU	22°.89	31°.20	87°.49	[7]
1991 RC	1.082 AU	0.8287	0.1854 AU	23°.54	8°.16	160°.65	[1]

But was this body an asteroid, or a comet? Comets are often observed to split, most recently periodic comet Chernykh (1991 *o*) in mid-September [3], and Icarus has been thought for some time to be a prime candidate as an extinct or dormant comet due to its high orbital eccentricity and the likelihood of an associated meteoroid stream, the Daytime Arietids [4,5] (although McIntosh [6] has indicated that this stream may be related to the δ-Aquarids, the Quadrantids and Comet 1986 VIII P/Machholz). Recently Don Yeomans (Jet Propulsion Laboratory, California) has shown that Icarus has a small but consistent variation in its orbit which may be ascribed to non-gravitational forces of the type observed in comets [7], most probably due to low-level outgassing not directly detected; this adds weight to the idea that Icarus is a comet masquerading as an asteroid.

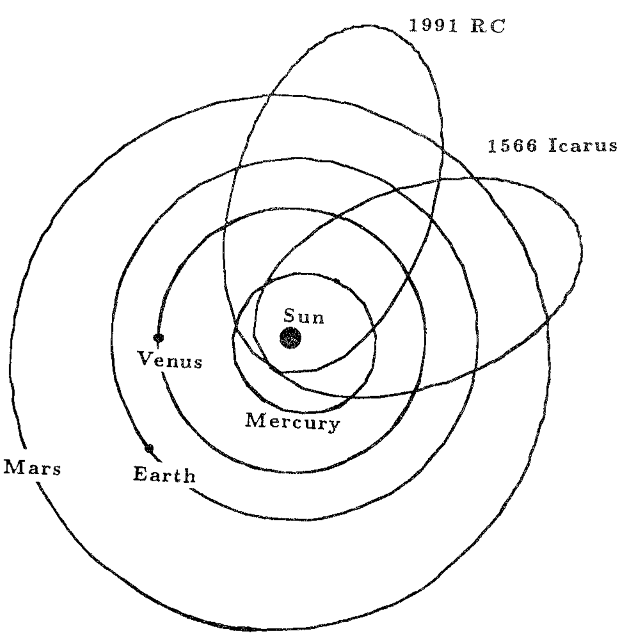

Figure 1 – Ecliptic projection of the orbits of the terrestrial planets plus asteroids 1566 Icarus and recent discovery 1991 RC

How long ago might Icarus and 1991 RC have been conjoined, as constituent parts of a single progenitor? The existence of non-gravitational forces means that any numerical integration cannot be viewed as physically realistic and therefore does not portray the actual orbital histories, but such integrations by Mark Bailey (University of Manchester) and David Asher (University of Oxford) indicate that the arguments of perihelion and the nodal longitudes for the two objects (which are now widely different: see Figure 1) may have been similar within the past 10 000–30 000 years. Astronomically-speaking this is very recent, and concurs with the collisional time-scale for circa 1 mm meteoroids in the radar-detected Daytime Arietids, whose lifetimes are limited by catastrophic collisions with the smaller zodiacal dust particles [8].

Icarus is about 900 meters in radius [7]; since 1991 RC is about 0.6 magnitudes fainter, its radius would be around 600–750 meters, although both objects are most likely irregular in shape. It seems probable that these are just two of the many more substantial fragments produced in the hierarchical disintegration of a rather larger body, presumably a comet, along the lines described by Clube and Napier [9]; the Daytime Arietids would represent the smaller particles, with many macroscopic bodies perhaps awaiting discovery. It is very unlikely that these are the only two large bodies of the type since only around 1% of the estimated circa 10 000 Apollo asteroids larger than 500 meters in size have yet been discovered: it is thus tempting to suggest that the progenitor produced a very large family indeed.

Unfortunately Daedalus is a name which has already been applied to another Earth-crossing asteroid (1864 Daedalus), so that another appellation for 1991 RC will need to be found. Are there any classical scholars out there who know whether Icarus had a brother, and if so what was his name?

Clube and Napier argue that the Earth is subject to frequent multiple impacts by the smaller (currently undetected from the Earth) members of complexes formed in the break-up of large comets. The fragments then produce airbursts in the atmosphere, such as the Tunguska event in 1908, but generally not craters on the ground. The members of such complexes make up in numbers what they lack in individual size. Such airbursts, Clube and others believe, are a frequently recurring phenomenon on time scales of centuries to millennia, with epochs of high impact rates occurring when a complex has a node at 1 AU. These they believe are evidenced in the historical record [10]. The discovery of 1991 RC adds considerable weight to the idea that many or most potential impactors exist in recently-produced streams, of which the Taurid Complex has been the most obvious to date [10,11], so that future asteroid search programs may need to accommodate strategies that are based upon this concept if they are to be optimally effective.

Acknowledgment

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Taurid Fireball Proportions

Alastair McBeath

Fireball proportions for the Taurid meteor stream obtained from *IMO*, *BAA Meteor Section* and *JAS Meteor Section* results are examined to try to determine whether the Taurids are richer in fireballs than other types of meteor activity. Some evidence is found to suggest the shower produces fireball activity at least at a similar level to other major streams, though variations from year to year may occur.

1. Introduction

In [1], it was reported that *BAA Meteor Section* Taurid results from 1981–1988 showed a comparable proportion of Taurid and sporadic (≥ -5) fireballs, contrary to expectations of higher Taurid fireball rates from literature sources based on previous data. An examination of Taurid magnitude distributions from *IMO* and *JAS Meteor Section* observations was carried out to see if this evidence could be verified independently. These results were then compared with similar distributions for the Perseid and Geminid showers and the sporadics, to see what conclusions could be drawn from them.

2. Results

IMO Taurid magnitude data were available from from 1988 [2], 1989 [3] and 1990 [4], while reliable *JASMS* results were collected for the shower from 1984–1990. Combined data from both Taurid stream branches was prepared, and a full numerical magnitude distribution obtained from the *BAAMS* [5], to enable an examination of all shower fireballs, using the international definition of meteors of magnitude −3 or brighter, to be carried out. In using the *IMO* results from [3] and [4], only information from known reliable observers under good skies was used, which may have resulted in the omission of some usable data whose quality could not be readily ascertained. Table 1 shows the findings of these examinations.

Table 1 – Numbers of fireballs of at least −3 ($N_{\rm Tau}$), fireball percentages ($\%_{\rm Tau}$), total meteor quantities ($\rm Tot_{Tau}$), mean limiting magnitude ($\overline{\rm Lm}$), corrected mean magnitude ($m_{6.5}$) values for the Taurid shower, listed by source. The years the data were obtained in and the appropriate references are also given.

Source	IMO	IMO	IMO	IMO (Combined)	BAAMS	JASMS	Combined
$N_{\rm Tau}$	36.5	0.5	7	44	15	13	72
$\%_{\rm Tau}$	2.0	0.1	0.8	1.4	0.9	3.5	1.4
$\rm Tot_{Tau}$	1820	355	864	3039	1657	368	5064
$\overline{\rm Lm}$	6.11	6.50	6.51	6.37	5.53	5.77	6.08
$m_{6.5}$	3.00	3.48	3.67	3.38	3.01	2.53	3.14
Dates	1988	1989	1990	1988–90	1981–88	1984–90	
Ref	[2]	[3]	[4]	[2, 3, 4]	[5]		

3. Discussion

On the principle that a better limiting magnitude will enable greater numbers of faint meteors to be seen, while brighter objects will remain at a roughly constant level, it follows that the proportion of fireball-class meteors for a given source should decrease as the limiting magnitude improves. This is certainly the case between the *JASMS* and *IMO* Taurid results, though the *JASMS* sample is unfortunately rather small. *JASMS* observations have the advantage of being performed from similar locations and under comparable conditions to most of those from the *BAAMS* results, however. The *BAAMS* data, with a poorer limiting magnitude than either of the other two sources, shows a far lower proportion of fireballs than would be expected on the above principle alone.

Comparing the *IMO* figures for 1989 and 1990 with 1988 does suggest a possible variation in Taurid fireball proportions in different years, though the combined *IMO* percentage is still 0.5% higher than the *BAAMS* eight-year mean. This variation may be due to short-lived increased flux of bright events from the Southern Taurids noted in 1988 by Roggemans [2] around $\lambda_\odot$ = 219°–220° (November 3–4), coincident with the Taurids' main visual maximum, and which either may not be apparent at every return or may easily be missed thanks to its seemingly short duration. If this is the case, *BAAMS* observers may simply have been unfortunate, but perhaps if atmospheric haze was responsible for the poorer *BAAMS* limiting magnitude, this may have resulted in suppressing the brightnesses of some meteors, which would also lead to a reduced proportion of fireballs, though this is rather conjectural. It is interesting that in the *IMO* results for 1989, there is little coverage of this early November period, while in 1990, virtually no data was recorded at all between October 24 and November 15. Data from only a few nights in the first week of November may thus be responsible for many of the Taurid fireballs that are seen, though further results from this spell are needed for verification.

Evidence for clumps of material within the Taurid complex—even up to objects large enough to cause devastating Earth impacts—already exists (e.g., [6] and references therein), so discovering the possibility that bright Taurids may occur in "bursts" is not too unexpected, if indeed this proves to be true. There is also some evidence to suggest an increased fireball flux was observed around the time of the 1908 June Tunguska event (see [7] and reference therein), whose parent body can probably be linked with the Taurid/β-Taurid/Comet Encke complex as well, and a repeat of which flux may perhaps provide the only forewarning of the next similar fall.

Overall then, the combined Taurid data examined suggests that a mean value of about 1.4% (72/5064) of the visual shower meteors were fireballs, which provides a further numerical value we can compare with other meteor activities.

4. Comparison with Perseids, Geminids and sporadics

Data on the two presently most reliable active meteor showers noted as productive of bright meteors, the Perseids and Geminids, and the sporadic background, were felt to be the best sources for comparison with the Taurids. *IMO*, *BAAMS* and *JASMS* results were obtained and analyzed accordingly, with the result presented in Tables 2, 3 and 4.

Table 2 – Perseid fireball proportions

Source	IMO	BAAMS	JASMS	Combined
$N_{\rm Per}$	182.5	622	37	841.5
$\%_{\rm Per}$	0.7	3.1	2.5	1.7
$\rm Tot_{Per}$	27 202	20 049	1464	48 715
Dates	1988	1980, 83	1988, 89	
Ref	[8]	[9]	[10, 11]	

Table 3 – Geminid fireball proportions

Source	IMO	BAAMS	JASMS	Combined
$N_{\rm Gem}$	66.5	218	21	305.5
$\%_{\rm Gem}$	0.9	1.6	2.1	1.4
$\rm Tot_{Gem}$	7575	13 397	1012	21 984
Dates	1988	1969–80	1988–89	
Ref	[12]	[13]	[14, 15]	

Table 4 – Sporadic fireball proportions. In selecting *IMO* data, the same criteria outlined in Section 2 above were respected. *BAAMS* sporadic data came from the same periods as the shower analyses in Tables 1, 2 and 3 above.

Source	IMO	BAAMS	JASMS	Combined
$N_{\rm Spor}$	65	133.5	41	239.5
$\%_{\rm Spor}$	0.15	0.8	0.7	0.4
$\rm Tot_{Spor}$	44 773	17 267	5660	67 700
Dates	1988–90	See	1984–88	
Ref	[16, 3, 4]	caption	[17]	

Generally, the *IMO* mean limiting magnitude under which these observations were made were much better than the same parameter for the *JASMS* and *BAAMS* observations, where these could be derived, usually by a difference of between roughly 0.4–0.9 magnitudes, so it is not surprising that the greater populations of faint meteors of all types in the *IMO* figures should reduce the fireball proportions relative to the *BAAMS* and *JASMS* totals. The *BAA* and *JAS* fireball percentages are similar, reflecting a general concordance in observing conditions.

Recent results and discussions have suggested that fresh cometary material may have been added to the Perseid stream in the early 1980s, by the unseen perihelion passage of Comet P/Swift-Tuttle at that time (see for instance [18] and references thereto), so it is possible results from that period may not be directly comparable to earlier or later results. Certainly, Grishchenyuk [19] suggests that large-scale "clouds" of greater concentration of meteoroids within the Perseid stream noted in 1980 and 1982 were not seen in 1958 or 1986, for example. This might perhaps have led to somewhat higher fireball proportions in the early 1980s, possibly as shown in the *BAAMS* 1980 and 1983 results by contrast to the *JASMS* 1988–89 details, though this cannot be definitely shown from this present analysis.

Geminid analyses too have indicated that this shower has undergone changes in the past decade, most notably an increase in its ZHR to over 100 [20, 12]. Again, this casts some doubt as to whether earlier results can be considered equivalent to the later ones, though there is little evidence to suggest the Geminid meteoroid population has undergone any significant alterations in features other than quantity.

Sporadic fireball proportions showed rather less fluctuation across the various observations, and in all cases except for the *BAAMS* Taurids, were generally far lower than the shower percentages. This was not unexpected, based on even anecdotal reports.

IMO and *JASMS* results suggest the Taurids are richer in fireballs in the main than the other three meteor sources examined, whereas the *BAAMS* data suggests the opposite is true. The approximate consistency between the relative fireball richnesses of the Perseids and Geminids is also not apparent from the *BAAMS* figures, perhaps because of reasons already outlined. Due to these variations between individual sources, it is perhaps best to examine only the combined totals for each activity, even though these are not absolute values. A comparison of these now shows that the three showers all relatively, and roughly equally, abundant in fireballs compared to the sporadics, though this abundance does not, for example, contrast at all favorable with the relative abundance of Perseid meteors leaving a train, as that figure is normally around 35% (e.g. [10,11]). Putting actual numbers of meteors to these mean values shows about one in 70 Taurids and Geminids were fireballs, roughly one in 60 Periods reached this brightness, while only circa one in 330 sporadics was recorded as attaining the required magnitude. Contrasting these very approximate rates with the probable observed hourly rates for a good observer under a dark, clear sky suggests the Perseid and Geminid showers (whose ZHRs are currently about 95 and 110 and respectively [21]) are likely to be more readily perceived as rich in bright meteors, particularly near their maxima, as observed rates may well equal or exceed the 60–70 meteors-per-hour level on one or more nights around their respective peaks. For the Taurids, even at best (maximum combined ZHR around 10–15 [2]) it may take several hours—perhaps even nights—to record anything approaching 70 shower members, which is liable to disappoint observers expecting frequent fireballs from this stream. The problem may be further compounded if Taurid fireballs are greatly time-dependent, as discussed earlier. With the sporadics, whose mean computed hourly rate is normally about 11–12 from the UK [17], the situation is still worse, where many nights of observing will be needed to amass the required meteor numbers. These are only statistical values however, and actual rates may well be better or worse than the figures suggest.

5. Conclusion

Taurid fireball proportions obtained in recent years seem at least comparable to (or perhaps on occasion greater than) those seen with the major showers of the Perseids and Geminids, and they are generally considerably greater than the mean sporadic level. *IMO* results suggest there may be variations in the relative quantity of Taurid fireballs from year to year, though this may depend on whether the main Taurid maximum is observed in a given year or not. Further results, with the numbers of Taurids seen per year at a level only the *IMO* has so far been able to achieve, are needed to examine this matter in more depth.

Acknowledgments

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Photographs for WGN

We like to thank everyone who sent us meteor photographs over the past year. Although not all photographs were used, either due to space limitations or to technical restrictions, the effort of sending us your photographs is always appreciated. We need suitable cover pictures for each issue of WGN*; moreover, a few photographs inside make the journal more pleasant to read. Therefore, we made a special effort during the latter half of last year to enhance the reproduction quality of photographs by using computer techniques; we hope you liked the result. Please continue your efforts as well: the more photographs we have at our disposal the better the selection will be we make for the journal! (Ed.)*

Fireballs and Meteorites

Daylight Fireball

Czechoslovakia, September 22, 1991, $16^{\mathrm{h}}48^{\mathrm{m}}$ UT

J. Borovicka and P. Spurný, Ondřejov Observatory

Shortly before sunset on September 22, 1991, a −20 absolute magnitude fireball appeared over Czechoslovakia.

A very bright fireball of about −20 absolute magnitude appeared over Central Bohemia 15 minutes before sunset on September 22, 1991. One day after the event we called for observations in the news media and received 170 reports from occasional observers. The sky at the event was not completely clear everywhere. The observed duration of the fireball was about five seconds. Some observers reported a splitting into five pieces at the end of the luminous trajectory and also intense sonic booms one to two minutes after the event. A persistent smoke train was visible for one minute and a small cloud at the location of the bright fireball was observed for ten minutes.

The data for computation of the trajectory were obtained from 20 observers, whom we visited. The position of the fireball at these locations was measured using a compass and a height measuring device. An apparent radiant at $\alpha = 146° \pm 13°$ and $\delta = +67° \pm 8°$ resulted. The fireball was first noticed at a height of 50 km at $\lambda = 13.^\circ9$ E and $\varphi = 50.^\circ2$ N. The fireball terminated at an extremely low height below 10 km.

Multiple meteorite falls with a total mass in the order of 100 kg is almost certain. The center of the impact area is located at $\lambda = 14.^\circ25$ E and $\varphi = 49.^\circ71$ N, i.e., 40 km south of Prague. The biggest meteorites should be within a radius of 5 km from this point and smaller pieces could have landed up to a distance of 20 km in the NNW direction. We distributed a public announcement inside the impact area and its close vicinity. Any systematic search is hardly possible due to the huge search area and we do not to intend to realize it.

An initial velocity lower than 20 km/s is very probable and the computation of the orbit is based on a realistic estimate of 16 ± 4 km/s. The resulting heliocentric orbit is a quite interesting exception belonging to the Athen-asteroid type. The resulting elements for the equinox 1950.0 are given in Table 1.

Table 1 – Orbital data.

a	0.73 ± 0.04 AU	ω	14° ± 6°
e	0.41 ± 0.10	Ω	$178.^\circ602$
q	0.43 ± 0.10 AU	i	19° ± 13°
Q	1.025 ± 0.024 AU		

The inclination is sensitive to the initial velocity: higher velocity implies higher inclination.

These results are only preliminary; we are still in the process of collecting further observations.

Please do not forget WGN

...when reporting your observations! Apart from giving thorough analyses of stream data, we also like to provide our readers up-to-date information on how shower displays were perceived by the observers.

The quick information regarding the 1991 Perseid outburst was very well received by our readers and on the following pages, we can present a fairly accurate impression on a strong meteor display on November 5 as well as on the 1992 Quadrantids. Help us in this task by sending in reports on your observations for *WGN* as soon as possible after the event!

The Strong Meteor Display of November 5, 1991

Peter Brown[1], *David Asher*[2], *and Duncan Steel*[3]

Reports of unusually strong meteor activity viewed from Mauna Kea associated with a radiant in Pegasus on November 5, 1991, are presented and discussed. The activity occurred close to the time expected for meteors associated with P/Hartley 2 or possibly the Taurid complex, but the radiants are widely separated so that the source of the activity cannot be ascertained at this stage. Further observations are needed to draw any firm conclusions.

1. Introduction

In the late evening and early morning hours of November 5, 1991, a strong meteor shower consisting of many faint meteors was detected by observers at the Mauna Kea (Hawaii) observatory complex. Uniquely for a meteor shower, the first signs of activity were detected from CCD readouts of the 3.6-m *Canada-France-Hawaii Telescope (CFHT)* which happened to be pointing to the apparent radiant within a fraction of degree.

The CFHT operator on this evening was Norman G. Purves. He described the event as follows:

> *The shower was first noticed in the readout of a CCD frame that was begun at* $9^{\mathrm{h}}30^{\mathrm{m}}$ *UT on November 5, and integrated for 30 minutes. We did not realize what it was at first—the appearance was of a large number of trails across the field, obviously divergent from a point off the edge of the CCD field. It was fairly easy to estimate the distance to the radiant, due to the splay of the trails.*
>
> *The field was centered at* $\alpha = 0^{\mathrm{h}}25^{\mathrm{m}}30^{\mathrm{s}}$, $\delta = +17°03'00''$, *and the convergence of the trails seemed to be about* $5'$ *north of the edge of the field, which at that night's configuration was about* $2' \times 1.5'$, *with the shorter axis parallel to the N-S axis. The radiant position therefore should be at* $\alpha = 0^{\mathrm{h}}25^{\mathrm{m}}30^{\mathrm{s}}$ *and* $\delta = +17°08'00'$", *with a probable error of about* $1'$.
>
> *The trails appearing on the CCD image were surprisingly wide, equivalent to two to three star diameters. (FWHM at this time for star images was a bit less than* $0''.5$. *There were so many trails that they overlapped each other in most cases; it was therefore impossible to get an accurate count of trails. My best guess is that there were in excess of 60 trails in this frame.*
>
> *We began another CCD integration immediately, at* $10^{\mathrm{h}}00^{\mathrm{m}}$ *UT, also for 30 minutes. We had not yet realized that this was a meteor shower; I would hate to have to estimate the odds against pointing a 3.6-m telescope so close to a shower radiant entirely by accident! The second frame looked very much like the first one, with the density of trails the same. It was during this second integration that it occurred to us that this might be a shower, so I went outside to look at about* $10^{\mathrm{h}}10^{\mathrm{m}}$ *UT.*
>
> *It took several minutes to get dark-adapted, but I soon was seeing meteors trailing across the sky, mostly toward the east and south, with the directions of travel intersecting at a point near the south edge of the square of Pegasus, which corresponds with the coordinates of the spot the telescope was observing. While concentrating on this spot (using slightly averted vision), I saw three "blinkers": small flashes of light at the apparent radiant point that did not move appreciably. I interpret these as meteors coming directly at me. It was at this time that I started listening* very *intently for any sounds—fortunately, for my peace of mind, I heard no unusual sounds at all.*
>
> *The trails' brightness ranged from perhaps 0.5 to perhaps 4.0 magnitudes or lower (it is notoriously difficult to make magnitude estimates up here; the lack of oxygen at this*

[1] University of Alberta, Canada.
[2] University of Oxford, England, UK.
[3] Anglo-Australian Observatory, NSW, Australia.

> *altitude reduces night vision, even for acclimatized veterans). The telescope operator at NASA IRTF reported seeing one fireball that may have been less than magnitude* 0.0. *I really cannot say much about the distribution of brightness—my recollection is that the less bright the meteors, the more of them there were, but I would not want to be held up to too much scrutiny on this point.*
>
> *Maximum angular speed seemed to be somewhat faster than that of a low-altitude earth-satellite (of which we see a large number here), maybe 1.25–1.5 times as fast. The meteors' color was a bluish—or greenish–white. I would, from what I am told about characteristic colors, guess a V_∞ of about* 40 *km/sec. I hope all this is consistent.*
>
> *My own naked-eye observations were between about* $10^{\rm h}12^{\rm m}$ *UT (Approximately when I started getting dark-adapted) and* $10^{\rm h}25^{\rm m}$, *and again at about* $10^{\rm h}55^{\rm m}$ *to* $11^{\rm h}05^{\rm m}$. *There was no evidence from any observer that the frequency was either increasing or decreasing during this period. My message to the IAU was at* $11^{\rm h}35^{\rm m}$ *UT, and sightings continued for some time after this. The last sightings I made were at about* $11^{\rm h}45^{\rm m}$ *UT.*

Purves also mentions in an initial communication about the shower to Daniel Green at the *IAU Central Bureau for Astronomical Telegrams* that hourly rates were 75–100 during the interval centered around $11^{\rm h}00^{\rm m}$ UT on November 5.

At least three other telescope operators witnessed the display [1].

2. Discussion

At the time the observation began the radiant altitude was nearly 70° and the radiant was almost directly to the West. This favorable radiant position combined with the dark skies for which Mauna Kea is renowned may help to explain why no other visual observations of the activity have been forthcoming, particularly as the display appears to have consisted of many faint meteors. Additionally, the day of the week the shower occurred (Tuesday) and its timing (very early morning hours in North America) may explain why no other observations have been recorded. According to Gyssens [2], no unusual activity was noted by visual observers in Europe either the night before or after the display observed in Hawaii. Other active visual observers in Oahu, Hawaii have also been unable to confirm the activity [3].

With no further observations, we are left to conclude simply that a moderately strong, sharply peaked display of small meteoroidal particles took place between $\lambda_\odot = 222\overset{\circ}{.}58$ and $\lambda_\odot = 222\overset{\circ}{.}68$ (2000.0), from a radiant at $\alpha = 0^{\rm h}25\overset{\rm m}{.}5$ and $\delta = +17°$. No shower radiant at this location for this time period are given in Cook [4], the *AMS* Radiant List [3], McCrosky and Posen [5], or Kronk [6].

Two origins for the display seem possible.

The first relates to P/Hartley 2 which reached perihelion on September 11, 1991 [7]. According to Ohtsuka [8], meteor activity was predicted on November 9.6, 1991 using the method of Hasegawa [9] based on the location of the comet's descending node at which time the Earth would be 0.036 AU from the comets orbit only 55 days after the comet passed the same point. The predicted radiant was given as $\alpha = 298\overset{\circ}{.}1$ and $\delta = +15\overset{\circ}{.}4$ and V_∞ was given to be 10.8 km/s. Ohtsuka also gives conditions at the closest approach to the comet's orbit on November 15.5, and based on this radiant position an extrapolated radiant location of $\alpha = 300\overset{\circ}{.}3$ and $\delta = +16\overset{\circ}{.}8$ for November 5.5 is found. This is some 66° in right ascension from the radiant given by Purves.

At the time the shower was first seen from Mauna Kea the P/Hartley-2 radiant was a mere 7° high in the WNW. The slow geocentric velocity suggests zenith attraction might be significant, but in fact this correction amounts to less than two degrees based on the observed radiant altitude of 70°. Even taking the Hartley-2 radiant elevation as the apparent radiant gives less than a 5° correction, completely inadequate to explain the roughly 60° altitude difference. Indeed, the Hartley-2 radiant is some 25° below the horizon when Purves reports he made his last sighting at

11^h45^m UT. At this stage, therefore, it seems that we must reject P/Hartley 2 as the originator of the shower.

The other origin which comes to mind involves the Taurid complex which has a broad maximum during the time this outburst took place. According to Cook [4] the Southern Taurids peak around November 3, so it seems possible that the two may be related. However, the radiants are separated by more than 50° that again we are forced to dismiss this stream as being related to the outburst. On the other hand the extent of the Taurid complex is huge; many meteors observed from October to December and classified as sporadic are actually related to the complex but are simply more dispersed than the meteors classified as Taurids [10]. It is conceivable that the November 5 display could be due to an object in the Taurid complex that recently disintegrated producing meteoroids on similar orbits that could give rise to a meteor shower with quite a localized radiant.

Indeed, according to Dutch reports given by Fonk [11,12] an outburst of fireballs related to the Taurids was observed for some time around the peak of the Southern Taurids with some radiants north of the ecliptic. There have been some attempts to link this outburst with a 7:2 resonant meteoroidal swarm in the Taurid Complex (see [12], and references therein).

The radiants were apparently near β Aurigae and the Pleiades, so association with the present outburst is questionable.

3. Conclusions

We are unable to find a known source for the brief meteor outburst observed from Hawaii on November 5, 1991, and centered around $\lambda_{\odot} = 222\overset{\circ}{.}63$ (2000.0). This outburst may be related to a fireball swarm observed around the same date from the Netherlands in 1951. Its origin remains enigmatic, like several other brief, non-recurrent showers seen this century, such as the December Phoenicids of 1956 [4]. Further reports of observations from visual or radar groups, if available, are urgently needed if the origin of the shower is to be elucidated. The same solar longitude will be encountered in 1992 at roughly November 4.7 UT.

Note added in proof

As this article was going to press several new observations have come to light regarding the November 5 display. Dr. Bill Jones of the University of Sheffield reports that the Sheffield radar detected an increase in activity near midday local time or 12^h UT on November 5. J. Watanabe of the National Astronomical Observatory, Japan reports that while the MU radar at Kyoto was not operational at the time of the outburst, several Japanese amateurs detected increased activity on dates in early November. He has suggested comet P/Biela as a possible progenitor.

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The 1992 Quadrantids

Strong Return of the Quadrantids over Europe

Ralf Koschack

ZHR data are presented for the 1992 Quadrantids as observed in the French Alps. A peak ZHR of about 170 was recorded around 4^h30^m UT.

The New Year started with a very positive surprise for European meteor observers. Those who were lucky to have clear skies in the maximum night of the Quadrantids could enjoy an exceptionally high activity. To give a first impression I report here the preliminary ZHRs of the group observing at the Col de Vars (2100 m, French Alps) under almost perfect conditions. Note that the ZHR of the first two periods may be more uncertain due to the low radiant elevation. The group consisted of:

Rainer Arlt (ARLRA), Ralf Koschack (KOSRA), Ina Rendtel (RENIN), Jürgen Rendtel (RENJU), Paul Roggemans (ROGPA)

An account of the observing campaign is given in the article below.

Table 1 – Quadrantid ZHRs for the night of January 3-4, 1992 computed with $r = 2.1$.

Period (UT)	Rad. elev.	ARLRA	KOSRA	RENIN	RENJU	ROGPA	Average
00^h00^m–01^h00^m	20°	95	56	148	116	90	101 ± 34
01^h00^m–02^h17^m	28°	140	118	155	124	120	131 ± 16
03^h11^m–03^h45^m	44°	183	124	140	101	98	129 ± 35
03^h45^m–04^h15^m	49°	180	167	191	143	148	166 ± 20
04^h15^m–04^h45^m	54°	200	167	188	150	163	174 ± 20
04^h45^m–05^h15^m	58°	190	160	147	126	147	154 ± 24
05^h15^m–06^h00^m	65°	139	115	130	118	144	130 ± 13

If the remarkably lower activity during the last period indicates the begin of the sharp decrease of the activity observed in recent returns, then the maximum of ZHR ≈ 170 was around 4^h30^m UT very close to the prediction in the *IMO 1992 Meteor Shower Calendar*. The last word however is to the North American observers.

Important note for observers

In order to analyze the rapid variations of the Quadrantid activity in detail, observers are urged, **in deviation of the general instructions for VMDB reports** *(see elsewhere in this issue, ed.)* to report for the maximum night ZHR data in intervals of about half an hour each and magnitude distributions separate for each interval.

The 1992 Quadrantids in Southern France

Jürgen Rendtel

An account is given of the observing campaign set up by the *Arbeitskreis Meteore* in Southern France.

The perfect arrangement of the New Moon and the Quadrantid maximum in 1992 led to our project to meet in Lardiers, Southern France, with some experienced observers. Still having in mind our past experience with the weather in the Provence, we thought about a silent change into the New Year, occasionally interrupted by some observations. Therefore we (Rainer Arlt, Ralf Koschack, Ina Rendtel and I) also took something with us to read or to deal with during all the rainy hours.

Murphy must have seen this. We left Potsdam in the late evening of December 27 with clear skies—and arrived the following afternoon in Lardiers under clear skies too. Paul Roggemans and Mark Vints had already arrived and we prepared a welcome-meal. Well, we were a bit tired after the long trip. Nevertheless, we decided to observe until moonrise "in order to have at least some data to deal with". Fortunately the Moon rose not too late.

To make things short: we did not see any more clouds in 1991. Each night, we were able to observe for several hours. There is only one shower in our working list for this period and the general activity was surprisingly low. Thus the determination of the first traces of the Quadrantid activity became a major goal of our series. The final results will be presented in a future issue of *WGN*.

With exactly the same conditions we entered 1992. At the last evening three of us saw an impressive sunset from one of the nearby mountains with the green flash being the final sign of the Sun in 1991. We found an inexpensive phone in Lardiers and phoned several members of *IMO* to wish them Happy New Year. This way, we heard the bells bringing the New Year in Japan and encouraged Peter Brown to start observing the Quadrantids *(see further in this issue, Ed.)*, and learned about the storm conditions with Bub Lunsford, who hoped for improving conditions for the Quadrantid peak and the solar eclipse in California ...

During the following nights the Quadrantid activity slightly increased. Someone said for fun that clouds will arrive only for the night of January 3-4. Why did he do so? Murphy was not sleeping; he really brought a substantial field of clouds to our area.

It is nearly impossible to receive valuable information about the weather in such sunny areas as Southern France (obviously it is a function of latitude, and because it is warm and sunny normally, nobody is interested in details—it is becoming warm again very soon ...). Thus we phoned André Knöfel in Potsdam in order to get information about our chances to see something of the maximum. After consulting the weather office he works at, he said something about a local cloud field of no large extension ...

Consequently, we went to sleep a bit, hoping that this local appearance would disappear quite soon. At 20^h UT we decided to leave Lardiers and to go as far as necessary to find a cloudless sky. This trip took longer than we expected! Near the town of Gap we saw the first stars. Since they appeared in the southwestern sky without interruption, we decided to go into the mountains hoping that the wind direction would not change and that the cloud-free area would be persistent.

At midnight (UT) we reached the Col de Vars, a pass at 2100 m elevation, being in a real winter world. It took only a few minutes to get started with the observations, and the Quadrantids were surprisingly active although the radiant was still low in the sky. The strong icing made the telescopic work of Mark as well as all photographic experiments hopeless. (At least one Quadrantid meteor reached the film through a partly ice-covered lens.)

After 2.5 hours, the clouds moved more towards our place, and we fled away from them to a somewhat lower point. Here we really felt like being in a space-ship traveling through a dense particle cloud. Under an optimal sky (dark background and not disturbance at all) we saw many synchronous meteors as well as fireballs. As already mentioned in the previous article, the densest parts was obviously crossed around 4^h30^m UT. During the final hours the number of Quadrantids did not increase any more although the radiant was still rising in the sky.

Probably this means that we saw the peak of the 1992 Quadrantids. Anyway, this adventure into the Alps was really worth all the effort!

After the observations we went back to the Col de Vars, situated between peaks of about 3000 m elevation, which were now just lit by the rising Sun—an impressive panorama. Then we returned to Lardiers. There, we saw the clouds disappearing in the late morning. Of course, the next night was clear again. In the evening we checked the Quadrantid activity, but as usual the decrease is very steep and with the radiant at low elevation there was nearly nothing to be seen. We finished our campaign with a last observation after midnight towards the morning of January 5 with still some fine Quadrantids and left Lardiers with a huge amount of data and unforgettable impressions.

The 1992 Quadrantids in England and Spain

compiled by Marc Gyssens

Data received thus far indicate that observing conditions for the 1992 Quadrantids were moderate to favorable for much of Western Europe. In most places the weather allowed at least some observing during the maximum night. All reports confirm a strong return. Here, first impressions from England and Spain are summarized. The Spanish observations also mention enhanced activity of the Coma Berenicids.

January started very stormily in England with severe gales in excess of 160 km/h locally a couple of times. As a consequence, *Alastair McBeath* suffered from some rather sleepless night. Alastair writes on January 5:

> *I was thus not in the most prepared state for the Quadrantid's peak, though the sky was partly clear on January 3-4, and I was able to make some observations then, interrupted by a number of breaks for clouds and rain. Indeed, the sky clouded over completely within only a few minutes twice during the course of the night, which was rather frustrating.*
>
> *Nevertheless, I was still able to put in over six hours of observing and was reasonably pleased to spot almost 350 meteors in that time. With a limiting magnitude between about* 5.8 *and* 6.1, *the ZHR worked out to be somewhere around 110–130 at best, implying that our predictions were not too far out. My personal impression was that the visual peak came at around* 3^h *UT, since I felt observed rates remained fairly static after that time, despite a higher radiant elevation, and I also got the impression that there were more brighter events later in the night. How correct these feelings are remains to be seen of course!*

Luis Bellot describes the 1992 Quadrantid display as very good. He observed together with Antonio Reche. Both observers report a remarkably high number of Coma Berenicids at the Quadrantids' maximum night. In one instance, Luis Bellot saw 12 Coma Berenicids in $1\overset{h}{.}1$ of effective observing time. A similar phenomenon has independently been reported by Trond Erik Hillestad from Norway in the article below.

The 1992 Quadrantids in Norway

Trond Erik Hillestad

An account is given of the author's observations of the 1992 Quadrantids in Kongsberg, Norway, during the maximum night of January 3-4. The highest uncorrected rates were recorded around 6^h15^m when about 50 meteors were seen per quarter of an hour under lm = 6.1-skies. About a quarter of the non-Quadrantids seen were Coma Berenicids.

The Quadrantids performed most impressively in 1992. I had not observed the shower since one night in the early '80s, and I think that was off-maximum, so there was not much to see.

The first clear night was December 31, but then of course I was busy partying with some friends. I could see a lot of fragmenting meteors and exploding fireballs. They did not seem to originate from a common point, so they must have been sporadics all together. My camera was outdoors too, and being lucky, it had captured something, I have not analyzed the film yet ... Observers on the west coast of Norway were more lucky because they experienced a storm. Must have been some nice event! Pity that they got their houses smashed. It was mentioned in the TV-news too. A jerk talked about speeds of 100 knots. I thought meteors moved a lot faster!

Turning more serious now, the next clear night was January 3-4. Weather was poor, but it cleared up by the evening. The stars were twinkling beautifully when I went to bed at 8 o'clock. A silly clock started beeping at 0^h30^m UT. The skies were clear, and since I had nothing better to do, I went outside to see some meteors. I struggled with my observing equipment for a while, placing myself in a comfortable position, just to experience that clouds were moving in. I could observe for 30 minutes, before the rain forced me indoors. Despite the poor conditions, the Quadrantids appeared to be quite active up there in the clouds, perhaps even like the Perseids or the Geminids at their best.

At 5^h00^m UT, I started my second observing session of the night. apart from a short interruption, when the clouds moved in, covered everything, and disappeared again within two minutes (!), the skies remained clear for the rest of the night. It has happened many times that when the west coast suffers from deep depressions and high winds, the skies are clear in the eastern part of the country. Conditions are usually not very stable though. Clouds can be formed and disappear within a short time. (Usually they are just formed without disappearing—at least that is what it seems like to an observer.)

But this night has fairly good conditions. The limiting magnitude was not perfect, but good (6.2). The dawn became more and more predominant towards the end of the observing session, and the observation was stopped at 6^h45^m UT with a limiting magnitude of about 5.9 in the west. The eastern sky was bluish, and white on the horizon.

Activity was good in the beginning, and even better at the end. A first impression (before analyzing the results on my cassette recorder) was that the Quadrantids were much more active than the Geminids of 1991, but (slightly) inferior to the 1985 Geminid return, which stands as the richest shower I have ever seen. Even when the Quadrantids were numerous, I did not at that time realize *how* numerous. After analyzing the data, I found that the highest rates occurred from 6^h00^m to 6^h30^m UT with more than 50 Quadrantids in a 15-minute interval (see Table 1).

The sporadic rates were around 20. During the observation, however, I saw several meteors originating from Coma Berenices, leading me to wonder if there was a shower going on in that area. Later in the night I remembered that there exists a shower called the Coma Berenicids ... The radiant that I found while observing later proved to match very well the position given in the *IMO* shower list. Without paying much attention to accuracy, I estimated "for fun" the velocity of these meteors as 40 km/s, while the list mentions 33 km/s. Of the sporadic rate mentioned, at least 4, and most likely 6, meteors were Coma Berenicids. Taking this into account, the sporadic rates were about 15 per hour: fairly good, but still 10 times lower than the Quadrantid rates!

Table 1 – Quadrantid activity on January 3-4 observed by Trond Erik Hillestad at Kongsberg, Norway. Notice that sporadic rates include Coma Berenicids which were responsible for approximately 25% of the sporadic totals.

Period (UT)	$T_{\rm eff}$	Lm	F	Quad	Spor
0^h36^m–1^h07^m	$0^h\!.48$	5.74	1.22	28	2
5^h00^m–5^h15^m	$0^h\!.25$	6.25	1.00	38	1
5^h15^m–5^h30^m	$0^h\!.25$	6.25	1.00	28	7
5^h30^m–5^h45^m	$0^h\!.25$	6.20	1.00	33	4
5^h45^m–6^h00^m	$0^h\!.25$	6.20	1.00	46	6
6^h00^m–6^h15^m	$0^h\!.21$	6.20	1.00	47	4
6^h15^m–6^h30^m	$0^h\!.25$	6.10	1.00	53	5
6^h30^m–6^h45^m	$0^h\!.24$	6.00	1.00	40	7

When the sky became to bright to carry out serious observations, I spent some additional minutes under lm = 5.70-skies. The dawn was moving in quickly, and the limiting magnitude was even much worse in other parts of the sky. Still, I counted 19 Quadrantids in 10 minutes!

From 7^h45^m to 7^h55^m UT I performed an "observation" standing on my feet, but the shower had ceased by then. No meteors were seen. Limiting magnitude about 1.5. Venus, Jupiter and Arcturus were still easily visible ...

The 1992 Quadrantids in Alberta, Canada

Peter Brown

An account is given of the observers' 1992 Quadrantid observations from Ft. McMurray, Alberta, Canada.

The Quadrantids in 1992 were certainly the best display from the shower I have ever had the pleasure of watching. After 7 years of trying to catch the peak of the shower I finally managed to see the Quadrantids at their very best around the time of maximum. Of course, the aurora was present and began casting shadows about 1.5 hours into the observing session, but this is a "given" from Fort McMurray. The shower circumstances were particularly pleasant as the air temperature was extremely warm, around $-10°$ C, certainly the warmest of all the times I have ever attempted to watch the display.

I had been expecting the display to start picking up around midnight local time when the radiant would start getting to a significant altitude. However, as early as 18^h local time (1^h00^m UT), bright shower meteors were noticed just while driving around Ft. McMurray. Later, around 5^h UT, several bright meteors were seen through the windshield of the car going out to the observing site.

When observing began at 6^h00^m UT it was obvious the shower was well underway, with a meteor visible every other minute. This in spite of diffuse auroral glow, and a very low radiant (around 20°). As the radiant climbed so did the intensity of the aurora, but a brief respite around 9^h20^m–9^h50^m UT when dark skies prevailed again just before a cloud bank wiped out the rest of the night showed that the rates had dropped noticeably to perhaps 1 meteor every 3 or 4 minutes.

Table 1 gives a breakdown of rates and conditions.

Table 1 – Quadrantid activity on January 3-4 observed by Peter Brown at Ft. McMurray, Alberta, Canada.

Period (UT)	T_{eff}	Lm	F	Quad	Spor
6^h10^m–7^h10^m	$1^h\!.00$	5.8	1.00	33	3
7^h10^m–8^h10^m	$1^h\!.00$	5.6	1.00	21	3
8^h10^m–9^h50^m	$1^h\!.25$	5.7	1.05	21	6

With Peter Brown's account, we close this first, preliminary overview of the 1992 Quadrantids. In view of the large numbers of data that are coming in, we hope to present a more comprehensive analysis in some future issue. (Ed.)

Possible α- and δ-Aurigid Activity

Alastair McBeath

JAS Meteor Section observations made between August to October during the years 1984–1990 show some evidence for low activity from a radiant or radiants in northern Auriga throughout this period.

1. Introduction

In [1], it was shown that minor meteor stream activity continues to be observed from northern Auriga during the declining phase of the α-Aurigid shower and beyond, into October, and that this activity is probably from the δ-Aurigid stream. In an effort to find further evidence for the existence or absence of δ-Aurigid activity, reliable *JAS Meteor Section* observations from August to October between the years 1984 to 1990 were examined.

When the *JAS Meteor Section* observing program was extensively revised in 1983–84, a fresh shower radiant list was drawn up based on data contained in the *Handbook of the British Astronomical Association* from several years prior to this date. One of the new minor showers added to the *JASMS* list was the α-Aurigids, and observations were secured on the stream from 1984. *BAAMS/JASMS* parameters for this shower are given in Table 1, along with *IMO* α- and δ-Aurigid data.

Table 1 – α- and δ-Aurigid parameters. Data from [2] are for epoch 1950.0, and r-values from here are estimates only.

Stream	Period	Max	$\lambda_\odot$	ZHR	Radiant			V_∞	r	Source
					α	δ	Diam.			
α-Aur	Aug –Sep	Aug 28	154°	12	74°	+43°	?	?	2.4	[2]
α-Aur	Aug –Sep	Sep 12	168°	?	?	?	?	?	?	[2]
α-Aur	Aug –Sep	Sep 14	171°	12	73°	+41°	?	?	2.4	[2]
α-Aur	Aug 24–Sep 05	Sep 01	158°6	15	84°	+42°	5°	66	2.5	[3]
δ-Aur	Sep 05–Oct 10	Sep 10	166°7	7	60°	+47°	5°	64	3.0	[3]

The September 12 peak was noted as a "fireball maximum" in [2] and no other information on it was given, nor was any radiant motion or size indicated for any of these radiants. The information given to *JASMS* observers consisted of the August 28 and September 14 α-Aurigid data from Table 1 [4]. Positions for the *BAAMS/JASMS* and *IMO* α- and δ-Aurigid radiants are shown in Figure 1. Radiant areas of $\alpha = 10° \times \delta = 5°$ have been assumed for the *BAAMS/JASMS* radiant in the absence of any daily motion figures.

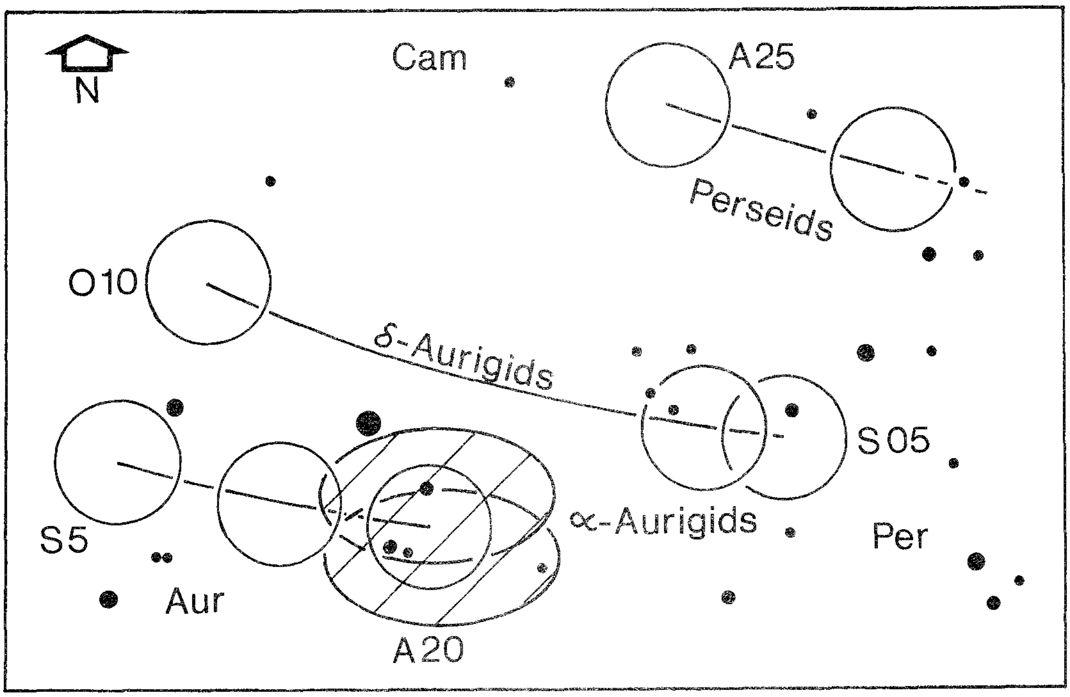

Figure 1 – α- and δ-Aurigid radiant positions plotted from [2] (shaded ellipses) and [3], showing drift where known and approximate radiant sizes. The Perseid radiant from mid to late August is also depicted. Start and end data are in August (A), September (S) and October (O), and radiant areas for shower maxima are shown as well.

2. Observations

During 1984–1990, *JASMS* observers used only meteor direction and rough path length estimates to assign shower association [4], though more experienced observers used meteor angular velocities too. The absence of meteor plots makes confirmation of the exact radiant positions possible, but meteors seeming to emanate from about the areas indicated in Figure 1 by the two α-Aurigid ovals would be recorded as such, and can thus be used as an approximate guide to the strength and extent of any Aurigid activity, due to their relative proximity to the *IMO* radiants. This is particularly true as the geometry of the radiants compared to the horizon means that the shower meteors are more likely to appear north and west of this area until around midnight local time in August–September, or about 23^{h} local time in October. After these times the radiants attain enough elevation for meteors to appear with almost equal likelihood in any direction about this zone. Even then, a good proportion of Aurigid meteors will still lie in planes intersecting both the *JAS/BAA* and *IMO* radiant positions.

With minor showers, there is always the problem of contamination from the sporadic background, and this is especially probable for the δ-Aurigids, whose r-value from *IMO* data is very similar to that normally assumed for the sporadics. From *JASMS* sporadic results in 1984–1988 [5], a possible dip in the annual sporadic rate during September–October is apparent, which could perhaps be the result of some contamination of Aurigid rates from this source, though this is uncertain. In addition, Perseid activity is another likely cause of enhanced "Aurigid" rates, especially as Perseid and α-Aurigid meteors have very nearly identical characteristics, although this would apply only during August. Figure 1 also shows the position of the Perseid radiant.

Analysis of the available data showed almost 330 "α-Aurigids" had been reported between 1984–1990, about 200 of those by experienced observers, though only just over 50 were in skies suitable for detailed examination, thus no magnitude distribution of any real value could be derived. All activity registered as "α-Aurigid" by reliable watchers regardless of sky conditions is given for every degree of solar longitude in a combined form in Table 2. ZHRs were calculated where possible based on an assumed r of 2.5.

Table 2 – *JASMS* Aurigid activity detected by solar longitude ($\lambda_\odot$) from 1984–1990. Each entry shows data collected in a single year, either as a rough ZHR or by "*", indicating activity was recorded, but in numbers too small or under skies too poor to allow further calculations.

$\lambda_\odot$	Activity	$\lambda_\odot$	Activity	$\lambda_\odot$	Activity	$\lambda_\odot$	Activity
128°		151°	*	174°		197°	4 ± 3,*
129°	*	152°	6 ± 4,*	175°	*	198°	5 ± 3
130°		153°		176°	*,*,*	199°	*
131°	*	154°	4 ± 3,*	177°		200°	*
132°		155°	*,*	178°	*	201°	*
133°		156°	6 ± 4,5 ± 4,*,*	179°	*,*,*	202°	*
134°	*,*	157°	*,*	180°	*	203°	
135°	*,*	158°	7 ± 4	181°	5 ± 4	204°	
136°	*	159°	*	182°	*	205°	*
137°	*	160°	6 ± 4,*,*	183°		206°	
138°	5 ± 4,5 ± 3,*,*	161°	6 ± 3,*	184°		207°	*,*
139°	*,*	162°	*,*	185°	*	208°	*
140°	6 ± 4	163°	*	186°	8 ± 5	209°	5 ± 3,*
141°	*,*	164°	6 ± 5,*	187°	*	210°	*,*
142°	3 ± 2	165°	8 ± 5,*	188°		211°	*
143°	*,*	166°		189°	8 ± 4,*	212°	
144°	*	167°	*,*	190°	*	213°	
145°	*,*	168°	*,*	191°		214°	*,*
146°	*	169°	4 ± 3,*	192°		215°	
147°	16 ± 9,*,*	170°	5 ± 4,*	193°		216°	
148°		171°	5 ± 4,*,*,*	194°	*,*	217°	
149°		172°	*	195°			
150°	*	173°		196°	6 ± 5		

3. Conclusion

Perseid contamination for much of August is almost certainly responsible for the rates found up to $\lambda_\odot = 147°$ (August 20) or so, much as [6] suggests, and should effectively be ignored. The one ZHR from $\lambda_\odot = 147°$ may perhaps result from combined α-Aurigid and Perseid activity, for instance. Rates at a more obvious level were recorded from about $\lambda_\odot = 150°$–$151°$ (August 24–25) until $\lambda_\odot = 172°$ (September 15), though not in the quantities needed to confirm any of the possible Aurigid maxima. Rates were again more obvious in late September to early October, and were around 5 meteors per hour even by $\lambda_\odot = 198°$ (About October 11–12), but by this time sporadic contamination may be important. Mid to late October data cluster around the main Orionid maxima, possibly given rise to some further contamination if observers are not looking near the Aurigid radiants then, or may perhaps simply be indicative of generally greater observer activity.

Comparison of these results with Kronk's δ-Aurigids [7], does show a reasonable match for his four filamental maxima at $\lambda_\odot = 186\overset{\circ}{.}5$ (filament "A"), $193\overset{\circ}{.}2$ ("B"), $\approx 198\overset{\circ}{.}5$ ("C"), and $188\overset{\circ}{.}2$ ("D"; probably telescopic however), which were derived from radio data, and also gives some support to his conclusion of a general maximum apparent from October 6–15 ($\lambda_\odot \approx 192°$–$201°$). The limiting dates of September 22 to October 23 ($\lambda_\odot \approx 178°$–$209°$) do not seem to be confirmed however, nor does the suggestion that filament "B" represents the stream's main core, but it would be unwise to try to be too precise about these matters based only on the current results.

Ignoring much of the August data, low Aurigid activity was noted from late August until mid-October with a reasonable degree of certainty, and may well continue until late October, though this cannot be definitely shown here. Possible further peaks around the September–October boundary and in early mid-October can perhaps be inferred in addition to those noted already by the *IMO*, and might be worth checking for in past or future years.

Although the *JASMS* radiant positions used did not coincide precisely with the *IMO* ones, the relative proximity to one another, coupled with the fact that "α-Aurigid" activity of some description was detected particularly in late August to September, implies that genuine Aurigid meteors were being seen. From 1992, *JASMS* observers will be encouraged to plot all Aurigid meteors to try to help better define activity from the individual streams.

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Visual Observational Results

ALPO Summer Observations

Robert Lunsford

Summer 1991 Observations of the *ALPO Meteor Section* are presented.

A total of 29 observers contributed 257 hours of observations and 2763 meteors during the past summer season to the *ALPO Meteor Section*. The normal highlight of this period, the Perseids, were hampered by clouds over most of the continental United States during the time of maximum. Michael Morrow's Hawaiian team was in a favorable position to view the strong rates that occurred on the morning of August 12. Unfortunately, clouds and a thick dust layer from Mt. Pinatubo spoiled the display. The highest hourly rate seen by an *ALPO* observer was 62 between 11^h and 12^h UT on August 13.

Unexpected activity was seen from four radiants during the summer months. Between June 22–30, observer John Gallagher of New Jersey saw 20 meteors with velocities similar to the June Lyrids radiating from near β Cygni (Albireo). The ZHR was 1.9. He also observed 13 swift meteors radiating from the δ Cephei area between July 8 and 18. The ZHR for this shower was 1.5. Activity from this radiant is mentioned by W.F. Denning in his "Monthly Notices" [1].

While reducing plots made on August 7 and 8 I noticed two sharp radiants occurring at $\alpha = 48°$, $\delta = -5°$ and $\alpha = 55°$, $\delta = +7°$. They produced 8 and 9 swift, bluish meteors respectively during 6.5 hours of plotting. These radiants are not listed among the usual lists of annual showers but both are mentioned by Gary Kronk [2]. He points out that the *August Eridanids* have an orbit similar to comet Pons-Gambart. Kronk also notes that "no visual evidence exists to support this radiant; however, there is strong evidence of activity 8°–10° north among records of the AMS" [2]. I believe that the activity seen by AMS observers coincides with my radiant near χ Tauri and that these two radiants are separate and distinguishable in the August morning sky.

References

[1] W.F. Denning, *Monthly Notices* 1, pp. 410–467.

[2] G. Kronk, "Meteor Showers: A Descriptive Catalog", Enslow, 1988, pp. 171–172.

I have to point out that it is generally agreed upon that many of the radiants mentioned by Denning are spurious. Trying to identify minor showers on Denning's radiant data may therefore well be building a hypothesis on top of another hypothesis (Ed.)

Hungarian Perseid Observations of 1991

László Gyarmati, Péter Spányi and István Tepliczky

An account is given of Hungarian observations of the 1991 Perseids and minor streams active during the same period.

Last summer's bad weather caused the Hungarian meteor observers much trouble. The otherwise dry and clear August was mostly cloudy this year. Like in the previous years we had prepared for the observations of the Perseid maximum. Because of the lack of high mountains in Hungary, our camping facilities are limited. This year we organized our Perseid camp near Szomolya (a small village 150 km east of Budapest) at $\lambda = 20°28'$ N, $\varphi = 47°53'$ N and an elevation of 300 m. Forty three people participated in the event between August 8 and 18. Due to the clouds passing over continuously, only 6 of the 10 nights were suitable for observation. Of these 6 nights, just 4 can be regarded as really successful.

During the camp, 4500 meteors were recorded. We plotted the paths of almost all meteors on gnomonic maps and noticed that the Perseids were coming from two to three separate radiants. We were able to record some smaller showers. Unfortunately the *IMO* does not want to deal with these showers, nor with the storage of the position data of meteors. If any organization or data center is interested in these questions we offer our new and earlier data for study.

Comments from the editor

In response to the last paragraph of the above article it should be made clear for once and for all that it is not true that the IMO *is not interested in positional data, radiant structures or minor showers. By definition the* IMO *is interested in* all *aspects of meteor astronomy. In order to be able to deal with radiant structure and smaller showers, the* IMO *refined its observing method (see* IMO Info 5*). Several studies about the observability of minor showers appeared in* WGN *(e.g., the 17-page article of Ralf Koschack in last year's December issue). And positional data are used in* IMO*'s Aquarid Project, of which we hope to present the results soon.*

Using the visual method to the limits of its capabilities however requires the imposing of very strong quality demands on the observations. Unfortunately, only a very limited number of observers has the necessary experience and self-discipline to meet these demands. Taking into account the low rates of minor showers this means that in most cases there are simply not enough data available to perform a meaningful analysis. Even worse, the IMO *gets hardly enough data about the major showers. If at this time we would ask observers to shift their attention to minor showers or radiant structure, we would risk that also the major showers become unanalyzable. For this very compelling reason, the* IMO *has no other choice but to give priority to the larger showers, as is also very well explained by Visual Commission Director Ralf Koschack on pp. 3–4.*

The 1991 Perseids from the USSR

A.I. Grishchenyuk and V.V. Martynenko

An overview is given of first impressions of the 1991 Perseid shower in the former Soviet Union. A tendency for clustering is reported as well as some arguments in favor of different atmospheric properties for meteors of which the meteoroids were ejected at different times from the comet nucleus.

In the USSR, the Perseid watch was concentrated mainly in Crimea where seven groups (the Crimean groups in Simferopol, Malorechenskoe, Kirch, Sudak and L'govskoe, and the groups from Chelyabinsk, Kirov and Leningrad) worked separately. Another group directed by A.S. Levina made a trip to Krasnoyarsk in Siberia in order to set up a longitudinal observational network. Other Soviet groups worked in the Northern Caucasus and in Middle Asia.

First, we wish to share with you some fresh impressions.

Some numerical results were already presented in last year's December issue and partially corrected and supplemented in this issue on p. 15. (Ed.)

1. The Perseids are still having a very narrow peak that is due to a very fine and dense shower's core. Crimean groups detected maximum activity around 22^h–0^h UT on August 12-13, but the group in Krasnoyarsk observed very high (crazy!) activity at 16^h UT.
2. An apparent tendency of the Perseids to appear together in "batches" or "clouds" of 10–15 meteors per 2–3 minutes, with large interruptions in between, was striking. A fine time resolution of our observations (1 second) gives us the opportunity of a quantitative analysis of meteor group parameters (mass, time and other).

   Our first impression is that in 90% of the cases, a bright meteor was followed by a series of fainter Perseids. There was a bulk of "twin"-Perseids, i.e., 2–4 meteors traveling through the same part of sky during 3–10 seconds. August 12-13 observers registered a simultaneous flight of four Perseids that close together that their mutual distance did not exceed 3°! Sometimes we registered 5–8 meteor groups traveling through a small area of the sky, such as the Pegasus Square, during 6–10 seconds.
3. Physical properties of the showers meteors were changing significantly. Up to August 13 most of the bright meteors had a double burst. From August 13 onwards, their number dropped, and most Perseids showed a flat brightness curve. Close to the radiant, short Perseids "leaked" from the radiant as in cartoons.
4. We also paid attention to minor showers. This year, we suspected a radiant in Cetus ($\alpha = 40°$, $\delta = +8°$) with a maximum around August 9-10.

In conjunction with item 3, we want to elaborate a little on the the atmospheric distinction of meteoroids ejected from the comet's nucleus at different times. Do they show a significant difference?

As far back as the early '70s N. Smirnof from Yaroslavl—one of the most outstanding meteor observers—noticed that the main Perseid radiant produced meteors of different colors: white and orange. Although Smirnof encountered sceptical objections in the '70s, we now got a new look to this phenomenon.

We are sure that meteoroids of different ages have different physical properties. It seems plausible to me that we can manage to detect some evident differences, e.g., in the character of the photometric curves.

For example in 1986 we registered a lot of "batches" from the radiant with the photometric curve shown in Figure 1 (left). (Intervals *a*-*b* and *c*-*d* were beyond the eye limit).

In 1991, "batch" meteors had a flatter photometric curve: meteors did not "burst" but "leaked" from the radiant. In 1992, Crimean meteor groups plan to set up a more detailed study of the physical properties of meteors in a specialized program.

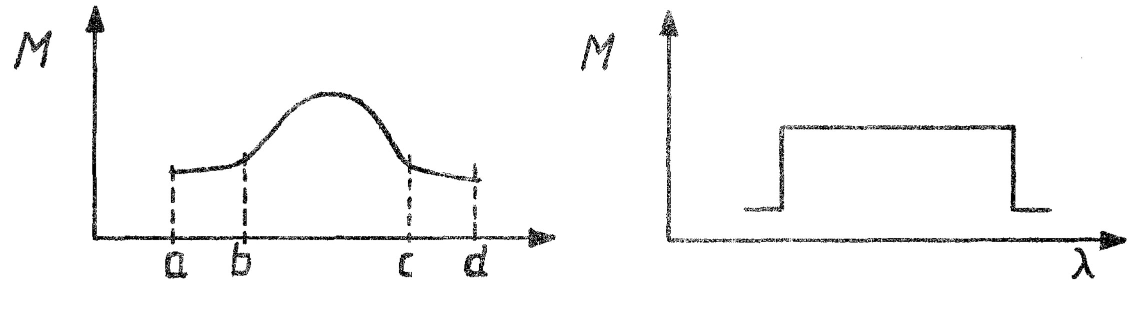

Figure 1 – Typical photometric curve of a Perseid "batch" meteor in 1986 *(left)* and 1991 *(right)*.

Puimichel Revisited: The 1991 Taurids

Paul Roggemans

An overview is given of the author's observations between November 4 and 10 in Southern France. Main target were the Taurids. A few late Orionids and early Leonids were seen as well, but no activity due to comet P/Hartley 2 could be detected.

When I found some holidays unused for what they were planned, I decided to go to Southern France during the Taurid activity. Being alone, I decided to go to Puimichel, a well-known observing site where I observed several times between 1984 and 1986. Having the poor weather of October 1990 in mind, I did not put my expectations very high and took some paper work with me.

The weather was rainy and cloudy when I arrived on November 2. This was no problem though, as I had enough paper work to do! The third day it became clear and it would stay clear until I left on November 10. Observing concentrated on any possible meteors produced by comet Hartley 2, late Orionids, early Leonids and of course Taurids. I could observe all nights except one, because I caught a cold and had to stay inside for one day. Some hours were spent to admire a spectacular aurora on November 8-9: a most rare phenomenon in Southern France. It was one of the most impressive things I ever saw during my so many observing nights. It was that fascinating that I even canceled my meteor observing for some time!

In the period of November 4 to 10, no activity of Hartley meteors could be detected. Very few Orionids were seen. In the last nights, a couple of possible early Leonids were detected. The first nights gave normal Taurid rates, with mainly members of the Southern branch. Later the Northern branch became more dominant. A few bright meteors were seen, the best being −6. Most of the time, I was alone to enjoy the clear sky with a cold Mistral wind blewing.

The beautiful landscape always attracts me for walks, so I also enjoyed the time as holidays. I left with a good impression of Puimichel. The house has been improved a lot and everything was done to help where necessary. The observatory got wind shields for people who work in the open field. Although more lights can be seen near Puimichel than in Lardiers, none of these hampered observing. Compared to 1986, I found major improvements for which the main manager in Puimichel, Arlette Steenmans, is to be congratulated.

1991 Geminid Expeditions of the AKM

Jürgen Rendtel

An overview is given of the 1991 Geminid observations of the *Arbeitskreis Meteore (AKM)* in Germany.

The Geminids are beyond any doubt the most attractive meteor shower. But the observations are much less comfortable than those of the summer period. Furthermore, in Central Europe the observers normally face unstable (sometimes unpredictable) weather conditions. Thus the opportunity to observe the Geminids from the "personal observing site" is a rare exception and the observers must be prepared for expeditions.

In 1991, the observers were surprised when cold and dry air came to Germany with the beginning of the Geminid activity. One already thought about a maximum visible from the backyard. But towards the maximum the situation became more and more like a thriller—except for the observers in the region of the Alps.

A team from Potsdam (Rainer Arlt, Ralf Kuschnik, my wife Ina and me) left in the afternoon of December 12 after consultation of the meteorological office in Potsdam with the advice that in the southeastern mountains the conditions will remain best. Ralf Koschack waited for us in Zittau and after moonset we observed for about seven hours lying in a frosty snow-covered landscape. When a few clouds appeared in the morning, we did not yet think about the next night.

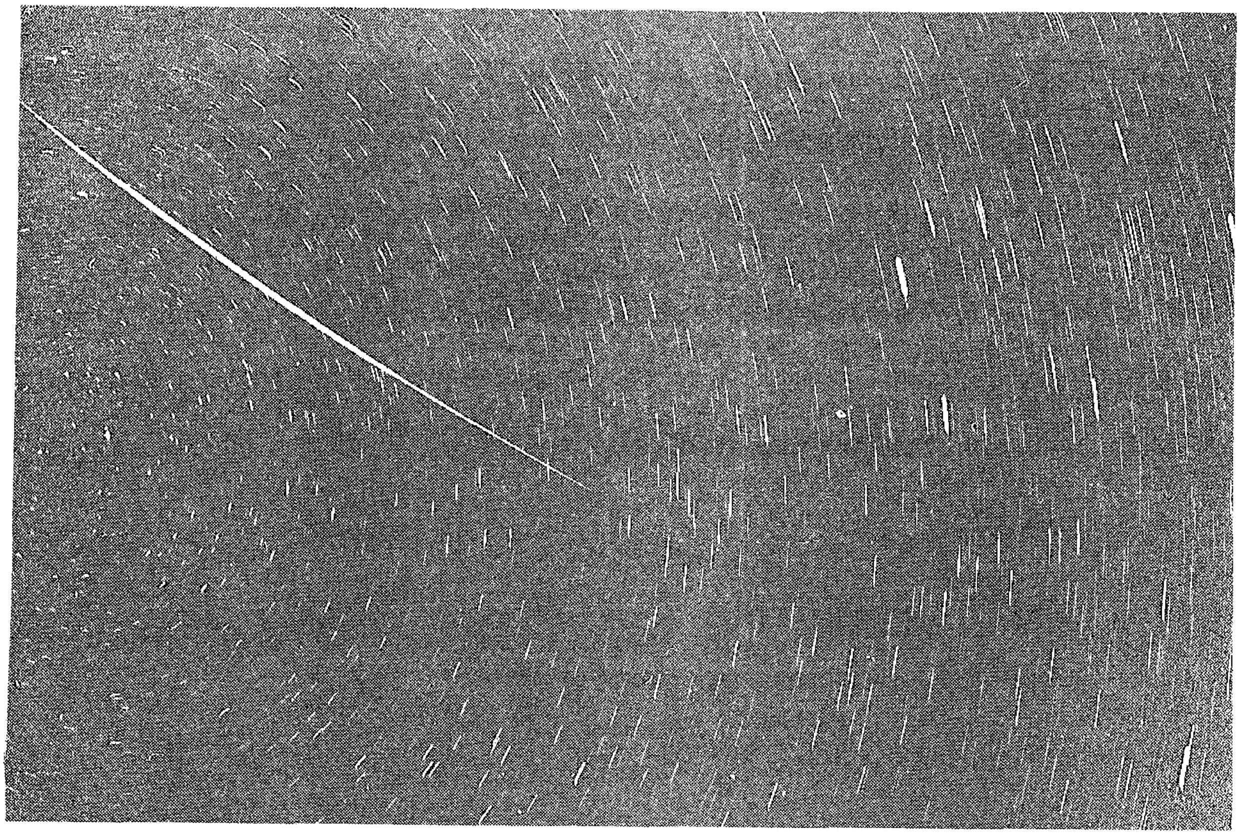

Figure 1 – Bright -5 Geminid photographed from the site in Thuringia on December 13, $23^h05^m25^s$ UT. (Exposure from $22^h57^m10^s$ till $23^h07^m10^s$ at ISO 400/27° using a fish-ey Zodiak $f/3.5$, $f = 30$ mm.)

When we wake up at noon on December 13, we became worried by the clouds. After a substantial meal we again phoned the meteorologist of the Potsdam station. Now he recommended any area in the southwest of Germany. With four observers we moved to Thuringia where we arrived at moonset and started to observe in a field right away. Only a few minutes later, our brightest Geminid fireball appeared—the cameras worked for just five minutes at that time! Again we were able to observe for about seven hours under reasonable conditions. The Geminid activity was at the expected level: ZHRs calculated so far are around 80 to 90.

The consultations of the meteorologist helped us a lot to find suitable sites. As in the previous years the expeditions were successful and the Geminid display made it worth-while to search for a favorable observing place. But also other observers of the *Arbeitskreis Meteore (AKM)* had good luck, some nearly at home, others also at preferable sites elsewhere in Europe.

Together with the series of data obtained in the nights before and after the maximum as well as the huge amount of data of other groups worldwide we will again see an interesting cross section of the remarkable Geminid meteor shower. The observers of the *AKM* contributed several thousands of Geminid data due to the successful trips made around the shower's maximum.

Photographic Observational Results

The 1991 Geminids in the Netherlands

Casper ter Kuile

An overview is given of the Dutch 1991 Geminid campaign at the Public Observatory of Twente.

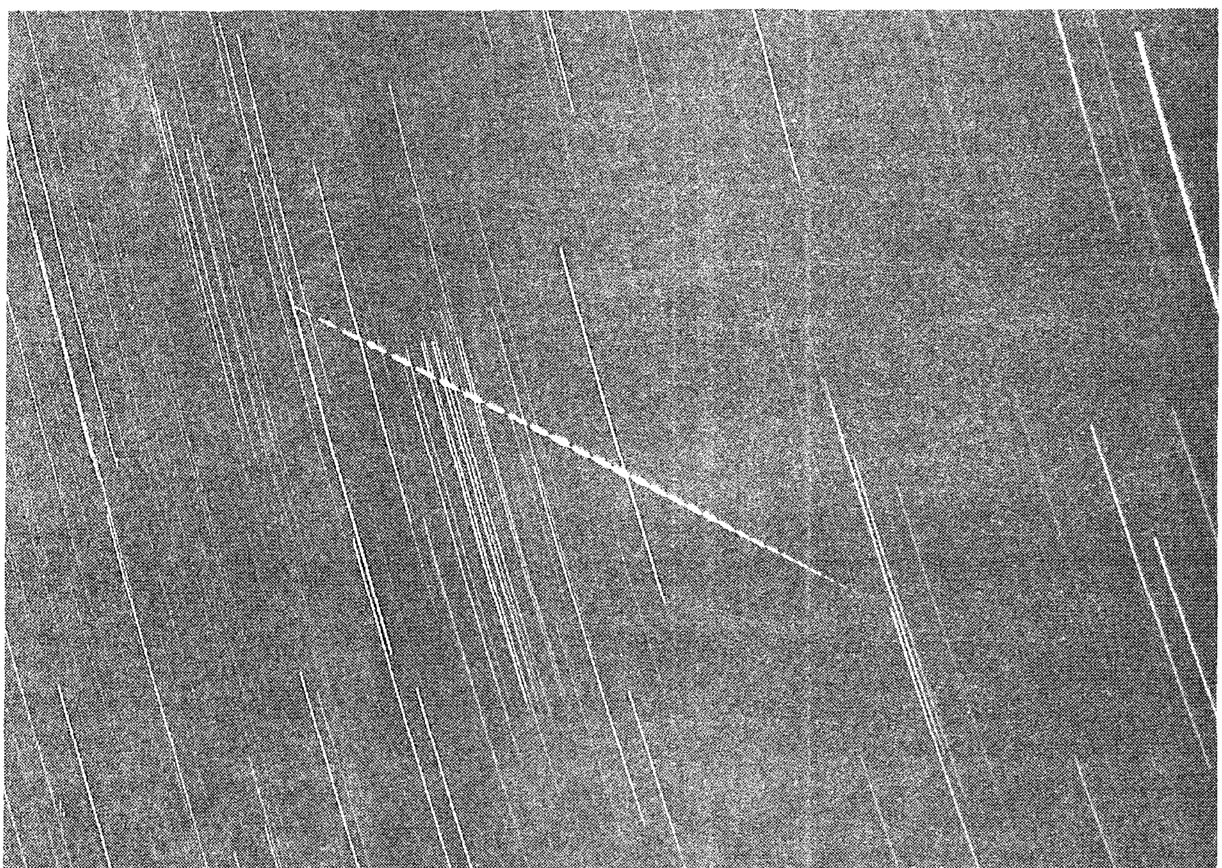

Figure 1 – Magnitude −3 Geminid in Cancer photographed on December 15 between $2^h10^m50^s$ and $2^h30^m00^s$ UT.

A splendid campaign, let us use these words to characterize the 1991 Geminids. Contrary to the 1990 Geminid action in Southern France, this adjective does not refer in first place to the obtained results but to campaign itself. The weather reminded us of the Provence. The first half of December we had an all-time high for the number of cloudless nights. Our first observing night of December 13-14 was very exciting. At the *Twente Public Observatory (VST)* a persistent cloud-layer blocked our view on the Geminids. We decided to start a "crash operation" which brought us to the farmhouse of the family Jenniskens in Meterik in the middle of the province of Limburg. The second night, December 14-15, we were lucky to observe from the specially designed observing roof of the *VST* at Lattrop near Denekamp (the site of the 1983 *IMW*).

Many observers enjoyed the Geminids majestically coming down along a black starry sky. After moonset we definitely had a fine display! Together with many enthusiastic observers on the roof of the *VST* we had a great time!

The results of the action are not bad at all but considering the excellent weather, we could have done better. Looking back it would have been better to stay at Lattrop on December 13-14. The nightly light-flood from the nearby greenhouse at Meterik sadly implied black negatives. We were hampered by technical problems too. Our Canons AE-1 were affected by some kind of "bug". Half of our negatives proved to be unexposed. These two "facts of life" only discovered in the dark room costed us many simultaneously photographed meteors with our colleagues in the Netherlands. Nevertheless, we are very lucky to have been able to immortalize some very fine specimens! Two of them accompany this article.

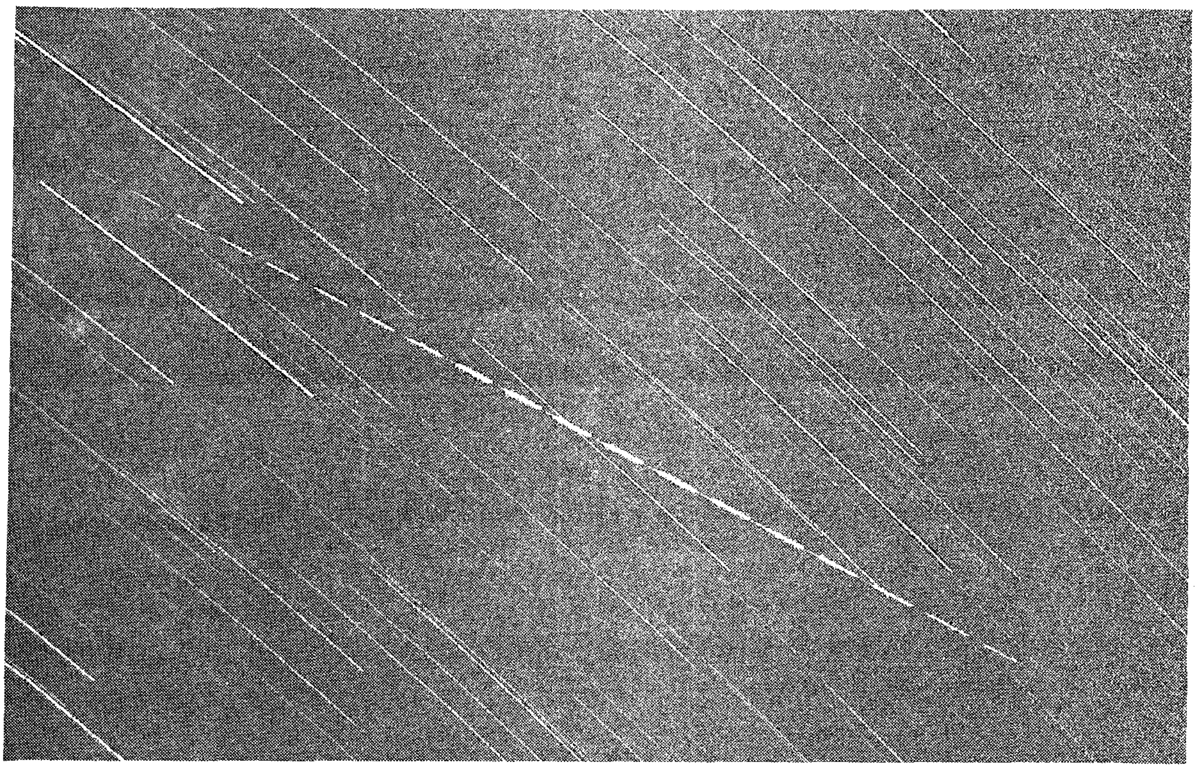

Figure 2 – Magnitude −2 Geminid in Leo Minor photographed on December 15 at $3^h00^m28^s$ UT. The negative was exposed from 2^h50^m till 3^h10^m UT.

The results of the 1991 Geminids are but a poor substitute for our famous 1990 Geminid campaign in Southern France. In spite of all this it was the best Geminid campaign ever in the Netherlands in many, many years. One thing we know for sure now: *VST* Lattrop is undoubtedly one of the best locations for meteor observers in this country! Many thanks to all the people of *VST* who made the observatory a worthy "staircase to heaven". To close, I would like to express our gratitude to Carl Johannink who offered free accommodation and again made the weekend an unforgettable one!

Telescopic Observational Results

Telescopic Observations of the 1991 Perseids in Czechoslovakia

Petr Pravec, Ondřejov Observatory

During August 7 to 16, 1991, 15 Czech and Slovak observers from three stations obtained 1558 telescopic records of meteors within the 1988–1992 Perseid Project and the Parallel TV and Telescopic Meteor Observation Program. Forty meteors was observed both telescopically and by means of a TV-camera. Obtained data will allow us to study structure of meteor stream of Perseids, compare telescopic and TV-records of common meteors and judge a quality and errors of telescopic observations of meteors.

1. Introduction

During several years already, the Perseid meteor shower is a subject of interest to Czechoslovak telescopic meteor observers. There is a chance for a possible return of the parent body of the Perseid stream, comet 1862 III P/Swift-Tuttle, in 1992 [1]. Therefore, regular telescopic observations of this shower were started in Czechoslovakia in 1988 within the 1988–1992 Perseid Project. Aim of this project is describing the structure of the component of the Perseid meteor shower consisting of particles corresponding to meteors of magnitude 4 to 9, and finding out whether changes will occur due to the return of P/Swift Tuttle.

From 1988 to 1990 we have obtained about 3500 records of telescopic meteors around the Perseid maximum. The first analysis of 687 reliable records from 1988 confirms the well-known fact of a relative excess of big particles in the Perseid stream (with respect to sporadic background). The mass distribution index s of the Perseids was found to be 1.51 ± 0.13, where for the sporadic background the value is $s = 2.24 \pm 0.05$.

Good observing conditions around the Perseid maximum this year (moon-free) and observers skilled in watching Perseids were the two qualities that allowed us to obtain the next set of useful data. More than 20 observers from five stations were ready for telescopic observations within the 1988–1992 Perseid Project in August 1991. One group of 8 telescopic observers and two operators of the TV-meteor camera (J. Boček and V. Padevět) were ready for the parallel telescopic and TV observations at the Ondřejov Observatory. Task of these observations was to obtain records of several tens of meteors both telescopically and by means of the TV-camera, what would be enabled us to study a quality and real errors of telescopic records of meteors and to find relations between records obtained by means of these different techniques (see [2]).

2. Observations of the 1991 Perseids

During August 7 to 16, 1991, 15 observers from three stations obtained 1558 telescopic records of meteors. The observers were:

> Denisa Dvořáková, Petr Halaxa, Kamil Hornoch, Filip Hroch, David Konečný, Ján Mušinský, Petr Pravec and Karel Trutnovský (Ondřejov station, 815 meteors), Igor Berky, Jaroslav Gerboš, Daniel Očenáš, Pavol Rapavý and Miroslav Znášik (station Lubietová-Žliabky, 399 meteors), Josef Kujal and Martin Lehký (station Sopotnice, 344 meteors).

They used binoculars db 10×80 (13 observers) and mb 12×60 (2 observers). All stations were situated in Czechoslovakia.

These data are still to be supplemented by records of several other observers from stations at Šibenický vrch and Zachotín. Already now, however, it is clear that these data are the best obtained thus far in the 1988–1992 Perseid Project.

Parallel Observations, telescopically and by means of TV-techniques, were also very successful. The TV-camera and several (usually 5 to 7) observers watched the same field in the sky simultaneously during 7 nights (covering 11.5 hours). Forty simultaneous meteors were recorded, each of them observed by means of the TV-camera and typically 3 to 5 telescopic observers. The brightest had magnitude 4, while the faintest were 8 to 8.5. The majority had magnitudes between 5.5 and 7.5.

The data of simultaneous TV and telescopic meteors enabled us to make an analysis of the errors on telescopic records (at least for meteors of magnitude of 8 and brighter, which is within the reach of the TV-camera we used). The results obtained agree with the expectations and previous statistical analyses of other (exclusively) telescopic data.

The standard deviation of the position angles (SDPA) of all telescopic records is 11°, while the standard deviation of the transversal shifts equals 0°5. There is however an interesting and important time dependence of the precision of telescopic records. When observers started observation after several months or one year of non-activity, they had very large errors during their first night (SDPA of 13°). During the following nights, their errors decreased and after three or four observing nights they became stable (SDPA of 9°). So when a typical (seasonal) observer of our group observes at a usual distance from the radiant of the investigated shower (from 12° for fast meteors to 20° for slow ones), the standard deviation of the radiant position of a shower meteor equals 1.9°–3.1°, about half the standard deviation for experienced visual observers [3].

Neither significant systematic deviations nor important dependences of the precision of telescopic records of meteors on any recorded meteor parameters(such as magnitude, length, velocity, position and orientation in the field of view, the observer's opinion about the quality of record etc.). These results confirm the validity of telescopic observations for studying meteors of magnitude between 4 and 8 [4].

The analysis of simultaneous TV and telescopic meteors also allow us to obtain results about the probability of observing meteors of different magnitudes (using db 10×80). The probability is constant for meteors of magnitude 6 or brighter and equals 80–85%. Towards fainter meteors, it gradually decreases; it is between 80 and 70% for meteors of magnitude 6.5 or 7, about 60% for magnitude 7.5 and 40–50% for meteors of magnitude 8. (It would probably be in the order of 10% for magnitude-9 meteors, but such faint meteors could not be detected by means of the TV-technique.)

The probability never equals 100%, not even for very bright meteors; its limiting value is between 80 and 85%This fact is caused by the relatively high rate of "dead time" in each telescopic observations. It is necessary to spend some time for drawing meteors also operating the telescope. Also, there regular drops of attention, e.g., by diverting from the telescope and looking to the sky or the surroundings. Hence these probability values are valid only for the actual observing conditions of our watches during August 1991. In case of different conditions (different telescopes, sky condition, observers, their physical and emotional conditions etc.) the probability must be different, especially for faint meteors. The situation here is more complex than for visual observations and that is the reason why no general expression for the telescopic probability of observing meteors can be given. However, if we want to do an analysis of the activity of telescopic meteors we have some reliable non-direct ways to deal with this.

Interesting to note is that two cases where found in which a satellite flash or brightening was taken for a meteor.

One of these cases was caused by a flash close to the edge of the telescopic field of view and observers considered it to be a meteor beginning close to the edge and moved out from the field of view. The second confusion was caused by a one-second brightening of an otherwise invisible satellite and was considered to be a very short and slow meteor. Detailed descriptions of these events will be given in a future article, but it is clear, that there is probably a non-negligible influence of satellite brightenings and flashes on telescopic meteor records.

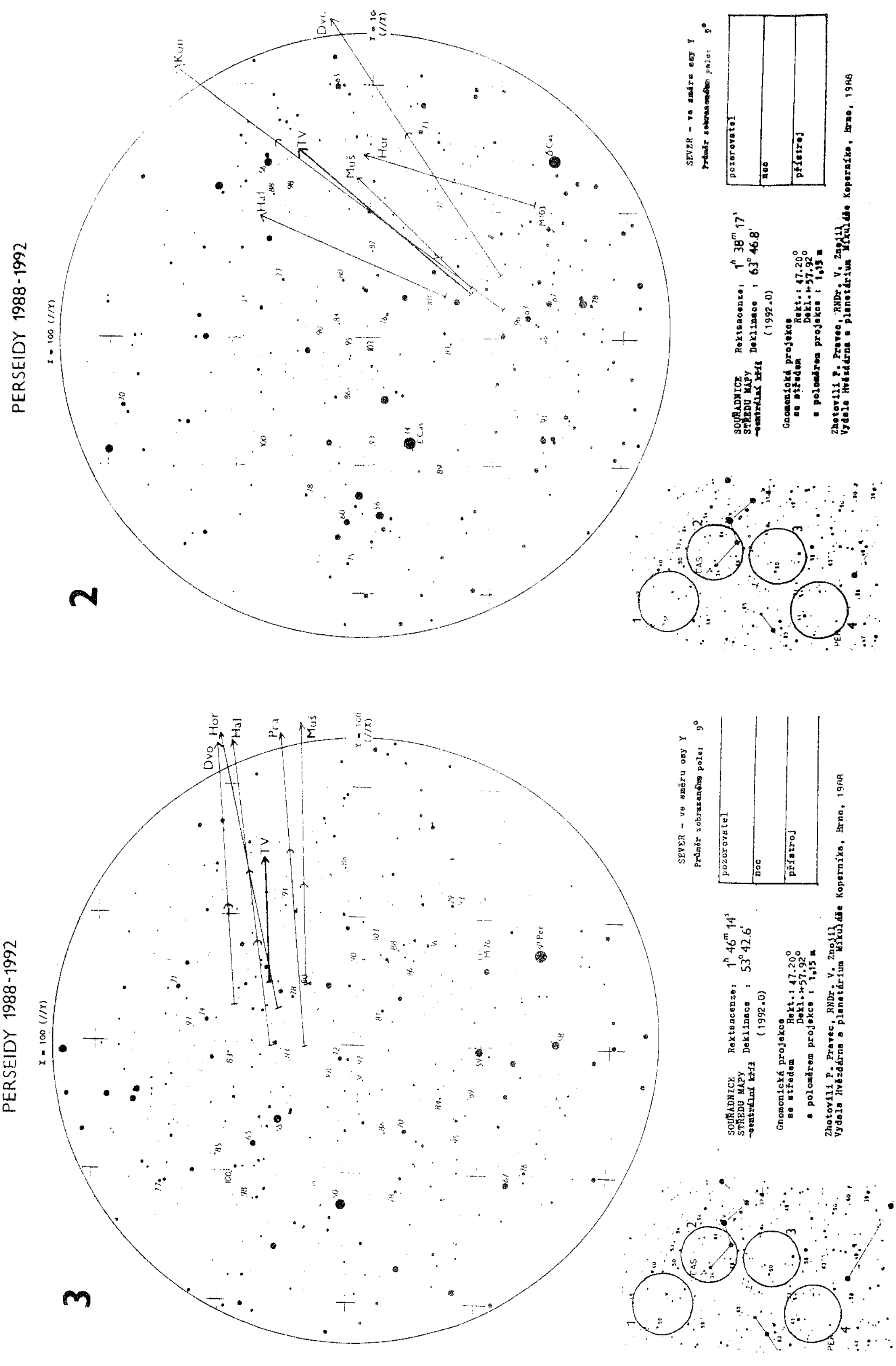

Figure 1 – *Left:* One of the telescopically well-recorded Perseids (August 10, 1991, $21^h10^m14^s$ UT, magnitude 7). The most important are good records of the position angle of the meteor; transversal displacements and different lengths are much less important. The small arcs indicate the intersections of recorded traces with the edge of the field of view. The distance between grid marks is approximately 2°. *Right:* An example of a poorly recorded Perseid (August 7, 1991, $23^h05^m58^s$ UT, magnitude 5).

Acknowledgments

I thank all Perseid observers for obtaining useful data of faint Perseids. I thank Mr. Jaroslav Boček and dr. Vladimír Padevět for their TV-work and their help with the analysis of the TV-records. We are indebted to all of them for an increased amount of knowledge on the Perseid meteor stream and on telescopic meteor observations in general. I am convinced that the 1991 Perseid observations gave them a great, beautiful and exciting experience.

References

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[2] Pravec P., *WGN* 19:4, August 1991, p. 141.

[3] Koschack R., communication at the *International Meteor Conference*, Potsdam, September 1991.

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Telescopic Orionids in the Night of October 22-23, 1990

Torsten Hansen

Five telescopic Orionids observed on October 22-23, 1990, allowed the determination of a sharp radiant.

In the night of October 22–30, 1990 ($\lambda_\odot$ = 209°.6, Ep. 2000.0) I was fortunate to observe a relatively sharp Orionid radiant. I used three different fields, as can be seen in Figure 1. The observation site was Unterhaslach near Ulm and my visual limiting magnitude was 5.7 that night. All data has been collected with a 7 × 50 wide angle binocular (field of 7°), during 2.97 hours effective observing time. In total, I saw 13 meteors. I used charts from [1].

In Figure 1 the center of each chart is marked and the position under the chart number refers to this center. The original scale of the maps is 1° = 15 mm. To assemble Figure 1, I had to reduce the maps. As a result, the scale of Figure 1 is 1° ≈ 7.5 mm.

In Figure 1 the position of the theoretical radiant is also marked (α = 95°.7, δ = 15°.9, Ep. 1950.0, from [2]). The position of the observed radiant is α = 94°.8, δ = 17°.4, Ep. 1950.0, using those five meteors that produced the sharp region of intersection (diameter of about 0°.5). All this results in a difference of about 2° between the theoretical and observed radiant center. These results are consistent with those in [3], Figure 2, for October 23, 1935 ($\lambda_\odot$ = 209°.8).

As a final conclusion one can say that the Orionid meteor stream is a very fine object for telescopic study and a good practise and motivation for beginning observers.

References

[1] H. Vehrenberg, "The Falkau Atlas, Photographic Star Atlas, 1950.0", Treugesell Verlag, Düsseldorf, 3rd edition, 1972.

[2] P. Roggemans (compiler), "1988 Visual Meteor Data", *WGN Report Series 3*, International Meteor Organization, 1990.

[3] M.J. Currie, "Telescopic Observers' Notes : Nov-Dec 1990", *WGN* 18:5, October 1990, p. 181.

It should be noted that the Orionids have a rather complex radiant structure as a consequence of which radiant positions may differ somewhat from year to year, explaining differences which may occur with literature values. (Ed.)

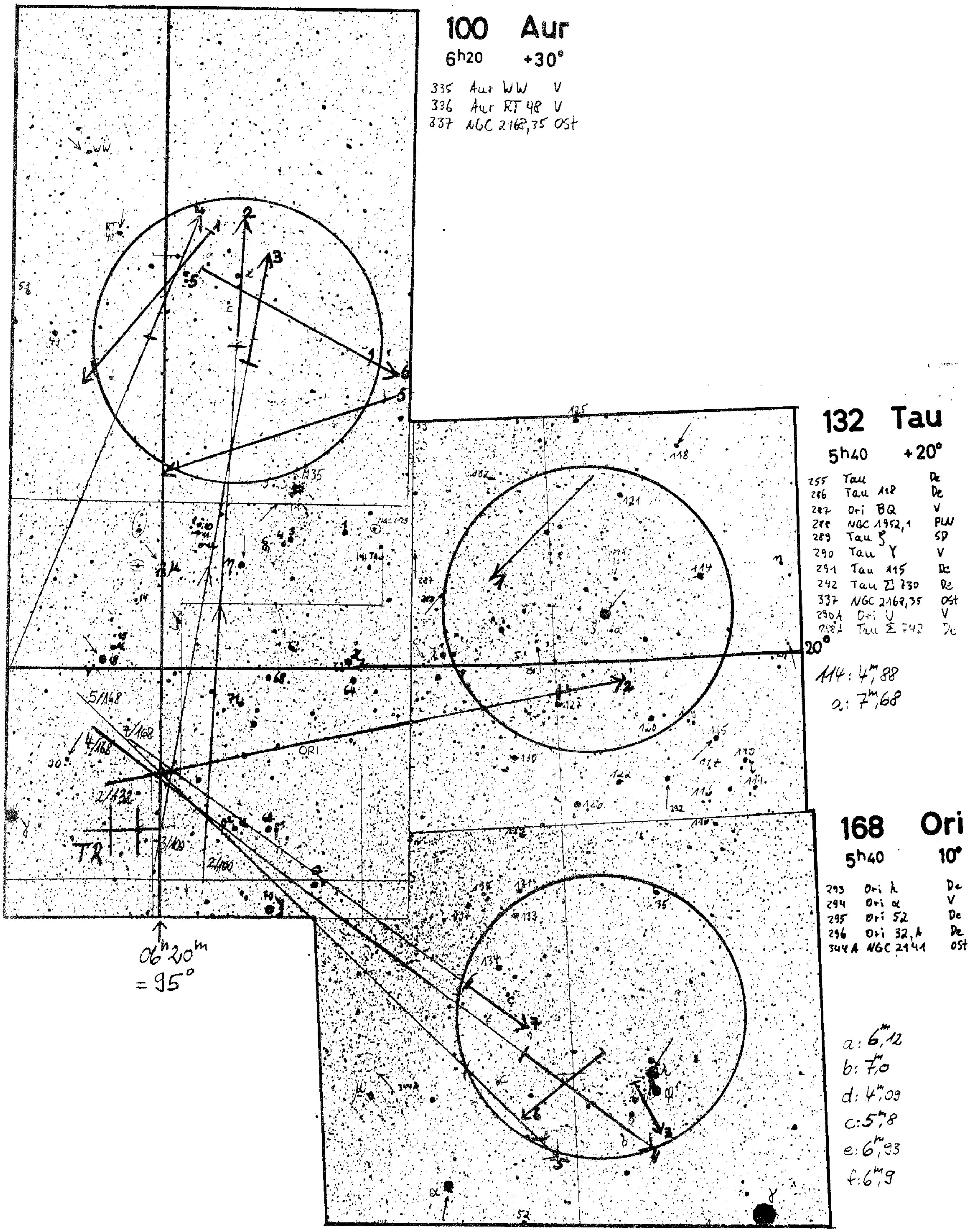

Figure 1 – Determination of the Orionid radiant from the author's telescopic observations on October 22-23, 1990.

Radio Observational Results

Bright Radio Leonids in 1989, 1990 and 1991

Gotfred Møbjerg Kristensen

The number of radio fireballs observed by the author around November is becoming more and more prominent since 1989.

It is of course interesting to see the activity of the Leonids develops over the latest years. The three graphs in Figure 1 show frequencies of bright radio meteors in November 1989, 1990 and 1991. They are based on around-the-clock observations registered by pen-recorder. The 17th of November is marked by a "hat".

In 1989, the Leonids hardly show up in the graphs. Maybe a few long-duration signals are due to the shower. In 1990, Leonid activity is definitely present,though only moderately visible on the graph. Several bright radio fireballs were noticed around November 18. In 1991, a clear peak of bright radio signals occurs around November 18.

I am concerned though that something caused a general increase in the numbers of signals this year. I am sure that the bright signals are mostly due to the Leonids (and the Taurids), but why should the general activity be so much higher in 1991 than in former years? In this connection, I want to warn radio-observers they should be very careful when interpretating their results. Some self-criticism is necessary.

Returning to the increased number of signals in 1991, I want to point out that I have not changed my equipment. However, I cannot neglect possible external factors. On the last day of November 1990, a powerful airport radar became operational, only a few kilometers north from where I live. It works on much higher frequencies though, probably around 1100 MHz. Is it possible that it could make my equipment more sensitive, Maybe because of Doppler-effects in the radar reflections from the meteors? Fact is, that since then, my level of radio reflections has always been higher.

Possibilities of RDS in Meteor Back-Scatter

Christian Steyaert

It is shown that the new *RDS (Radio Data System)* for FM radio will provide unique identification of the transmitter in meteor back-scatter.

1. Introduction

RDS (Radio Data System) supplies extra information to FM broadcasts. It has been specified by the *European Broadcasting Union (EBU)*, and it is being implemented by more and more transmitters. At the same time, almost all new car radios and higher priced home tuners have that feature.

In meteor back-scatter, one selects an "empty" frequency, i.e., one without direct reception. Most of the time, a meteor reflection is too short to allow audio identification, based e.g., on the language spoken. With automatic recording equipment (pen recorders, computer), only the signal strength is available. Which transmitter has reflected sometimes remains an open question, as the frequency is almost always shared between various transmitters. This is no problem for normal FM reception, as on the same location no two or more transmitters on the same frequency are in the line of sight. But in back-scatter, reflections from two transmitters of similar power and a couple of hundred kilometers away can be received.

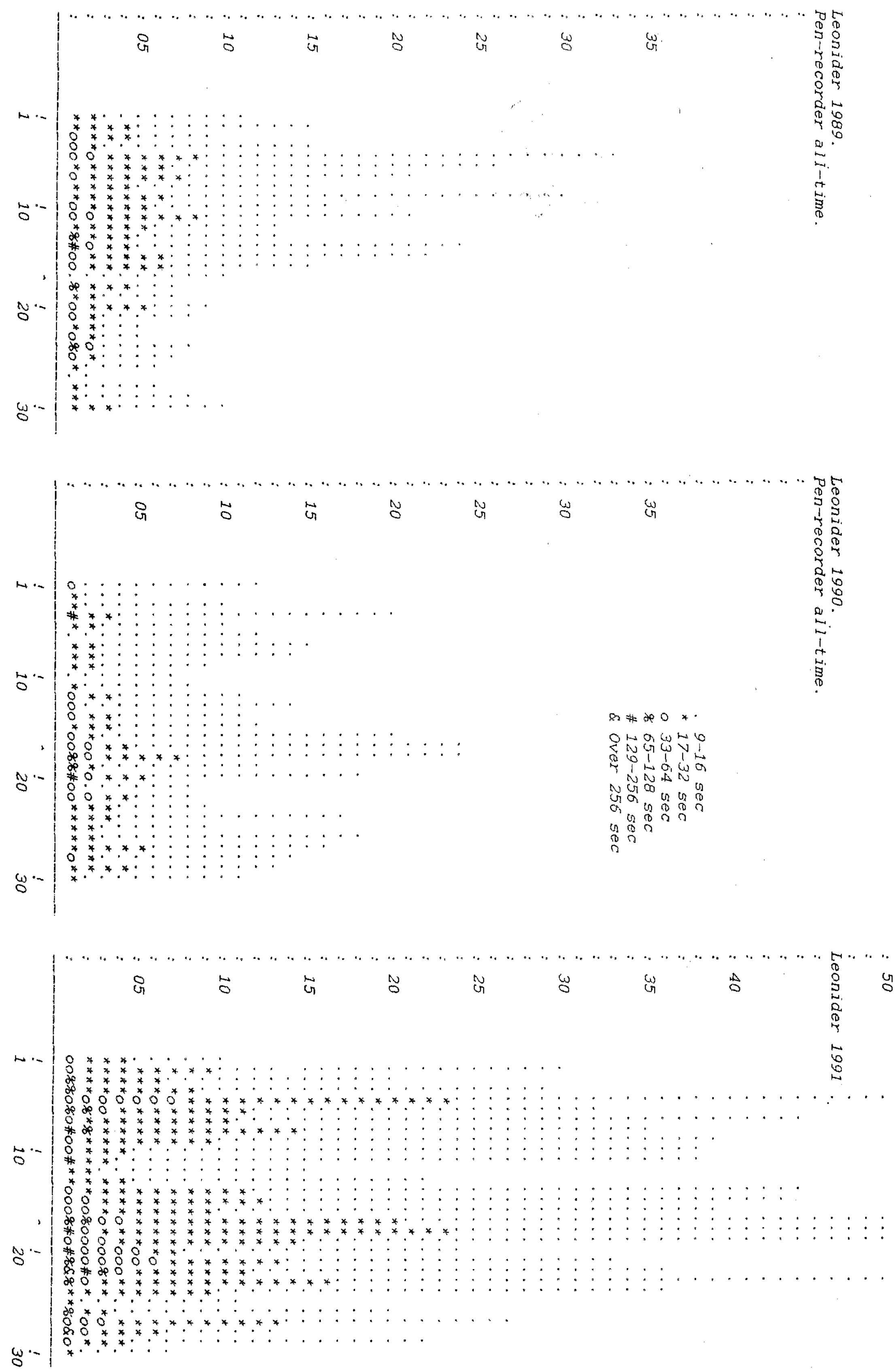

Figure 1 – Radio observations by the author in November 1989, 1990 and 1991.

Hence, automatic identification of the transmitter by means of RDS can be of great help in reducing radio observations based on the exact known geometry.

2. Functions of RDS

The functions of RDS are divided in three groups:

- *Primary functions:*
  - PI program identification
  - PS program service name
  - AF alternative frequencies
  - TP/TA traffic program/announcement
- *Secondary functions:*
  - ON other networks
  - CT clock time and date
  - PTY program type
  - PIN program item number
  - RT radio text
  - TDC transparent data channel
  - DI decoder identification
  - M/S music/speech
  - IH in-house information
- *Supplementary functions:*
  - RP radio paging
  - TMC traffic message channel

Most important for us is *PI, Program Identification.* It is a 16-bits binary number which contains an identification number, a country indication and the range of the transmitter.

The *PS, Program Service name,* gives in plain text the name of the station (8 characters). This is normally shown on the display of the receiver.

We will not discuss the other functions, some of which are not yet implemented today.

RDS is implemented in Western Germany, the UK, the Scandinavian countries and Switzerland. Belgium and the Netherlands are following gradually. We are not aware of plans to introduce RDS in the lower FM band (66 MHz–72 MHz), still in use in most East-European countries. Vice versa, radio observers in these countries can today benefit from fairly free 88–108 MHz FM bands, and RDS in the West-European countries.

3. Modulation method

RDS is of course compatible with the existing broadcasting of stereo signals, i.e. existing receivers simply do not feel the presence of RDS. The spectrum is shown in Figure 1.

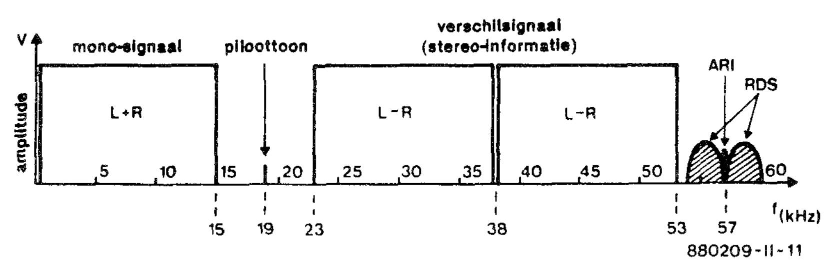

Figure 1 – Signal spectrum.

RDS is added on top of the 53 kHz multiplex signal of stereo broadcasts by means of double sideband (DSB) modulation. There is no carrier in the DSB: at this frequency (57 kHz, three times the pilot tone of 19 kHz) the ARI signal (Autofahrer Rundfunk Information) can be added.

In order to limit the bandwidth for RDS, differential biphase modulation is used. The result of this process, which we do not discuss in detail, is a data rate of 1187.5 bits per second. This type of modulation is rather insensitive to noise, which indicates that RDS might allow the identification of even faint meteor reflections.

4. Data flow

The various data elements of RDS are broadcast in a similar way to Teletext (the data pages of a TV channel): the most used or most important pages are repeated most frequently.

With RDS, the data are divided into groups. Each group in turn is divided in four blocks.

The system gives the possibility to define 32 groups, but only a few are in use yet. Block 1 of every group contains the PI code, the most important for us. Block 2 always starts with TP and PTY. In some groups, the PI code is repeated in block 3. Besides the 16 databits, each block contains a 10 bit checkword and offset. The checkword allows the decoder to detect and correct errors in a very reliable way and to identify the block number. In this way, the decoder can synchronize the demodulation.

The length of a block is $(16 + 10) \times 4 = 104$ bits, requiring 87.6 ms. Hence, it will be possible to identify reflections of at least 0.1 s, i.e., the large majority of all reflections.

5. Demodulation/decoding

An RDS decoder can be connected directly to the exit of an FM decoder (before de-emphasis). Generation of the clock signal and the demodulation of the data stream can be done by means of a single chip. A second chip handles the block synchronization and error detection. In this way, the processor handling the information is offloaded from that function.

The processor can, e.g., control a display showing the Program Identification (PI) and the service name. In back-scatter, most of the time, no signal is received. Hence, the PI should only be displayed for a couple of seconds after a meteor reflection, allowing the observer to record it.

In a automated set-up, once the signal strength is higher than a certain trigger level, details of the recording are stored in computer memory, together with the time and other details. Reading the PI code from the stand-alone detector and adding it to the digital recording increases significantly the value of each reflection recorded.

For further details and building plans, please contact the Radio Commission Director.

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

Other author's addresses

M. Beech, Astronomy Dept., Univ. of Western Ontario, London, *Ont. N6A 3K7, Canada*
D. Očenas, M. Razusa St. 5, CS-974 00 Banska Bystrica, *Czechoslovakia*
P. Ziminkoval, Hvezdaren, CS-975 90 Banska Bystrica, *Czechoslovakia*
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J. Borovicka, P. Spurný, Astronomical Institute, CS-25 165 Ondřejov, *Czechoslovakia*
R. Lunsford, Vance Street 161, Chula Vista, *CA 91910, USA*
I. Tepliczky et al., Baji ut 42, H-2890 Tata, *Hungary*
P. Pravec, Astronomical Institute, CS-25 165 Ondřejov, *Czechoslovakia*
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