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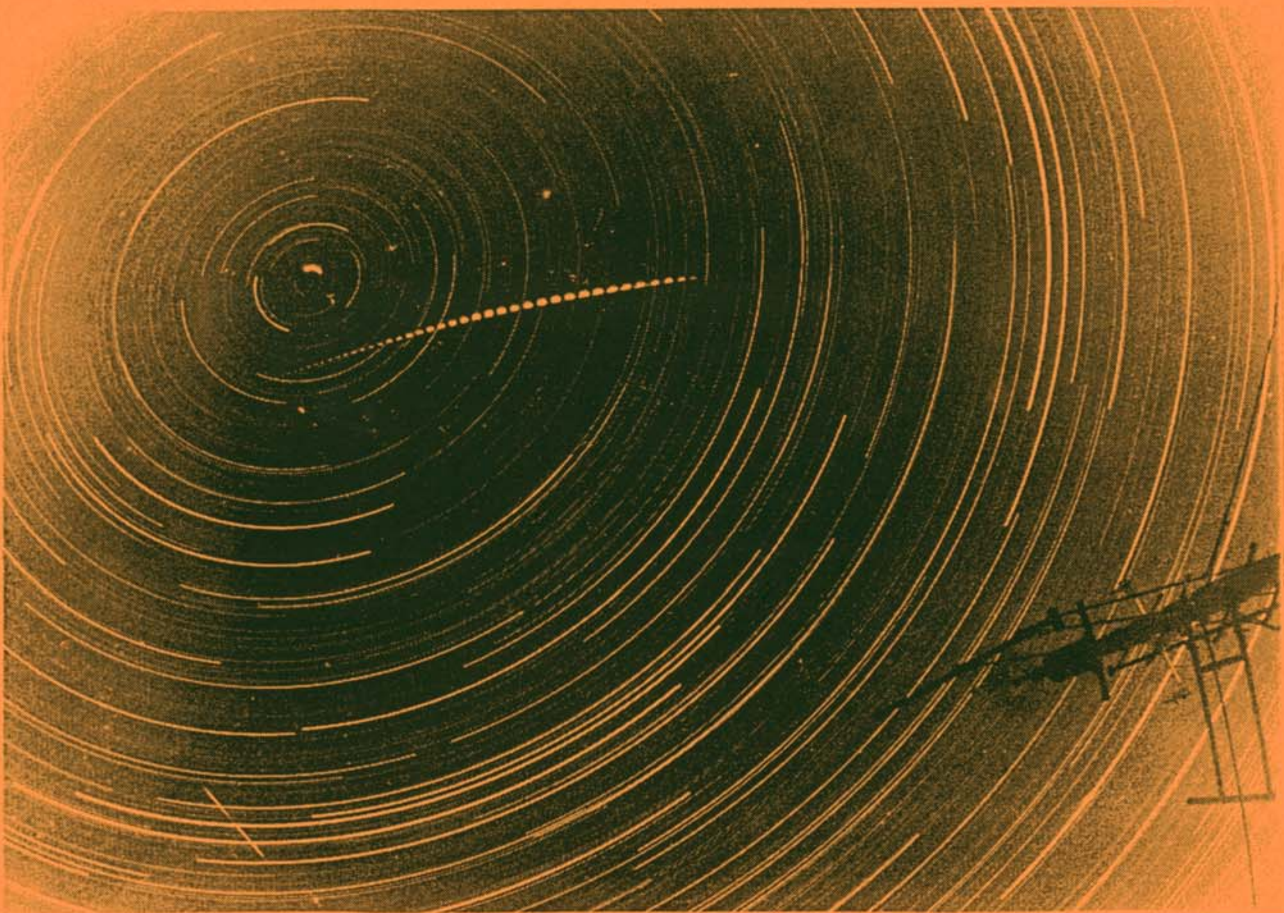

Detailed view of the EN160197 "Chrudim" fireball photographed near the pole from the closest Czech EN station #9, Svratouch, by a fixed fish-eye camera ($f = 30$ mm, $f/3.5$, 15 shutter breaks per second). The direction of the fireball flight is approximately from the east to the west. (See also elsewhere in this issue.)

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

WGN, Vol. 25, No. 1, April 1997, pp. 69–118

Contents

Useful Information

The June Issue *(WGN 25:3)*

The *June issue* will be mailed during the second week of June. Contributions are due on *May 23* at the latest. They should be sent to *Marc Gyssens*.

Administrative Correspondence

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

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

Letters to WGN

compiled by Marc Gyssens

The Draconids

Marco Langbroek's article on the Draconids (*WGN* 25:1, 1997, pp. 37–39), which usefully drew further attention to the importance of observing this shower, especially in 1998, was interesting, but I feel Marco did a disservice to those of us who have repeatedly stressed the value of covering this shower, and others, in recent years. The Draconids have featured in all the shower lists issued by the *IMO* since its foundation, for instance, unlike the listings distributed by some other meteor observing groups. His argument for possible Draconid activity in 1996 was also very weak. The strongest case was made using Peter Bus's observations from the Netherlands in September-October 1996. However, these observations were made only on September 22, October 6, and October 8 (system operating between 6^h00^m–11^h30^m UT on each date), October 12 (10^h00^m–11^h30^m UT), and October 13 (7^h00^m–9^h00^m UT) [1]. This does not allow a comparison of data at the same time on the days immediately preceding or following October 8, while the echo counts obtained on October 8 were not significantly different to those at identical times on September 22, October 6, or October 13.

Only two other radio operators active at the same time have made their data available so far (both data sets are given in [1]). Maurice de Meyere in Belgium, whose data collection ceased at 7^h UT on October 8, recorded lower activity around 4^h–7^h UT then than the next morning, or on October 6. His data from October 7 were almost identical to those from October 8. In Japan, Kazuhiro Suzuki ceased observing around 11^h UT on October 8, but recorded nothing unusual at all before then compared to his results at this time of day throughout October (excepting October 9), despite the Draconid radiant being well above his horizon around 8^h UT on October 8. Radio observing does not always benefit from a nearer-zenithal radiant, since it is dependent on the transmitter-meteor trail-receiver geometry, but a higher radiant elevation will normally assist in enhancing the echo count numbers, assuming any activity is present to be detected.

None of this definitely shows the Draconids did not produce detectable activity in 1996, although none was present when observations were made from data reported so far. While automatic forward-scatter radio meteor observing is a far more objective technique than either visual observing or non-automatic radio observing, it still suffers from interpretational problems. As with visual work, radio meteor observing currently works best when observers are prepared to pool their results, rather than attempting to make definite statements about meteor activity based on just a single observer's view. Without such comparison between data sets, radio observations, like visual ones, should be treated with great caution.

I would encourage all meteor observers to cover periods when we hope unusual meteor activity might manifest, as well as more routine monitoring of meteor rates throughout the year. This is particularly true in the case of the Draconids, since the shower is liable to prove critical to our further understanding of meteoroid stream formation theory. Radio monitoring may well be of particular importance for the 1998 Draconid return, since the waning gibbous Moon will be a severe deterrent to accurate visual, photographic, and video work around October 8–10.

[1] C. Steyaert, *Radio Meteor Observation Bulletin* 39, November 1996.

Alastair McBeath, March 16, 1997

The 1997 International Meteor Conference

Petnica, Yugoslavia, September 25–28, 1997

Vladimir Lukić

Another *International Meteor Conference* in the Balkans takes place in Petnica, Yugoslavia, from September 25 to 28, 1997. For our readers' convenience, we republish the information and registration form provided in an earlier issue of *WGN*. To keep informed, you should return it as soon as possible to Treasurer Ina Rendtel. If you need or want to stay in Petnica, Valjevo, or Belgrade, some days before or after the *IMC*, you will be offered various solutions.

I would like to urge observers from the nearby countries to encourage their meteor friends not to miss the unique opportunity provided by the *IMC* being held in their neighborhood and observers from not-so-nearby countries to come and meet their colleagues!

If you have any questions, please feel free to write to *Petnica Science Center/IMC 97, P.F. 118, YU-14000 Valjevo, Yugoslavia* or to send an email to the author (`f2lukicv@rcub.rcub.bg.ac.yu`).

Looking forward to your registration!

International Meteor Conference

Petnica, Valjevo, Yugoslavia, September 25–28, 1997

Registration Form

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

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

Name: ______________________ Birth date: ____________

Address: ______________________________

____

____

Phone: ____________ Fax: ____________ E-Mail: ____________

- o wishes to register for the 1997 *IMC* from September 25 to 28;
- o intends to participate, cannot yet register, but wishes to stay on the mailing list.

I intend to travel by ________, together with ______________________

Additional requests:

- o I need travel information from ______________ to Petnica;
- o I wish to stay in Yugoslavia before or after the *IMC* and require additional information re. this matter.

For participants wishing to contribute to the program:

Lecture: ______________________________

Duration: ________min. Required equipment: ______________________

Workshop or discussion: ______________________________

Poster presentation: ______________________ Space: ________ m^2

Either the entire fee of 140 DEM or a pre-payment of at least 100 DEM should be sent to the Treasurer, *Ina Rendtel*. Follow the payment instructions below. Participants paying only 100 DEM have to pay the remaining 40 DEM upon arrival in Petnica.

Date and signature: ______________________________

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

- in Europe: pay in DEM to Ina Rendtel, postal giro account number 547234107 at Postgiroamt Berlin, bank code 10010010. No bank checks, please! (Bank checks can only be sent to Robert Lunsford, see below).
- in the UK: proceed as above or pay to Alastair McBeath, 12A Prior's Walk, Morpeth, Northumberland NE61 2RF, England.
- in Japan: pay to Masahiro Koseki, 4-3-5 Annaka, Annaka-shi, 379-01 Gunma-ken, Japan.
- all others pay in USD to Robert Lunsford, 161 Vance Street, Chula Vista, California 91910, USA. In case you pay by bank check, make it payable to Robert Lunsford, *not* the *IMO*!

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

Practical Meteor Photography
Part VII: Meteor Photograph Position Measurement Instructions

Marc de Lignie

Preface

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

1. Introduction

In the previous issue of this series, the different methods for measuring meteor photographs were described in a global way. Presently, a step-by-step description is provided to make position measurements on prints with a ruler, or to measure digitized images by computer.

2. Measuring prints with a ruler

When you choose to measure prints by hand with an ordinary ruler, the following list takes you through all the steps of the measuring process:

1. Make two prints; a small print showing the entire negative, and a large print showing only the meteor and a number of stars *at each side of the meteor*. When the meteor enters or leaves the negative, make sure that the edge of the negative is visible on the large print. Do not use photographic paper with high contrast; this makes the star trails unnecessarily wide and makes it more difficult to read a transparent ruler.
2. Write down all the information asked for on the header of the astrometric form (see next page). Preferably, times should be accurate within one second. The visual reference could contain the observer code of the person who recorded the time of the meteor and maybe a serial number of the meteor for that observer, e.g., `LIGMA1473`. The archive code can be used to link this form with the prints or with other forms or files with information regarding this meteor; it could contain the year and a serial number, e.g., `970034`. On the lines marked with "Observer" you can write your name and address or e-mail address.
3. Using the large print, decide whether you will measure only the begin points of the star trails or only the end points. Usually, it is best to measure the begin points of the stars. However, when there were clouds at the beginning of the exposure, or when the camera moved shortly after the start of the exposure, you should measure the end points of the stars.
4. Using the small print, write down the approximate equatorial (sky atlas) coordinates of the center of the plate taking into account the choice for begin or end points (these numbers are required during the astrometric calculations to convert the polar equatorial coordinates into linear, orthogonal coordinates). Also note the equinox of the sky atlas used (usually 1950 or 2000).
5. Using the large print, mark six stars to be used as reference stars. The stars should be chosen such that the meteor trail is entirely surrounded by them. Further, the area covered by the reference stars should have about equal width and height and there should be one or two stars in the center of the area (see Figure 1 for an example). Again the choice for begin or end points should be taken into account; e.g., begin points were used in Figure 1, assuming a northern hemisphere picture. As a further boundary condition, avoid trails that are recognizable as double stars.

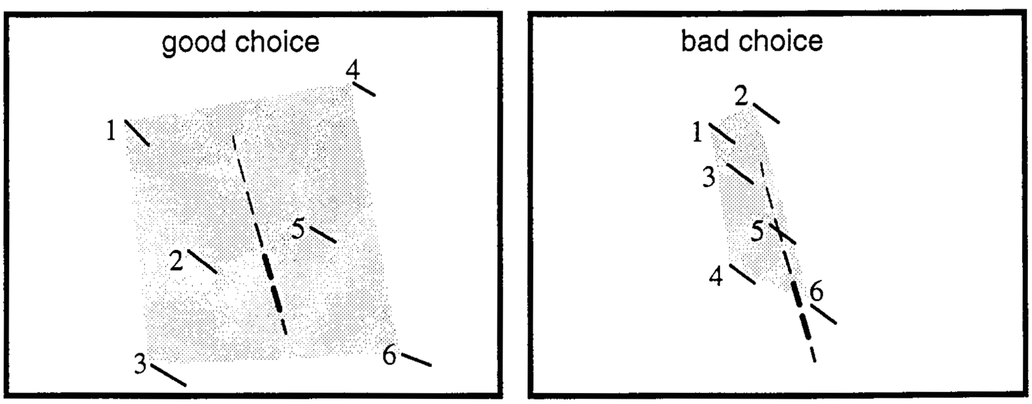

Figure 1 – Selection of reference stars for astrometric measurements.

6. Write the names of the stars in the first column of the star table on the astrometric form. Depending on the atlas and catalogue that you have available, you can write down the names in either of the following formats: 16 And, λ And, HD222107, SAO53204, or GC3481 (HD = Henry Draper Catalogue, SAO = Smithsonian Astrophysical Observatory Star Catalog, GC = Boss General Catalogue). If you have no catalogue available, you can write down the approximate equatorial coordinates of the stars in the format 23^h37^m, $46°28'$, in the same way as for the plate center.
7. Using the large print, measure the X and Y coordinates of the begin or end points of the selected star trails (see Figure 2). Any ruler can be used that has a scale in millimeters and looks sufficiently solid. A transparent ruler is the most practical. For the measurements to be accurate, it is essential that the edges of the print are straight and cut at right angles. If this is not the case, attach the print to some other piece of paper and do the measurements relative to the edges of that piece of paper. When measuring the X coordinate, be sure that the ruler is exactly parallel to the X axis. Try to make estimates in tenths of a millimeter (e.g., 12.47 cm) even when the last digit is not very accurate. Depending on whether you measure the begin or end points of the trails, use the first or last columns of the star table of the astrometric form.

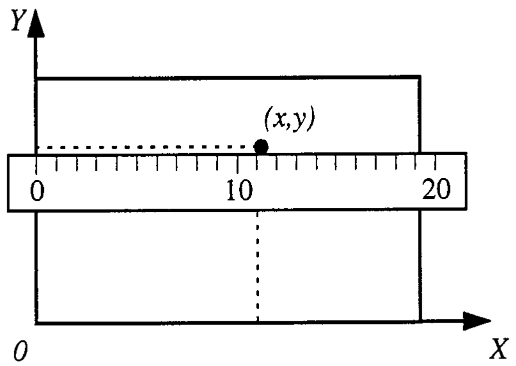

Figure 2 – The X, Y coordinate grid on the print and the position of the ruler to measure the X coordinate of a point (x, y).

8. Measure the X and Y coordinates of the following meteor points (see Figure 3): the begin point, the visible to nonvisible transitions of all shutter breaks (if present), the point of maximum intensity of the meteor, and the end point. In the meteor table of the astrometric form you can indicate the different points as "begin," "break 1," "break 2," ..., "break 6," "maximum," ..., "break 8," "end." If a shutter break is not visible due to an overlapping star trail, you can skip the measurement. However, if you skip break 3, note "break 4" in the meteor table for the following break. The table has room for 19 shutter breaks. If the meteor has more than 19 breaks, you can skip every second break, etc. If the meteor has multiple flares, you only need to note the position of the brightest flare. This step ends the procedure for manual position measurements of a print.

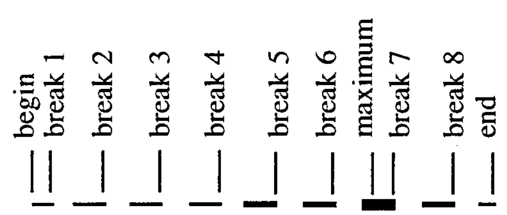

Figure 3 – The points on the meteor trail to be measured.

3. Measuring digitized images with Astro Record

One specific computer tool for making position measurements of meteors is the program ASTRO RECORD. It has been used within the *Dutch Meteor Society* since 1994, and, recently, a new version was produced that includes the procedures for astrometric calculations [1].

IMO - The International Meteor Organization
The Photographic Meteor DataBase - PMDB
ASTROMETRIC FORM

Date (dd/mm/yyyy) ____ / ____ / ________ Time of meteor (hh:mm:ss) ____ : ____ : ____ UTC
Magnitude ____ Shower __________ Visual ref. __________ Archive code __________

Location site ____________________
latitude ____° ____' ____"
longitude ____° ____' ____"
height ______ m

Observer ____________________
address ____________________
____
____

Exposure start (hh:mm:ss) ____ : ____ : ____ UTC; end (hh:mm:ss) ____ : ____ : ____ UTC
Camera lens f = ____ mm; focal ratio f /d = ____; shutter speed ______ breaks/second

Star name	X begin	Y begin	X end	Y end

Estimated plate center
$\alpha =$ ____ h ____ m
$\delta =$ ______ °
Eq. ______

Meteor point	X	Y	Meteor point	X	Y
begin					

Remarks

____

____

____

____

The main characteristics of the program are the following:

- runs on PCs running Microsoft Windows (3.*x*, '95, NT);
- accepts photographic images in bitmap (BMP) and Photo-CD (PCD) format and video images in Video for Windows (AVI) format;
- has read-out accuracy of 1/4 pixel, so 3 micrometer accuracy for Photo-CD images;
- makes use of the *Sky Catalogue 2000.0* (Sky Publishing Corporation);
- automatic identification of stars after three stars have been measured;
- astrometric procedures that use a linear, second order or third order polynomial least squares fit (Turner's method); and
- output files with raw measurements as well as a log file with the begin and end point of each meteor in equatorial coordinates and its angular velocity.

Anyone who is interested in making position measurements of meteors, can download the program from the photographer's page of the *IMO* Web site (`http://www.imo.net/photo`). The package includes an extensive help file with a more detailed description of the program's capabilities and instructions how to use the program. Experience has shown that people have little difficulty in using the program when they understand the goals of astrometry.

4. Administration of the PMDB

The administration of the *Photographic Meteor DataBase* (*PMDB*), which contains positions of photographic single-station meteor trails, is currently done by Jürgen Rendtel. You can send him the completed astrometric forms by post. If you use ASTRO RECORD, send both the files with raw measurements and the log file with astrometric results, e.g., by combining all the files into a ZIP archive and attaching it to an e-mail message (`jrendtel@aip.de`). It is not necessary to send the prints, when you measured them yourself. However, when the meteor is above average beautiful, or a member of a minor stream, we would appreciate receiving a print or a digital scan for the "picture archive." *Also, do not forget* WGN *in this case!* (ed.)

Reference

[1] M.C. de Lignie, "Astro Record 3.0", *Radiant* 19, 1997, in press.

IMO Web Site Has Its Own Name

communicated by Marc Gyssens

Most *IMO* and other readers of *WGN* by now know that the *International Meteor Organization* has its own WWW site. A couple of months ago, this site was physically moved to a computer in Belgium, and, at this occasion, the site got its "own" name:

`http://www.imo.net.`

We encourage everybody who did not yet check out the *IMO* World-Wide Web site to do this now!

In connection with this name change, generic electronic mail addresses were introduced for key *IMO* functions: you can correspond with *IMO* President Jürgen Rendtel by sending a message to **`president@imo.net`**, you can electronically submit an article to this journal at **`wgn@imo.net`**, which will reach me, or you can send your visual observations to **`visual@imo.net`** and make sure Rainer Arlt can incorporate them in future analyses, to give just three examples.

Of course, these generic email addresses have great advantages, as they are robust for all sorts of changes. For instance, there is no Radio Commission within the *IMO* at this moment, but nevertheless there is an email address **`radio@imo.net`** to ensure that queries concerning radio work reach an appropriate person and are satisfactorily answered.

From now on, these generic email addresses will be used systematically in *WGN*, also on the inside back cover. Of course, this does not mean that the addresses mentioned before suddenly become obsolete; the point is that by using the new addresses you never have to worry anymore whether or not some email address is still valid!

Ongoing Meteor Work

Activity Analysis of the 1996 Geminids

Jürgen Rendtel and Rainer Arlt

An analysis of 19 604 Geminids seen in 1996 is given. The maximum occurred at $\lambda_\odot = 262\overset{\circ}{.}15 \pm 0\overset{\circ}{.}20$ (December 13, $20^{\rm h}$ UT) with ZHR $= 115 \pm 10$. The profile of the population index shows a decrease of the r-value during the maximum. Small-scale features in the ZHR-profile could not be found.

1. Introduction

Another successful Geminid year was logged by observers from several continents in 1996 with a very thin waxing Moon not interfering with the maximum of the meteor shower. In total, 119 observers recorded 19 604 Geminids in 491 man hours. We are very grateful to the following observers who contributed to the analysis below:

Rainer Arlt (ARLRA, $6^{\rm h}.65$), Adrian Paulo Arquiola (ARQAD, $4^{\rm h}.33$), Joseph D. Assmus (ASSJO, $11^{\rm h}.60$), Lars Bakmann (BAKLA, $2^{\rm h}.50$), Luc Bastiaens (BASLU, $0^{\rm h}.92$), Jim Bedient (BEDJI, $3^{\rm h}.75$), Luis R. Bellot (BELLU, $10^{\rm h}.66$), Orlando Benítez Sánchez (BENOR, $2^{\rm h}.24$), Felix Bettonvil (BETFE, $3^{\rm h}.67$), Michael Boschat (BOSMI, $1^{\rm h}.34$), Lieve Bresseleers (BRELI, $3^{\rm h}.45$), Salvatore Calafiore (CALSA, $0^{\rm h}.86$), Koen Clement (CLEKO, $2^{\rm h}.70$), Tim Cooper (COOTI, $5^{\rm h}.44$), Celina Raquel Cudiciotti (CUDCE, $4^{\rm h}.34$), Alberto Darias (DARAL, $2^{\rm h}.79$), Mark Davis (DAVMA, $14^{\rm h}.42$), Johan de Hert (DE JO, $0^{\rm h}.92$), Goedele Deconink (DECGO, $2^{\rm h}.70$), Adrián Fernández Vigo (FERAD, $1^{\rm h}.84$), David Antonio Fernández Vigo (FERND, $1^{\rm h}.29$), Keiiti Fukui (FUKKE, $2^{\rm h}.70$), Tositake Fukuhara (FUKTO, $1^{\rm h}.83$), Yosinori Fuyube (FUYYO, $3^{\rm h}.18$), M. Inmaculada Gómez Fernández (GOMIN, $1^{\rm h}.00$), Roberto Gorelli (GORRO, $1^{\rm h}.91$), Peter S. Gural (GURPE, $5^{\rm h}.12$), Michael Hann (HANMI, $1^{\rm h}.50$), Yukiti Hattori (HATYU, $1^{\rm h}.50$), David Hernandez (HERDA, $0^{\rm h}.90$), Veerle Herrygers (HERVE, $2^{\rm h}.55$), Richard Huziak (HUZRI, $1^{\rm h}.50$), Kiyoshi Izumi (IZUKI, $3^{\rm h}.08$), Carl Johannink (JOHCA, $4^{\rm h}.05$), Ron Johnson (JOHRO, $5^{\rm h}.88$), Geoffrey Johnstone (JOHGE, $0^{\rm h}.60$), Aram Karalič (KARAR, $1^{\rm h}.05$), Niladri Kar (KARNI, $6^{\rm h}.31$), Jana Kasparova (KASJA, $1^{\rm h}.55$), Atusi Kisanuki (KISAU, $1^{\rm h}.42$), Miroslav Kopal (KOPMI, $1^{\rm h}.55$), Detlef Koschny (KOSDE, $1^{\rm h}.32$), Ralf Koschack (KOSRA, $6^{\rm h}.42$), Gotfred M. Kristensen (KRIGO, $4^{\rm h}.08$), Alexander Kupco (KUPAL, $1^{\rm h}.62$), Marco Langbroek (LANMA, $8^{\rm h}.99$), Alberto Latini (LATAL, $4^{\rm h}.00$), Sebastiano Leggio (LEGSE, $1^{\rm h}.00$), Inge Leyssens (LEYIN, $1^{\rm h}.88$), Alister Ling (LINAL, $4^{\rm h}.49$), Robert Lunsford (LUNRO, $20^{\rm h}.17$), Ake Lysell (LYSAK, $0^{\rm h}.33$), Katuhiko Mameta (MAMKA, $3^{\rm h}.66$), Martin Nick (MARNI, $1^{\rm h}.63$), Takuya Maruyama (MARTA, $3^{\rm h}.83$), Yukihisa Matumoto (MATYU, $1^{\rm h}.67$), Alastair McBeath (MCBAL, $6^{\rm h}.37$), Bruce McCurdy (MCCBR, $5^{\rm h}.00$), Tom McEwan (MCETO, $3^{\rm h}.00$), Norman McLeod (MCLNO, $34^{\rm h}.08$), Carl B. Miller (MILCA, $2^{\rm h}.16$), Dante Militano (MILDA, $4^{\rm h}.33$), Koen Miskotte (MISKO, $9^{\rm h}.46$), Hidekatu Mizoguchi (MIZHI, $3^{\rm h}.10$), Sirko Molau (MOLSI, $4^{\rm h}.94$), Koiti Nagano (NAGKO, $0^{\rm h}.75$), Dragana Okolić (OKODR, $2^{\rm h}.35$), Jens O. Olesen (OLEJE, $1^{\rm h}.00$), Urška Pajer (PAJUR, $1^{\rm h}.67$), Gregg Pasterick (PASGR, $1^{\rm h}.94$), John Penner (PENJO, $1^{\rm h}.56$), Jorge Pena Pinedo (PENJR, $1^{\rm h}.78$), Tim Polfliet (POLTI, $7^{\rm h}.43$), Tim Printy (PRITI, $3^{\rm h}.33$), Luis Quintana Armas (QUILU, $2^{\rm h}.60$), Andreas Rendtel (RENAN, $17^{\rm h}.28$), Jürgen Rendtel (RENJU, $25^{\rm h}.06$), Rigney Ian (RIGIA, $1^{\rm h}.62$), Natalia Risiglione (RISNA, $4^{\rm h}.33$), Mike Rosseel (ROSMI, $2^{\rm h}.95$), John Ruddy (RUDJO, $5^{\rm h}.00$), Javier Sanchez (SANJA, $1^{\rm h}.34$), Sergio Sánchez Jiménez (SANSE, $1^{\rm h}.34$), Branislav Savic (SAVBR, $2^{\rm h}.82$), René Scurbecq (SCURE, $5^{\rm h}.03$), Miguel Serra Martin (SERMI, $2^{\rm h}.22$), Francisco Sevilla (SEVFR, $11^{\rm h}.81$), Yasuo Shiba (SIBYA, $3^{\rm h}.67$), Hiroyuki Sioi (SIOHI, $1^{\rm h}.83$), Manuel Solano Ruiz (SOLMA, $2^{\rm h}.11$), Carlos F. Sosa (SOSCA, $4^{\rm h}.33$), George Spalding (SPAGE, $6^{\rm h}.50$), Ulrich Sperberg (SPEUL, $2^{\rm h}.00$), Umberto Mule Stagno (STAUM, $3^{\rm h}.50$), Plamen Stoichev (STOPL, $3^{\rm h}.00$), Wesley Stone (STOWE, $2^{\rm h}.91$), Máximo Svárez Tejera (SVAMX, $0^{\rm h}.63$), David Swann (SWADA, $1^{\rm h}.95$), Yosihiro Takahasi (TAKYO, $3^{\rm h}.17$), Taylor Melvyn (TAYME, $3^{\rm h}.50$), Marko Toivonen (TOIMA, $2^{\rm h}.83$), Josep M. Trigo Rodriguez (TRIJO, $1^{\rm h}.55$), Yoshiaki Uyama (UYAYO, $2^{\rm h}.59$), Erwin Van Ballegoy (VANER, $1^{\rm h}.82$), Frans Van Loo (VANFA, $2^{\rm h}.00$), Hendrik Vandenbruaene (VANHE, $6^{\rm h}.06$), Michel Vandeputte (VANMC, $6^{\rm h}.71$), Valentin Velkov (VELVA, $4^{\rm h}.51$), Cis Verbeeck (VERCI, $3^{\rm h}.60$), Daniel Verde (VERDA, $2^{\rm h}.60$), Jan Verbert (VERJN, $3^{\rm h}.03$), Damian Wacker (WACDA, $4^{\rm h}.33$), Michael Webb (WEBMC, $0^{\rm h}.77$), Graham Winstanley (WINGR, $1^{\rm h}.00$), Yasuo Yabu (YABYA, $5^{\rm h}.26$), Hiromiti Yosidome (YOSHI, $1^{\rm h}.00$), Ilkka Yrjölä (YRJIL, $2^{\rm h}.28$), George Zay (ZAYGE, $16^{\rm h}.02$), Irena Zivkovic (ZIVIR, $1^{\rm h}.55$).

2. Data reduction and perception coefficients

The large amount of data allowed the computation of a population index profile which is then used to calculate the individual zenithal hourly rates (ZHR) of each observing period. Magnitude distributions used for population index determinations should contain at least 20 meteors, and at least 3 meteors in at least 5 consecutive magnitude classes after being corrected with perception probabilities (the probability to detect a meteor of given magnitude; do not mix them up with perception coefficients which are described later). The faintest magnitude class should be at least 2^{m} brighter than the limiting magnitude since the perception probabilities at the faint end of the magnitude distribution introduce large errors because of the small number of meteors compared to the large correction necessary. Perception probabilities and computation of population indices and their errors are taken from [1].

Different window lengths for the average r-profile were used: Until $\lambda_\odot = 260.^\circ5$ (December 12, 5^{h} UT), a window size of $2.^\circ0$ (48 hours) shifted by $1.^\circ0$ was used; in the period $\lambda_\odot = 260.^\circ5$–$262.^\circ8$ (December 12, 5^{h}–December 14, 11^{h} UT), the window had a length of $0.^\circ5$ (12 hours) shifted by $0.^\circ25$; and after $\lambda_\odot = 262.^\circ8$, we used a window of $2.^\circ0$ duration shifted by $1.^\circ0$ again.

The individual ZHRs are computed by

$$\mathrm{ZHR} = \frac{r^{6.^{\mathrm{m}}5-\mathrm{lm}-\Delta\mathrm{lm}}\,F\,n}{T_{\mathrm{eff}}\,\sin h_{\mathrm{R}}}$$

where r is the population index, lm is the limiting magnitude, Δlm is perception correction (see below), F is the correction for observing field obstructions, n is the number of Geminids seen during T_{eff}, which is the effective observing time (excluding any times during which the observer was not facing the sky, e.g., recording times), and h_{R} is the altitude of the Geminid radiant.

Like the r-profile, the ZHR-profile was created from the individual values with different averaging windows: until $\lambda_\odot = 260.^\circ5$, a window of $2.^\circ0$ shifted by $1.^\circ0$ was used; in the interval $\lambda_\odot = 260.^\circ5$–$262.^\circ8$ the length of the window was $0.^\circ4$ (10 h) shifted by $0.^\circ2$; after $\lambda_\odot = 262.^\circ8$, the window was again $2.^\circ0$ shifted by $1.^\circ0$. The individual ZHRs were only considered for the ZHR-profile if the average radiant altitude exceeded 20°, and the total correction $C = r^{6.^{\mathrm{m}}5-\mathrm{lm}-\Delta\mathrm{lm}}F/\sin h_{\mathrm{R}}$ was smaller than 5.0. The individual ZHRs are weighted with $1/C$.

A comprehensive set of perception coefficients was derived in an analysis of Geminid returns of the last 9 years [2]. The coefficients are obtained by comparing Geminid ZHRs of individual observers with the average during relatively short periods of almost constant activity. The perception coefficients are expressed by differences in the limiting magnitude Δlm.

3. The *r*-profile and ZHR-profile

The profile of the population index r derived from 1996 Geminid observations is shown in Figure 1. The first value is based on very few magnitude distributions and covers the whole period $\lambda_\odot = 259°$–$261°$. The population index fell significantly lower than in 1991 [3] and 1993 [4]. Maximum and minimum of the r-profile (neglecting the uncertain far-end values) coincide with the ascending and descending part of the activity curve. A high population index before the ZHR maximum and a low r-value after the peak is shown by both the 1991 and 1996 data. This behavior is not visible in the 1993 r-profile, though it lacks data after $\lambda_\odot = 262.^\circ3$. The continuous decrease of r from 2.4 before the ZHR peak to $r = 1.9$ after the rate maximum shows the mass sorting within the meteoroid stream. During the ascending rate branch, the Earth encounters a region containing a rather small portion of larger meteoroids (of order 10 mg), while their portion increases until after the actual ZHR peak. This feature is generally known by meteor photographers because of the higher success rate after the peak compared to the ascending branch. It may also explain the impression of different maximum times in years with strong moonlight interference and other years.

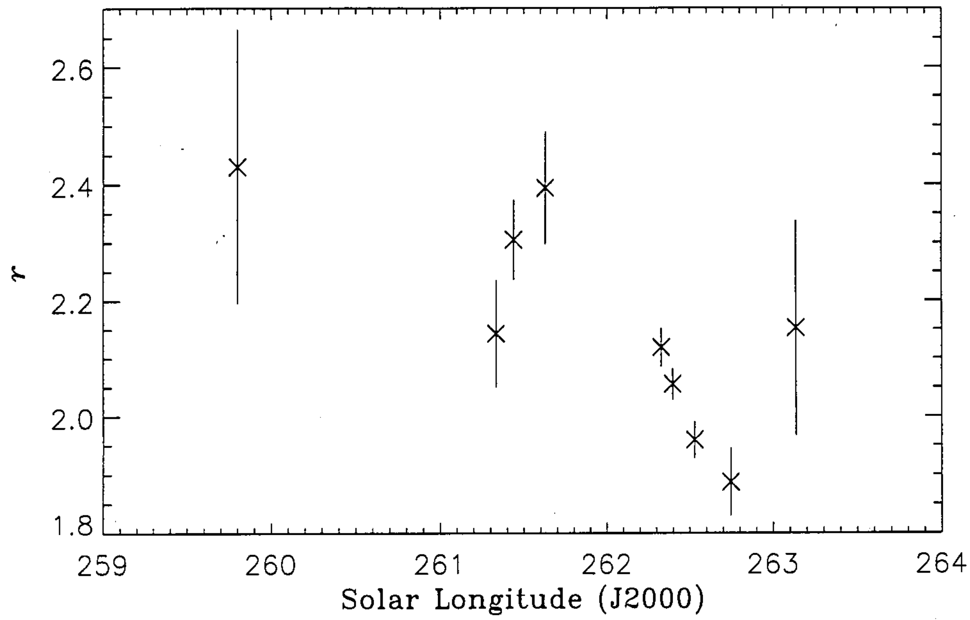

Figure 1 – Profile of the population index r of the 1996 Geminids. The first value is an average of only 3 observations before $\lambda_\odot = 261°$.

The ZHR-profile of the 1996 Geminids is shown in Figure 2. The profile is very smooth and does not show any peculiarities.

A profile with higher time resolution during the maximum applying only observing periods with $T_{\text{eff}} \leq 2^{\text{h}}\!.0$ does not show a significant fine structure different from a round summit either (Figure 3).

Observations from East Asian longitudes mainly covering $\lambda_\odot = 261\overset{\circ}{.}9$–$262\overset{\circ}{.}1$ result in much larger scatters of the averages. Most of the Japanese observers have higher than average perception coefficients which is also expressed in their high sporadic rates. Hence, we only consider the whole summit to be the activity maximum occurring at $\lambda_\odot = 262\overset{\circ}{.}15 \pm 0\overset{\circ}{.}20$ (December 13, 20^{h} UT) with ZHR $= 115 \pm 10$.

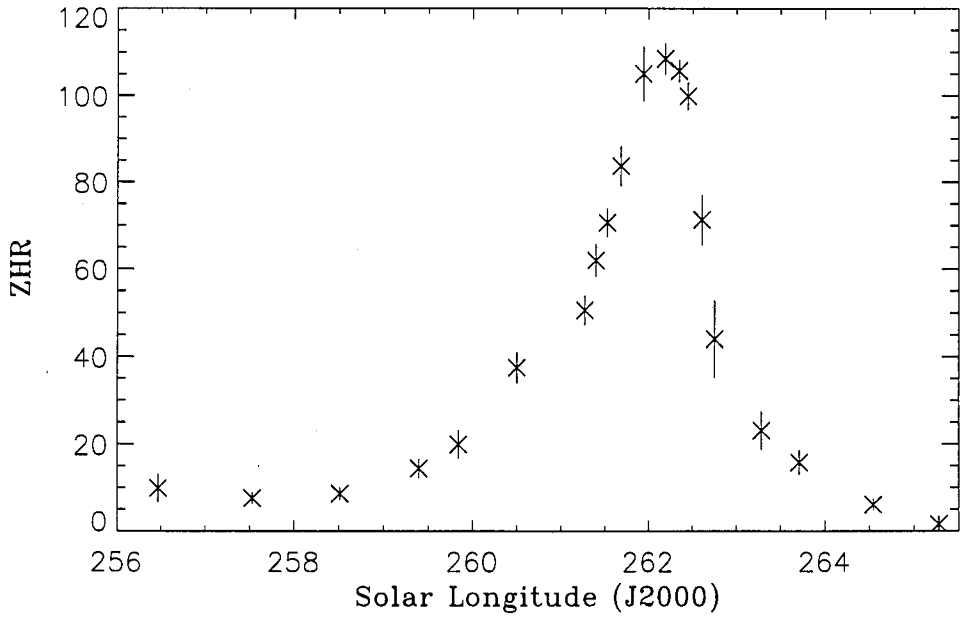

Figure 2 – ZHR-profile of the 1996 Geminids.

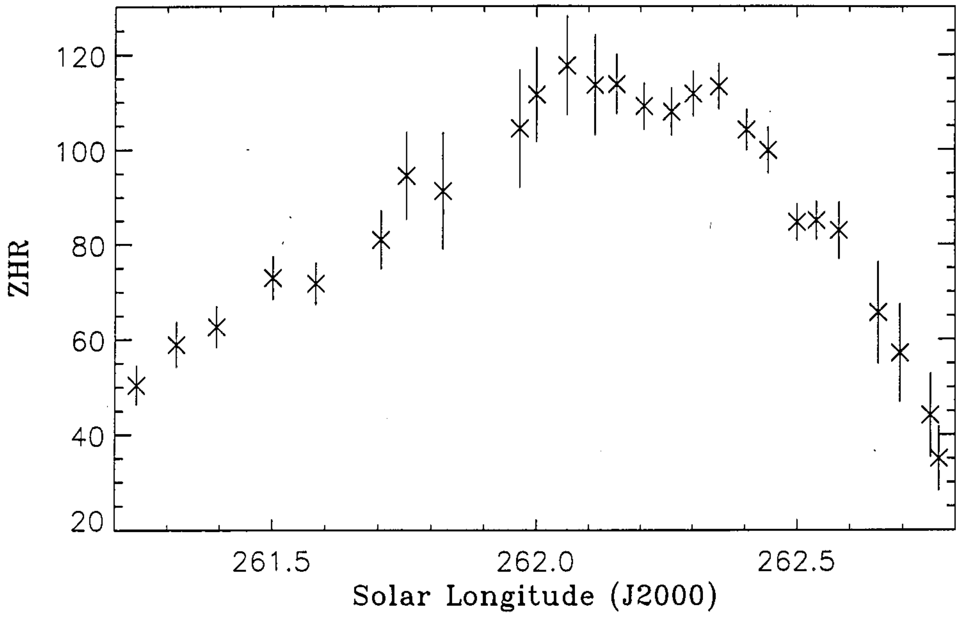

Figure 3 – Fine structure of the Geminid maximum. Only observing periods with $T_{\mathrm{eff}} \leq 2^{\mathrm{h}}.0$ were used; the window for averaging was 0°.20 (4.8 hours), shifted by 0°.1 until $\lambda_\odot = 261°.8$, and 0°.10 (2.4 hours), shifted by 0°.05 for the right part of the graph.

The peak rate agrees well with previous occurrences of the Geminids; Table 1 gives an overview of the last reliably analyzed Geminid maxima since 1988.

Table 1 – Time and ZHR of Geminid maxima derived from global analyses since 1988. The values were taken from [2–6].

Year	$\lambda_\odot$	ZHR
1988	262°.1	130
1990	262°.26	110
1991	262°.3	110
1993	262°.1	130
1996	262°.15	115

The full width at half maximum of the Geminid peak is 1°.4 in solar longitude, or 31 hours. This agrees well other returns like 1990 (1°.25), 1991 (1°.6), and 1993 (1°.4). The 1996 data confirm a plateau activity: the high activity of ZHR > 100 lasted for about 12 hours (December 13/14, 15^{h}–3^{h} UT). We may conclude that the 1996 activity fits well in the stable behavior of the Geminid meteor shower.

References

[1] R. Koschack, J. Rendtel, "Determination of Spatial Number Density and Mass Index from Visual Observations (II)", *WGN* 18:4, August 1990, pp. 119–140.

[2] P. Brown, J. Rendtel, "The Current Geminid Meteoroid Stream", *in preparation*, 1997.

[3] J. Rendtel, R. Arlt, P. Brown, "The 1991 Geminid Meteor Shower", *WGN* 21:1, February 1993, pp. 19–28.

[4] R. Arlt, J. Rendtel, "A Global Analysis of the 1993 Geminids", *WGN* 22:5, October 1994, pp. 167–172.

[5] P. Roggemans, "The Geminid Meteor Stream in 1988", *WGN* 17:6, December 1989, pp. 229–239.

[6] P. Roggemans, R. Koschack, "The 1990 Geminids", *WGN* 19:5, October 1991, pp. 184–193.

Comparison of Two Methods of Visual Meteor Observations

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The main formulae of two methods of visual meteor observation processing—the method used in the *IMO* and variations on it on the one hand and the method used in Kazan, Russia, on the other hand—are compared and discussed.

1. Introduction

The final purpose of any meteor shower observation is the determination of the two parameters that vary along the Earth's path: the meteor flux density or volume density of meteoroids with masses above some minimum value, and the exponent S of the mass distribution law for meteoroids.

It is a pity that there is no general agreement on the extent of an observer's collecting area and on the precise relation between meteor magnitude and the mass of the corresponding meteoroid, resulting in some degree of uncertainty. The above problems demand separate considerations and we shall touch upon them at the end of this paper.

The main attention here will be paid to the accuracy of the reduction of observed meteor rates to the zenithal hourly rate (ZHR) of meteors brighter than some fixed magnitude. Two types of reduction methods will be considered: the first one consists of the method worked out by Koschack and Rendtel [1,2], and a similar method worked out by Jenniskens [3], and the second one consists of the method worked out at the Engelhardt Astronomical Observatory by O. Belkovich and M. Ishmukhametova [4,5].

2. The basic formulae

A cumulative meteoroid flux density is calculated by the formula

$$\Phi = \frac{N}{\Sigma T}, \tag{1}$$

where N is the number of meteoroids with masses greater than some given mass, Σ is the collecting area orthogonal to the meteoroid velocity vector, and T is the duration of the observation. Conditions under which meteor shower observations are carried out change with time due to the diurnal variation of zenith distance of a shower radiant, and one has to reduce observations to the case when the radiant zenith distance is 0°. Equation (1) then becomes

$$\Phi_z = \frac{N_z}{\Sigma_z T}, \tag{2}$$

The relationship between two cumulative meteoroid flux densities Φ_1 and Φ_2 corresponding to masses greater than M_1 and M_2, respectively, is

$$\frac{\Phi_1}{\Phi_2} = \left(\frac{M_2}{M_1}\right)^{S-1}, \tag{3}$$

where S is the exponent in the mass distribution law for meteoroids. Let $\Phi_1 = \Phi_z$ (equation (2)), $\Phi_2 = \Phi$ (equation (1)), and let M_z correspond to $z = 0°$. Then we obtain

$$\frac{N_z}{N}\frac{\Sigma}{\Sigma_z} = \left(\frac{M}{M_z}\right)^{S-1}. \tag{4}$$

Now, we consider the ratios Σ/Σ_z and M/M_z. Since the area Σ_z is horizontal,we have

$$\frac{\Sigma}{\Sigma_z} = \cos z\,, \tag{5}$$

where z is the zenith distance of a shower radiant. One can find from equations (7.4), (7.17) and (7.19) of the widely cited book of McKinley [6] that the maximum meteor intensity I_{max} is given by

$$I_{\max} = \frac{2}{9}\,\tau\,\frac{V^3}{H}\,M\cos z\,, \tag{6}$$

where τ is the luminous efficiency, H the atmospheric scale height, and V the meteoroid velocity. Levin [7] has argued that a human eye integrates the variation of meteor intensity I along a meteor path. In this case, we have an estimate of I_{max} as $\overline{I}_{\max}$ with

$$\overline{I}_{\max} = CM^b\cos z\,, \tag{7}$$

where C is a constant depending on the shower considered. Levin has found the value 0.7 as an underbound of b (see [4]), and Koschack and Rendtel have found $b = 0.92$ [1]. Equation (7) shows that, for constant meteor magnitude, the meteoroid mass M is a function of the radiant zenith distance z:

$$\frac{M}{M_z} = \cos^{-1/b} z\,. \tag{8}$$

From equations (4), (5), and (8) we obtain

$$N_z = N\cos^{-\frac{S-1}{b}-1} z \approx N\cos^{-\frac{S}{b}} z\,. \tag{9}$$

The cumulative flux density of meteoroids with masses greater than some given mass corresponding to some faintest registered magnitude (limiting magnitude) m can now be found by substituting the above expression for N_z in equation (2):

$$\Phi_z = \frac{N}{\Sigma_z T\cos^{S/b} z}\,. \tag{10}$$

Equation (10) is only valid when all of the meteors brighter than m are registered. In reality, however, the limiting magnitude depends on the sensitivity of the eye and the weather conditions, and, therefore, one has to reduce the flux density to a constant limiting magnitude m_0. If M_0 is the meteoroid mass corresponding to meteor magnitude m_0, formula (10) becomes

$$\Phi_0 = \frac{N}{\Sigma_z T\cos^{S/b} z}\left(\frac{M_z}{M_0}\right)^{\frac{S-1}{b}} = \frac{\mathrm{ZHR}_0}{\Sigma_z}\,, \tag{11}$$

where the zenithal hourly rate of meteors equals

$$\mathrm{ZHR}_0 = \frac{N_z}{T}\left(\frac{M_z}{M_0}\right)^{\frac{S-1}{b}} = \frac{N}{T}\left(\frac{M_z}{M_0}\right)^{\frac{S-1}{b}}\cos^{-\frac{S-1}{b}-1} z\,, \tag{12}$$

or

$$\mathrm{ZHR}_0 \approx \frac{N}{T}\left(\frac{M_z}{M_0}\right)^{\frac{S-1}{b}}\cos^{-\frac{S}{b}} z\,. \tag{13}$$

The value of S can be obtained from a cumulative distribution of meteor magnitudes:

$$S = 1 + 2.5\,b\log r\,, \tag{14}$$

where r is the population index.

3. Two ways of solving the problem

We compare the method worked out in Kazan for processing visual observations [4,5] with the method worked out by Koschack and Rendtel [1,2] used in the *IMO*, and similar methods, such as the one used by Jenniskens [3].

First, we point out that there are no differences in the determination of r or S.

We in Kazan calculate $\mathrm{ZHR_0}$ by the formula

$$\mathrm{ZHR_0} = \frac{N}{T_{\rm eff}} \cos^{-\frac{S}{b}+c} z e^{-k} q, \tag{15}$$

where

$$e^{-k} = \left(\frac{M_z}{M_0}\right)^{\frac{S-1}{b}}, \tag{16}$$

M_0 corresponds to a meteor of magnitude +3, q is the correction for moonlight and c is an additional correction coefficient taking into account some unknown factors.

The values of k and $\log_e r = \Delta \log_e N/\Delta M$ can be obtained from a cumulative meteor magnitude distribution by the least square method as shown in Figure 1.

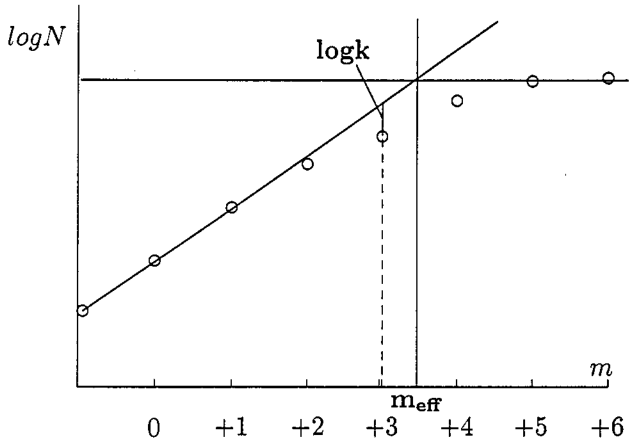

Figure 1 – Cumulative distribution of observed meteor magnitudes.

We assume here that there are no losses for bright meteors. Actually, the k coefficient reduces the observed number of meteors to the number of meteors brighter than magnitude +3. One can see that this value is close to the effective magnitude $m_{\rm eff}$, i.e., the magnitude that corresponds to the number of observed meteors without any losses (see Figure 1). The k value depends on the losses of faint meteors, so, at least partially, it takes into account the weather conditions during the observations. The S value can be found using the equation (14).

At first, the moonlight correction q was found empirically [6], but, later, correlation analysis has resulted in the formula $q = e^{0.4f}$ (17), where f is the phase of the Moon. The correlation analysis has been applied to three meteor showers: Perseids, Geminids, and Leonids. The coefficient 0.4 is valid within the error limits for all of these showers. Dispersion analysis has shown that the correction q does not depend on the elevation of the Moon above the horizon.

If the reduction to zenithal hourly rates has been done correctly then ZHR variations are not supposed to have any diurnal components. Unfortunately, this is generally not the case. To remove the remaining variations, we were compelled to introduce the additional coefficient c in equation (15). Its values have been found by correlation analysis for the three showers considered; they are 0.10 ± 0.01, 0.27 ± 0.02 and 0.40 ± 0.06 for Perseids, Geminids, and Leonids, correspondingly. The last value differs from one given previously in [5], and was found as the result of a more thorough analysis.

Let us now turn to the *IMO* method. In this method, the following formula is used [5]:

$$\mathrm{ZHR}_0 = \frac{NFp}{T_{\mathrm{eff}}} \sin^{-1} h_R \, r^{6.5-\mathrm{lm}} \,, \tag{18}$$

where h_R is the elevation of the radiant, lm the limiting magnitude, F the correction factor due to obstruction of the field of view, and p the perception factor. In this formula,

$$\sin^{-1} h_R = \cos^{-1} z \tag{19}$$

and

$$r^{6.5-\mathrm{lm}} = \left(\frac{M_z}{M_0}\right)^{\frac{S-1}{b}} . \tag{20}$$

By comparing equations (15) and (18), one can find three principal differences between both methods:

1. the powers of $\sin h_R = \cos z$ are different;
2. the reductions $\exp(-k)$ and $r^{6.5-\mathrm{lm}}$ are done to different meteor magnitudes—to magnitude +3 in Kazan and to magnitude +6.5 by the *IMO*; and
3. in the Kazan method, there is the coefficient q which corrects for moonlight.

As was shown above (see equation (8)), the first difference occurs because the *IMO* method does not take into account the variation of meteor magnitude as a function of a radiant zenith distance. In the similar reduction method of Jenniskens [3], the power of $\sin h_R$ has been denoted by γ, and was found to be equal to 1.42 ± 0.08 for the Perseids, 1.33 ± 0.12 for the Geminids and 1.23 ± 0.50 for the Leonids. The values we found for S/b during maxima activity are 1.57, 1.67, and 1.32 correspondingly. Taking into account the values of c given above, the powers of $\cos z$ in our formula become 1.47, 1.40, and 0.92, respectively, which lie within the error ranges of γ given by Jenniskens.

However, Jenniskens takes a fixed value of 1.4 for all showers, which leads to increased errors because of the variability of S from shower to shower and, inside one shower, on the solar longitude.

It is generally known that, the larger the value of a correction factor, the larger is the error. There is no principal difference in to what meteor magnitude we reduce the ZHR, but the error will be minimum if reduced magnitude is closer to the effective one.

The moonlight correction is not used in the *IMO* method. Jenniskens, however, proposed the limitation that the moon phase should not be closer than 0.3 to Full Moon, and that the Moon should be no more than 30° above the horizon [3]. The use of moonlight correction in the Kazan method increases the number of observations available for processing.

In the Kazan method, the perception factor p is actually absorbed by the k coefficient.

In the *IMO* method, a spatial number density of meteoroids is calculated as follows [1]:

$$\rho(m \leq 6.5) = \frac{\mathrm{ZHR}_0 \, c(r)}{3600 \, A_{\mathrm{red}} v_\infty} \,, \tag{21}$$

where v_∞ is the meteoroid velocity. In fact,

$$\frac{A_{\mathrm{red}}}{c(r)} = \Sigma_z \,, \tag{22}$$

the horizontal collecting area of a field of view with a radius $R = 52^\circ\!.5$ taking into account the sensitivity of the eye for different meteor magnitudes.

We have doubts as to the reliability of the Σ_z calculation until comparisons with other methods of observation become available, and, therefore, we consider ZHR_0 to be a sufficiently valuable parameter for analyses of meteor shower structures. In this aspect we completely agree with Jenniskens [3].

4. Comparison of the precisions of both methods

Observations of the 1989 Perseid meteor shower [8] in the range $\lambda_\odot = 132°–140°$ (2000.0) have been used to estimate the errors of the methods considered. Averaging was done and error evaluations were made for every night with five or more observations. Three experienced observers were chosen: Jürgen Rendtel, Ralf Koschack, and Rainer Arlt. We have taken $\gamma = 1.4$ [3]. First of all, errors due to the next parts of the equations reducing to the fixed meteor magnitude are considered:

$$e^{-k}q \qquad \text{and} \qquad Fpr^{6.5-\text{lm}}\,.$$

For the latter subformula, two variants were considered: $r = 1.78$ [3] and $r = \varphi(\lambda_\odot)$ is a function of the solar longitude $\lambda_\odot$ [9]. The results are shown in Table 1.

Table 1 – Errors related to reducing to a fixed meteor magnitude.

Error	$e^{-k}q$	$Fpr^{6.5-\text{lm}}$	
		$r = 1.78$	$r = \varphi(\lambda_\odot)$
σ	2.22	6.94	4.46
$\sigma/\sqrt{\text{ZHR}_0}$	0.45	1.26	0.91
σ/ZHR_0	0.10	0.26	0.21

Next, the comparison of errors due to the powers of $\sin h_R$ or $\cos z$ are given in Table 2. Here, we only considered $r = \varphi(\lambda_\odot)$.

Table 2 – Errors related to the corrections for radiant elevation.

	$\cos^{-\frac{s}{b}+c} z$	$\sin^\gamma h_R$
σ	2.61	5.34
$\sigma/\sqrt{\text{ZHR}_0}$	0.51	0.99
σ/ZHR_0	0.10	0.21

The errors of the second method are more than twice as large. Adopting a constant value of r appreciably increases the errors.

The final error comparisons have been made for the same conditions as for Table 2, but for less experienced observers: Lars Trygve Heen, Ghislain Plesier and Ralf Kuschnik (Table 3).

Table 3 – Same as Table 2, for less experienced observers.

	$\cos^{-\frac{s}{b}+c} z$	$\sin^\gamma h_R$
σ	2.23	7.36
$\sigma/\sqrt{\text{ZHR}_0}$	0.50	1.35
σ/ZHR_0	0.12	0.27

The errors are nearly the same if the Kazan method is applied, and are about one and a half times greater than for experienced observers, if the other method is applied.

5. Conclusions

The principal difference between the two methods is that the variation of meteor magnitude as a function of radiant zenith distance is not taken into account in the *IMO* method. The reduction of the ZHR in the *IMO* method to magnitude +6.5 is not justified, because it leads to an increase not only of the ZHR values but also of their errors especially for inexperienced observers. The constant values of r and γ used by Jenniskens in the processing of observations [3] also increase errors.

As an interesting experiment, we propose to do combined visual and TV observations of some shower. As a result, the size of the effective collecting area Σ_{eff} for visual observations can be found. Furthermore, conjectures about the values of the coefficients b and c can be verified.

References

[1] R. Koschack, J. Rendtel, "Determination of Spatial Number Density and Mass Index from Visual Meteor Observations (I)", *WGN* 18:2, April 1990, pp. 44–58.

[2] R. Koschack, J. Rendtel, "Determination of Spatial Number Density and Mass Index from Visual Meteor Observations (II)", *WGN* 18:4, August 1990, pp. 119–140.

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

[4] O. Bel'kovich, "Visual Meteors Observations—What is the Use?", in *Proceedings of the International Meteor Conference*, Potsdam, 19–22 September, 1991, pp. 27–29.

[5] O. Belkovich, M. Ishmukhametova, N. Suleymanov, "On When Leonids Woke Up", *WGN* 23:4, 1995, pp. 117–119.

[6] D.W.R. McKinley, "Meteor Science and Engineering", McGraw-Hill Book Company, 1961.

[7] B.U. Levin, "Physical Meteor Theory", Moscow, 1956.

[8] *WGN, Report Series*, Vol. 2, 1990.

[9] R. Koschack, P. Roggemans, "The 1989 Perseid Meteor Stream", *WGN* 19:3, June 1991, pp. 87–98.

Editor's postscript

For clarity's sake, I want to emphasize that, although the methods used by the IMO *and Jenniskens are very similar, there are nevertheless important differences, so they should not be confused. In an article on the 1996 Geminids elsewhere in this issue, a short summary of the* IMO *method can be found.*

Prediction of Meteor Radiant Points Associated with Minor Planet 1997 BR

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Radiant points and orbital elements are given for possible meteors associated with near-Earth object 1997 BR near the time of its closest approach on July 13, 1997.

Minor Planet 1997 BR was discovered at the Xinglong station of the Peking Observatory on January 20, 1997 [1]. Its orbital elements (eq. 2000.0) are as follows:

Epoch = 1997 February 1.0 TT

$M = 280.^\circ 18574$	$\omega = 133.^\circ 73230$
$a = 1.3360011$ AU	$\Omega = 116.^\circ 79327$
$e = 0.3059080$ AU	$i = 17.^\circ 23718$
$P = 1.54$ years	$H = 17.5 \quad G = 0.15$

It is also predicted that this minor planet will pass near the Earth at a distance of 0.080 AU on July 13, 1997.

Predicted radiant points and orbital elements of meteors associated with 1997 BR (all referred to equinox 2000.0) are given in Table 1.

Table 1 – Radiant point and orbital elements for meteors associated with 1997 BR (all referred to eq. 2000.0).

$\lambda_{\odot}$	Date	Radiant		V_G	Δ	Orbital elements			
	(UT)	α	δ	(km/s)	(AU)	ω'	Ω'	i'	q'
116°0	Jul 19	174°9	+68°3	11.5	0.019	134°5	116°0	17°2	0.945
117°0	Jul 20	174°4	+67°9	11.5	0.016	133°5	117°0	17°2	0.942
118°0	Jul 21	173°9	+67°5	11.6	0.014	132°6	118°0	17°2	0.939
119°0	Jul 22	173°4	+67°0	11.6	0.015	131°6	119°0	17°2	0.936
120°0	Jul 23	173°0	+66°5	11.6	0.017	130°7	120°0	17°2	0.933
121°0	Jul 24	172°6	+66°1	11.7	0.021	129°7	121°0	17°2	0.930

In Table 1, predicted positions (α and δ for eq. 2000.0) of radiant points and the meteors' geocentric velocity are given for the dates when the heliocentric distance at a particular point on the parent body's orbit is equal to that of the Earth. The solar longitude of that date (eq. 2000) is given in the column "$\lambda_{\odot}$." The symbol Δ denotes the separation between the orbit of the parent body and the Earth in AU. Finally, ω', Ω', i', and q' are the adjusted angular orbital elements and the perihelion distance of the meteors. Details of the method used can be found in [3].

References

[1] G.V. Williams, *MPEC* 1997-B13, January 25, 1997.
[2] G.V. Williams, *MPEC* 1997-D04, February 18, 1997.
[3] I. Hasegawa, *Publ. Astron. Soc. Japan* 42, 1990, p. 175.

Predictions of Radiants Associated with Minor Planets

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This is a continuation of our meteor radiant predictions in [1]. Here, predictions are presented of meteor orbits and radiant points associated with Earth-approaching minor planets discovered between September 1992 and December 1996.

In Table 1, predicted positions (α and δ for eq. 2000.0) of radiant points and the meteors' geocentric velocities are given for the date when the heliocentric distance at a particular point on the parent body's orbit is equal to that of the Earth. The solar longitude of that date referred to the mean equinox of 2000.0 is denoted by $\lambda_{\odot}$. The symbol Δ denotes the separation between the orbits of the parent body and the Earth in AU, Finally, ω', Ω', and i' are the adjusted angular orbital elements of the meteor orbit, and q' the adopted or adjusted perihelion distance. More details on the method used for these predictions can be found in [2].

More detailed predictions for (7025) = 1993 QA are already presented in [3]. Minor planet 1996 SK is probably a member of the Taurid Complex. Some meteors probably related to this minor planet were observed visually in China and in Japan last October, and nearly ten orbits of those related meteors were found in the files of the IAU Meteor Data Center (Lund), and they may belong to the Piscids [4]. The discussion on those meteors will be published elsewhere.

Table 1 – Predictions of meteor radiant points associated with a minor planet

Object	$\lambda_\odot$	Date	α	δ	V_G	Δ	ω'	Ω'	i'	q'
1992 SK	355°3	Mar 17	192°4	+41°4	12.1	0.065	247°8	355°3	14°9	0.843
1992 SL	181°1	Sep 25	231°3	−62°9	7.1	0.100	344°5	1°1	8°6	0.994
1992 UY4	150°0	Aug 24	264°6	−34°5	8.9	0.023	16°6	330°0	2°7	0.995
1992 YD3	274°4	Dec 27	254°9	+63°3	14.7	0.023	173°6	274°4	27°1	0.983
1993 BD3	302°4	Jan 23	30°0	+18°8	5.0	0.038	180°0	302°4	0°9	0.984
1993 BW2	292°2	Jan 13	319°7	−77°1	14.1	0.101	295°8	112°2	21°6	0.853
1993 BX3	285°5	Jan 7	18°0	− 1°6	3.8	0.050	0°0	105°5	0°9	0.983
1993 DQ1	133°8	Aug 7	171°8	−43°3	9.3	0.036	344°6	313°8	10°0	1.002
(5693)	68°5	May 31	256°0	−16°5	18.8	0.043	287°4	68°5	4°4	0.527
1993 EA	280°7	Jan 2	272°7	−30°9	18.8	0.005	255°2	100°7	5°1	0.527
1993 FA1	7°4	Mar 28	77°4	−56°5	12.0	0.024	343°5	187°4	20°5	0.989
1993 HD	22°6	Apr 13	15°6	− 1°3	21.0	0.000	253°0	202°6	5°7	0.485
	168°4	Sep 12	354°8	+ 4°3	20.9	0.057	287°3	168°4	4°7	0.485
1993 HP1	34°3	Apr 25	81°9	+56°1	9.2	0.007	154°6	34°3	8°0	0.973
1993 KA	55°9	May 17	111°4	−27°5	4.5	0.005	341°8	235°9	6°1	1.003
1993 KA2	59°9	May 22	54°4	+15°6	23.9	0.000	261°1	239°9	3°2	0.502
	223°4	Nov 6	44°0	+20°5	23.9	0.015	277°6	223°4	3°1	0.502
1993 KH	234°1	Nov 17	223°0	−58°6	11.0	0.002	294°1	54°1	12°8	0.850
1993 OM7	297°7	Jan 19	276°2	+51°7	14.8	0.086	142°4	297°7	26°0	0.945
1993 PC	70°0	Jun 1	61°7	+20°5	14.3	0.073	255°6	250°0	0°2	0.607
	223°8	Nov 7	48°8	+14°6	14.3	0.066	101°9	43°8	1°7	0.607
(7025) 1993 QA	319°0	Feb 9	28°9	−51°4	8.7	0.063	330°7	139°0	12°5	0.956
1993 TZ	208°3	Oct 22	355°4	+12°0	11.4	0.006	226°5	208°3	4°2	0.884
	298°9	Jan 20	330°0	−13°5	11.2	0.071	315°8	118°9	0°4	0.884
1993 UA	145°7	Aug 19	283°8	−31°6	9.0	0.071	31°6	325°7	2°2	0.960
	203°8	Oct 18	243°0	−39°7	9.3	0.005	333°4	23°8	4°6	0.960
(7350) 1993 VA	356°3	Mar 18	14°3	−12°3	10.2	0.086	293°2	176°3	5°3	0.825
1993 VB	251°7	Dec 4	35°4	+ 8°5	9.4	0.084	36°9	71°7	1°4	0.918
	326°0	Feb 16	8°5	−16°7	9.8	0.000	322°6	146°0	5°1	0.918
1993 VD	210°9	Oct 25	186°3	− 5°5	16.7	0.017	225°6	30°9	1°8	0.395
	303°0	Jan 24	149°0	+14°1	16.7	0.031	313°5	303°0	1°0	0.395
(6611) 1993 VW	25°2	Apr 16	51°1	− 6°1	11.3	0.067	307°2	205°2	7°8	0.874
1994 AW1	110°5	Jul 13	66°9	−67°7	12.6	0.020	37°1	290°5	24°1	1.002
1994 CC	76°4	Jun 8	212°2	−32°5	8.6	0.018	37°1	256°4	4°5	0.954
	149°4	Aug 23	180°9	−10°8	8.3	0.071	324°0	329°4	2°3	0.954
1994 CJ1	57°2	May 19	150°9	+ 4°4	4.7	0.036	0°0	237°2	1°0	1.012
1994 CK1	100°4	Jul 3	272°8	−28°9	16.9	0.059	76°2	280°4	2°9	0.720
	249°3	Dec 2	256°7	−21°3	16.8	0.075	107°2	249°3	0°8	0.720
1994 CN2	128°8	Aug 2	273°0	−17°9	7.7	0.013	218°7	128°8	1°3	0.952
	200°6	Oct 14	234°9	−20°9	7.6	0.025	327°0	20°6	0°3	0.952

Table 1 – continued.

Object	$\lambda_\odot$	Date	α	δ	V_G	Δ	ω'	Ω'	i'	q'
1994 EK	186°.2	Sep 30	357°.7	−13°.0	15.7	0.055	65°.6	6°.2	5°.1	0.772
	315°.8	Feb 5	327°.2	− 0°.1	15.7	0.034	116°.3	315°.8	5°.7	0.772
1994 ES1	192°.3	Oct 6	186°.7	− 4°.7	18.7	0.007	261°.1	12°.3	1°.1	0.572
	354°.9	Mar 16	180°.0	+ 1°.9	18.7	0.001	278°.4	354°.9	1°.2	0.572
1994 EU	351°.7	Mar 13	9°.6	+46°.0	6.1	0.039	145°.5	351°.7	6°.5	0.956
1994 FA	355°.8	Mar 17	5°.7	+63°.6	9.8	0.049	154°.6	355°.8	13°.0	0.967
1994 GK	13°.6	Apr 4	19°.5	+21°.7	15.3	0.003	113°.4	13°.6	5°.7	0.771
	241°.9	Nov 25	48°.6	+ 8°.9	15.1	0.072	65°.0	61°.9	3°.9	0.771
1994 GL	2°.0	Mar 23	304°.9	−27°.4	9.9	0.017	194°.3	182°.0	3°.5	0.338
	28°.7	Apr 19	268°.0	−31°.1	10.0	0.013	167°.6	208°.7	3°.6	0.338
1994 GV	19°.8	Apr 10	69°.0	+24°.1	8.1	0.000	154°.1	19°.8	0°.5	0.967
	333°.1	Feb 23	101°.6	+24°.4	8.1	0.006	200°.7	333°.1	0°.3	0.967
1994 NE	107°.5	Jul 10	282°.2	+24°.7	20.9	0.023	243°.4	107°.5	27°.5	0.805
1994 PC1	297°.9	Jan 19	115°.1	−49°.3	19.7	0.001	47°.7	117°.9	33°.5	0.905
1994 PM	144°.0	Aug 17	335°.6	+ 7°.1	26.1	0.022	299°.2	144°.0	17°.9	0.366
1994 RB	167°.3	Sep 11	11°.3	−59°.3	19.2	0.067	43°.9	347°.3	26°.3	0.897
1994 RC	46°.6	May 8	198°.7	− 0°.7	12.2	0.071	223°.8	46°.6	2°.3	0.904
	135°.4	Aug 9	160°.9	− 4°.4	12.3	0.042	315°.2	315°.4	4°.0	0.904
1994 UG	7°.2	Mar 28	177°.7	+25°.2	6.7	0.007	231°.1	7°.2	4°.5	0.925
	115°.5	Jul 19	136°.6	+11°.1	6.2	0.078	302°.9	295°.5	1°.0	0.925
1994 VH8	123°.1	Jul 27	277°.0	−22°.2	9.5	0.059	228°.9	123°.1	0°.3	0.909
	215°.7	Oct 30	238°.0	−32°.5	9.6	0.003	316°.4	35°.7	3°.3	0.909
1994 WR12	241°.9	Nov 25	191°.8	−23°.6	9.8	0.002	206°.9	61°.9	6°.9	0.456
	296°.1	Jan 17	155°.3	− 1°.1	9.5	0.094	152°.4	116°.1	4°.1	0.456
1994 XD	82°.6	Jun 14	258°.2	−16°.8	20.8	0.020	262°.9	82°.6	4°.2	0.641
	245°.9	Nov 29	247°.6	−27°.6	20.8	0.039	279°.7	65°.9	3°.7	0.641
1994 XL1	252°.7	Dec 5	177°.9	+44°.2	15.5	0.036	356°.5	252°.7	28°.2	0.307
1994 XM1	257°.5	Dec 10	49°.9	− 0°.8	11.1	0.001	41°.6	77°.5	5°.6	0.896
	342°.1	Mar 4	12°.5	+ 3°.5	10.6	0.097	317°.0	162°.1	0°.5	0.896
1995 CR	278°.1	Dec 30	243°.7	−20°.4	29.6	0.062	27°.1	278°.1	1°.7	0.120
	332°.1	Feb 22	184°.8	0°.0	29°.7	0.013	333°.1	332°.1	3°.9	0.120
1995 CS	100°.0	Jul 2	289°.2	−20°.1	25.3	0.027	287°.9	100°.0	2°.1	0.436
	313°.9	Feb 4	308°.7	−21°.5	25.3	0.001	254°.0	133°.9	2°.6	0.436
1995 DV1	257°.8	Dec 10	16°.2	+ 8°.1	9.7	0.063	198°.5	257°.8	0°.3	0.964
	294°.3	Jan 15	357°.7	− 9°.5	9.8	0.054	342°.1	114°.3	2°.0	0.964
1995 EK1	14°.6	Apr 5	201°.0	+ 1°.3	25.1	0.050	277°.4	14°.6	8°.4	0.507
	209°.0	Oct 23	199°.9	−17°.5	25.0	0.085	263°.0	29°.0	7°.4	0.507
1995 FF	6°.2	Mar 28	12°.3	+ 4°.1	18.9	0.003	282°.6	186°.2	0°.6	0.673
	211°.8	Oct 26	22°.9	+10°.5	18.9	0.006	257°.1	211°.8	0°.5	0.673
1995 FX	12°.0	Apr 2	129°.8	−47°.4	15.2	0.063	23°.9	192°.0	21°.7	0.969
1995 LA	67°.8	May 30	172°.7	−36°.4	9.3	0.024	17°.5	247°.8	8°.7	0.998

Table 1 – continued.

Object	$\lambda_\odot$	Date	α	δ	V_G	Δ	ω'	Ω'	i'	q'
1995 NA	96°2	Jun 28	218°1	−65°8	10.2	0.062	33°8	276°2	12°7	0.968
1995 SA	354°0	Mar 15	142°6	−31°7	18.1	0.013	48°8	174°0	20°4	0.861
1995 SA4	158°0	Sep 1	241°6	− 9°1	7.9	0.048	178°0	158°0	2°4	1.010
1995 UB	204°3	Oct 18	219°0	+ 9°8	12.3	0.009	111°6	204°3	8°9	0.813
1995 YR1	163°6	Sep 7	149°9	+13°8	30.2	0.055	53°9	163°6	2°0	0.275
	272°4	Dec 25	110°6	+19°5	30.1	0.016	125°1	92°4	3°6	0.275
1996 AJ1	20°8	Apr 11	216°7	−13°8	27.0	0.041	308°6	20°8	0°8	0.291
	277°0	Dec 29	257°4	−25°0	26.9	0.005	232°3	97°0	2°5	0.291
1996 AP1	241°4	Nov 24	10°2	−11°7	7.5	0.078	20°5	61°4	3°0	0.967
	280°3	Jan 2	349°5	−31°7	7.9	0.029	341°6	100°3	5°2	0.967
1996 AW1	87°5	Jun 19	261°1	−14°6	14.7	0.042	258°9	87°5	4°1	0.735
	241°9	Nov 25	245°8	−27°4	14.6	0.068	284°6	61°9	2°6	0.735
1996 BG1	235°8	Nov 19	214°1	−15°0	8.0	0.063	234°8	55°8	0°4	0.657
	344°6	Mar 6	178°9	−11°8	8.2	0.026	126°0	164°6	3°3	0.657
1996 BT	306°6	Jan 27	155°6	+18°0	28.1	0.032	318°0	306°6	10°7	0.222
1996 EN	167°9	Sep 11	195°8	+64°7	22.9	0.050	120°4	167°9	37°9	0.857
1996 EO	169°0	Sep 12	16°8	−46°4	15.4	0.053	72°8	349°0	21°5	0.804
1996 FG3	40°4	May 1	223°5	−17°6	11.0	0.034	103°5	220°4	0°3	0.686
	244°1	Nov 27	236°6	−17°0	11.0	0.028	79°7	244°1	1°1	0.686
1996 FO3	333°8	Feb 23	13°6	+50°2	5.3	0.045	162°4	333°8	5°8	0.979
1996 FQ3	48°0	May 9	143°5	+13°3	6.5	0.068	0°0	228°0	0°2	1.009
1996 FR3	348°6	Mar 10	339°8	− 1°4	25.7	0.093	75°4	348°6	6°4	0.442
1996 FT1	232°6	Nov 16	32°0	+ 4°6	9.0	0.030	53°5	52°6	2°1	0.874
	340°0	Mar 1	357°6	+ 8°2	9.0	0.025	126°2	340°0	2°3	0.874
1996 GD1	233°1	Nov 16	206°9	−56°0	14.0	0.083	278°0	53°1	17°5	0.769
1996 GQ	323°7	Feb 13	55°0	+16°9	6.9	0.023	0°0	143°7	0°5	0.987
1996 GT	150°0	Aug 24	317°3	−15°0	12.7	0.068	245°4	150°0	0°5	0.810
	276°4	Dec 29	294°6	−30°6	12.8	0.032	298°9	96°4	3°4	0.810
1996 JA1	58°9	May 20	239°9	+17°0	21.2	0.001	245°8	58°9	22°2	0.767
1996 JG	63°3	May 25	242°4	−13°1	20.0	0.016	269°7	63°3	5°2	0.612
	240°5	Nov 23	236°8	−28°2	20.0	0.011	272°5	60°5	5°3	0.612
1996 MO	42°1	May 3	65°2	+11°2	11.2	0.090	307°2	222°1	3°3	0.873
	301°4	Jan 22	97°6	+ 9°5	11.3	0.073	48°2	121°4	4°4	0.873
1996 MQ	101°0	Jul 3	200°8	−25°0	8.3	0.025	10°3	281°0	3°4	1.011
1996 PC1	152°0	Aug 26	14°0	−69°5	16.1	0.089	40°6	332°0	24°9	0.935
1996 RG3	215°6	Oct 30	16°9	+12°1	14.3	0.052	242°7	215°6	1°9	0.791
	340°7	Mar 2	359°6	− 9°3	14.4	0.002	297°6	160°7	3°6	0.791
1996 SK	40°2	May 1	34°6	+11°6	24.5	0.013	261°4	220°2	1°8	0.494
	203°8	Oct 18	25°1	+12°8	24.5	0.003	277°8	203°8	1°9	0.494

Table 1 – continued.

Object	$\lambda_\odot$	Date	α	δ	V_G	Δ	ω'	Ω'	i'	q'
1996 TC1	182°.2	Sep 26	169°.5	−14°.1	24.0	0.013	261°.8	2°.2	14°.5	0.523
	347°.0	Mar 8	180°.2	+17°.9	24.0	0.079	277°.5	347°.0	13°.8	0.523
1996 TD9	41°.2	May 2	296°.4	−24°.8	11.8	0.023	74°.6	221°.2	4°.9	0.795
	189°.4	Oct 3	200°.8	+ 5°.1	11.8	0.026	106°.5	189°.4	4°.8	0.795
1996 TP6	70°.5	Jun 2	222°.7	+ 7°.8	13.1	0.086	219°.1	70°.5	8°.2	0.925
1996 VB3	57°.2	May 19	226°.1	−20°.7	15.2	0.041	76°.1	237°.2	1°.5	0.741
	207°.4	Oct 21	214°.7	− 8°.3	15.3	0.022	105°.9	207°.4	2°.5	0.741
1996 VZ4	229°.1	Nov 12	67°.3	−62°.6	14.5	0.044	15°.3	49°.1	24°.3	0.981
1996 XZ12	5°.9	Mar 27	198°.5	−11°.9	15.9	0.090	121°.7	185°.9	2°.3	0.490
	248°.1	Dec 1	231°.9	− 9°.4	16.1	0.006	59°.4	248°.1	5°.7	0.490

References

[1] Hasegawa I., *WGN* 21, 1993, p. 29.

[2] Hasegawa I., *Publ. Astron. Soc. Japan* 42, 1990, p. 175.

[3] Hasegawa I., *WGN* 23, 1995, p. 212.

[4] Lindblad B.A., *Smiths. Contr. Astrophys.* 12, 1971, p. 14.

Fireballs and Meteorites

A New Meteorite in Italy: the Fermo Chondrite

Giordano Cevolani, Romano Serra, and Roberto Haver

A stony meteorite fell in central Italy on September 25, 1996, at a site ($\lambda = 13°45'12''$ E, $\varphi = 43°10'52''$ N) close to a field, 3–4 km north-east of the town of Fermo and a few kilometers from the Adriatic coast. The meteorite is one piece of 10.2 kg of stone and exhibits the characteristic fusion crust. The body is classified as a H3-5 chondrite breccia. Production in stony meteorites as Fermo, of cosmogenic isotopes (^{22}Na and ^{44}Ti) by means of galactic cosmic rays, offers a direct assessment of the solar activity at different time scales (11-year solar cycle and century-scale variations).

1. Introduction: description of the event

Stony meteorites are well represented by the very numerous chondrites, which most closely approximate primitive solar nebula condensate and contain spherical millimeter- to centimeter-sized chondrules, i.e., silicates that rapidly melted and immediately cooled early in the Solar System's history. Objects responsible for bright fireballs from which meteorites may drop occupy the low-mass end of the asteroid spectrum.

On September 25, 1996, a stony meteorite fell in central Italy at a site ($\lambda = 13°45'12''$ E, $\varphi = 43°10'52''$ N) close to a field, some 3–4 km north-east of the town of Fermo and a few kilometers from the Adriatic coast (Figure 1). At 15^h30^m UT, a farmer, Mr. Luigi Benedetti, heard the sound of an explosion followed by a loud noise similar to that of "an approaching helicopter." After a few seconds, a crash was heard, about 200 meters away from the nearest farm-house. Two days later, on September 27, at about 06^h00^m UT, Mr. G. Santarelli discovered the stone at approximately the point described by the first witness, at the margin of a narrow country path. The meteorite was recovered as a single stone on a wet and soft clay bedrock within a crater of 30–40 cm (Figure 2) and is now housed at the Polar Museum of Villa Vitali in Fermo.

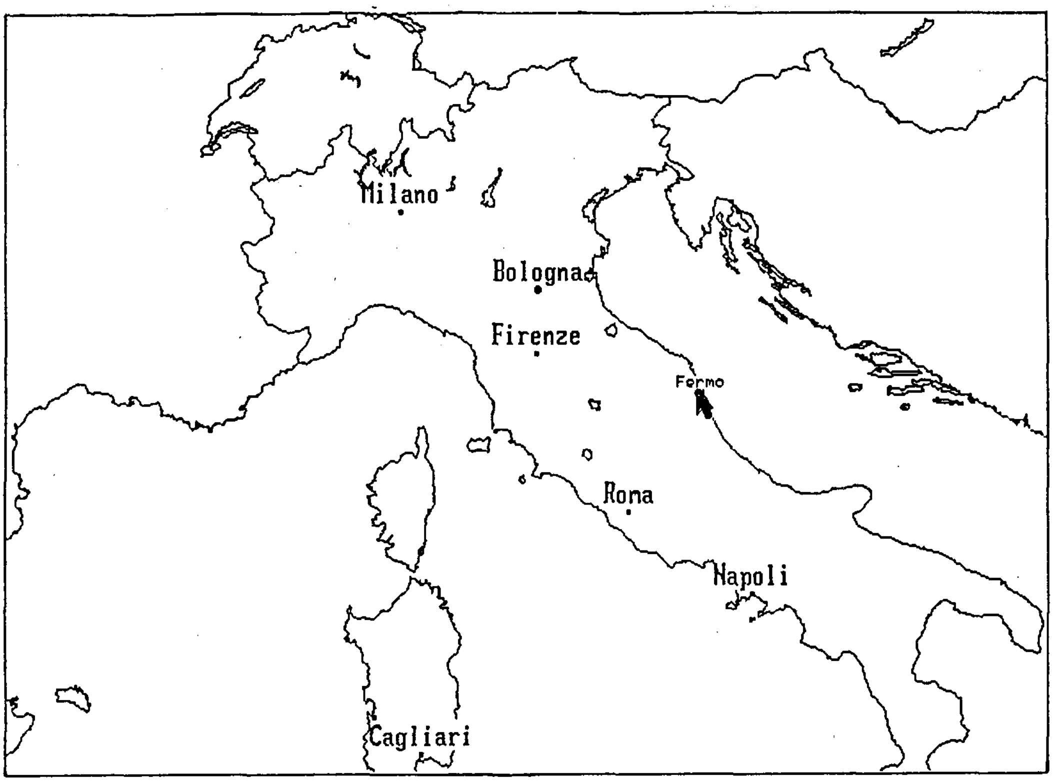

Figure 1 – The geographic area of the fall of the meteorite near the town of Fermo in central Italy.

Fermo is the 12th meteorite find in Italy in this century, but is the third most important in terms of weight, after Vigarano (a carbonaceous chondrite of two pieces, 11.5 kg and 4.5 kg, recovered in 1910) and Bagnone (an iron body of 48 kg found in 1904). The stone (size 19 × 24 × 16 cm), weighing 10.2 kg, has an irregular, angular, prismatic shape with rather sharp corners (Figure 3).

It was almost completely covered by a very thin (0.2 mm) black fusion crust. Depressions similar to thumb prints (*regmaglypts*) are evident on two faces of the stone. Due to the impact after fall, small pieces of the corners have broken off.

So far, only four meteorites have been recovered for which detailed data on atmospheric trajectory and orbit exist. At present, we are unable as yet to calculate the Fermo meteorite trajectory as Italy does not possess an all-sky photographic camera network of the kind coordinated by the *European Fireball Network* and those operating in the 1970s in the USA and Canada.

The only four photographed fireball trajectories with associated falls—Pribram [1], Lost City [2], Innisfree [3], and Peekskill [4]—relate to ordinary chondrites with low-inclination orbits (between about 5° and 12°), low pre-atmospheric velocities (between 14 and 21 km/s), eccentricities ranging from 0.40 to 0.67, and aphelia in the asteroidal belt.

The eye-witness accounts have allowed up to now only a rough reconstruction of the true fall path of the meteorite through the Earth's atmosphere. In addition, few accounts are available concerning the light phenomena associated to the fireball before reaching the *retardation point* (when the decelerated meteorite usually bursts into parts and its cosmic velocity is overcome).

As a partial explanation, the event took place during daylight and the fireball was possibly traveling south-southeast. After the retardation point, light phenomena ceased and the dark body fell only under the influence of its weight and the air resistance, almost vertically (10°–20° with respect to the vertical).

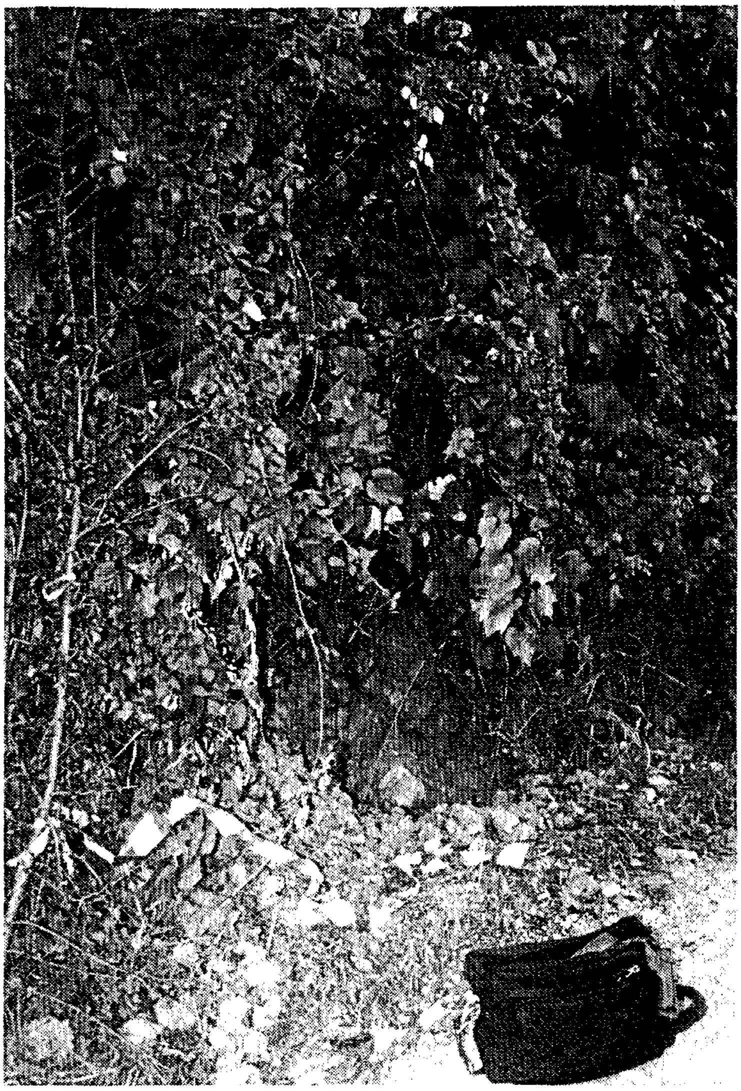

Figure 2 – The little crater formed after the fall of the Fermo meteorite..

2. Brief description of the current analysis

Petrography and mineral chemistry:

The exposed surfaces of two broken chips of a few grams when examined visually and under a low-magnification stereomicroscope, display areas of varying grey also characterized by subtle differences in texture and grain size.

One polished thin section was examined under a polarizing microscope in transmitted and reflected light, and the chemical composition of mineral phases and glass were determined by using an electron microprobe.

Centrimetric to millimetric dark and light clasts are cemented by a grey matrix, suggesting that Fermo is a brecciated meteorite. The different areas of one examined chip have different chondritic textures. The chondrules are of various types: granular, porphyritic (Figure 4), eccentroradial, and barred. In order of importance the included minerals are: olivine, pyroxene, plagioclase, kamacite, taenite, and troilite; and, in minor quantity, cromite and apatite. Glass rich in potassium was also present.

Figure 3 – A view of the Fermo meteorite.

Figure 4 – Porphyritic chondrule in the H3 clast of the Fermo meteorite.

The relatively low FeO/(FeO + MgO) ratios of olivine and low-Ca pyroxene measured in centrimetric to millimetric dark and light clasts cemented by a grey matrix, and petrologic type determination according to Van Schmus and Wood [5] criteria, allow the Fermo meteorite to be classified as a genomictic, regolith breccia of chondritic group H, with fragments of petrologic types 3 to 5 [6].

Analysis of cosmogenic isotopes:

After about twenty days after the fall a 2–3 cm thick slab (weight 800 g) was cut parallel to the outer surface of the meteorite and was sent to the Istituto di Cosmogeofisica del CNR and Dipartimento di Fisica dell'Università di Torino for Gamma-Ray Spectroscopy of short-living cosmonuclides and trapped gas. By using a high-efficiency and very low-background gamma spectrometer, it was possible to identify so far a large number of cosmogenic isotopes with a different half-life. In particular, the discovery of ^{22}Na (half-life=2.6 years) and ^{44}Ti (half-life=66.6 years) allow us to study the 11-year (Schwabe cycle) and secular (Gleissberg cycle) variation of solar activity, respectively (Bonino, *personal communication*).

From investigations of the Fermo and other recently fallen meteorites, important consequences on the terrestrial environment can be deduced, since a persistent low solar activity for decades is able to produce significant changes on the climate [7]. The thick slab will be utilized for further scientific investigations.

3. Concluding remarks

From the morphology characterized by flat surfaces, sharp edges, and shallow regmaglypts located on only two sides, we suspect that the breakdown of the body took place in the upper atmosphere (probably at stratospheric levels) and it is therefore possible that other undiscovered fragments exist. The main recovered piece of the Lost City and Peekskill meteorites of similar mass to that of Fermo (9.8 kg and 12.4 kg respectively) were also classified as H-chondrite, both of them having almost the same velocity (14.0 km/s and 14.7 km/s), very similar eccentricities (0.40 and 0.41), and similar very low-inclination (12° and 5°).

If the angle of the trajectory of the fireball is in fact shallow, as suggested by the overview of all four cited fireballs, the fall ellipse can be elongated. An intensive survey of the area of the find site is therefore planned to recover other eventual fragments.

References

[1] Z. Ceplecha, "Multiple fall of Pribram meteorites photographed", *Bull. Astron. Inst. Czech.* 12, 1961, pp. 21–47.

[2] R.E. McCrosky, "The Lost City meteorite fall", *Sky and Telescope* 39, 1970, pp. 1–6.

[3] I. Halliday, A.T. Blackwell, and A.A. Griffin, "The Innisfree meteorite and the Canadian camera network", *J. Roy. Astron. Soc. Canada* 72, 1978, pp. 15–39.

[4] M. Beech, P. Brown, R.L. Hawkes, Z. Ceplecha, K. Mossman, and G. Wetherill, "The fall of the Peekskill meteorite: video observations, atmospheric path, fragmentation record and orbit", *Earth, Moon, and Planets* 68, 1995, pp. 189–197.

[5] W.R. Van Schmus and J.A. Wood, "A chemical-petrologic classification for chondritic meteorites", *Geochim. Cosmochim. Acta* 31, 1967, pp. 747–765.

[6] G. Molin, A.M. Fioretti, G. Cevolani, R. Carampin, and R. Serra, "A new fall in Italy: the Fermo H-chondrite breccia. A preliminary investigation", *Planet. Space Sci.*, 1997, *in press*.

[7] G. Bonino, G. Cini Castagnoli, N. Bandhari, and G. Taricco, "Behavior of the heliosphere over prolonged solar quiet periods by ^{44}Ti measurements in meteorites", *Science* 270, 1995, pp. 1648–1650.

Six Fireballs over Central Europe

Pavel Spurný and Jiři Borovicka

An overview is given of the data regarding five recent fireballs photographed by stations of the European Fireball Network.

1. Austria, June 7, 1996, $21^h16^m39^s \pm 13^s$ UT

A bright fireball of −9 maximum absolute magnitude was photographed by five Czech stations of the European Fireball Network. The six fish-eye records were obtained at the EN stations #15 Telč, #9 Svratouch, #20 Ondřejov (fixed and guided picture), #14 Červená hora, and #16 Lysá hora). The fireball traveled a 146.6-km luminous trajectory in 6.72 seconds and terminated at a relatively large altitude of 42.7 km in the vicinity of the Austrian-Czech border near the Austrian town Laa an der Thaya. The time of the fireball passage was determined from the combination of the records from Ondřejov fixed and guided cameras and it is in good agreement with several visual observations. In spite of an unfavorable geometry, the following results based on all available records have a good precision.

Table 1 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	24.46 ± 0.03	22.2	11.0 ± 1.5
Height (km)	86.7 ± 0.4	51.3	42.7 ± 0.4
Latitude (° N)	47.483 ± 0.002	48.43	48.665 ± 0.002
Longitude (° E)	16.924 ± 0.006	16.46	16.340 ± 0.005
Abs. magnitude	− 3.9 ± 0.9	− 9.0 ± 0.8	− 3.1 ± 0.9
Photomet. mass (kg)	5.8	2.3	none
Z R (°)	71.915 ± 0.010		73.150 ± 0.010

Fireball type: I
Ablation coefficient: $(0.0097 \pm 0.0016)\ s^2/km^2$

Table 2 – Radiant data.

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	247.15 ± 0.06	247.59 ± 0.07	
δ (°)	− 22.447 ± 0.009	− 27.27 ± 0.02	
λ (°)			200.86 ± 0.05
β (°)			− 3.021 ± 0.008
Initial velocity (km/s)	24.47 ± 0.03	21.69 ± 0.04	38.51 ± 0.03

Table 3 – Orbital data.

Orbit (2000.0)	
a	3.35 ± 0.03 AU
e	0.801 ± 0.002
q	0.6667 ± 0.0007 AU
Q	6.02 ± 0.06 AU
ω	76°80 ± 0°10
Ω	257°4260 ± 0°0001
i	3°619 ± 0°008

2. Czech Republic, July 27, 1996, $0^h16^m02^s \pm 7^s$ UT

A bright fireball of −14 maximum absolute magnitude was photographed by four Czech stations of the European Fireball Network. The five fish-eye records were obtained at the EN stations #9 Svratouch, #15 Telč, #14 Červená hora, and #4 Churáňov (fixed and guided picture). The fireball traveled a 49.1-km luminous trajectory in 1.69 seconds and terminated at a large altitude of 69.38 km. It is very important that all data, but most of all dynamic data, describing this fireball were obtained with a very good accuracy, because this fireball belongs to the fireball type IIIB. These fireballs are admittedly relatively frequent, but the determination of especially their dynamic data is for many reasons very difficult (especially because of a small change in velocity). They distinguish themselves by their very high terminal altitude, large value of the ablation coefficient, very small density, and also by their assumed cometary origin. This fireball was very probably a member of the α-Capricornid meteoroid stream, because all orbital elements are in good agreement with mean orbital elements of this meteoroid stream, except somewhat higher values of semimajor axis and eccentricity. The following precise results are based on all available records.

Table 4 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	29.26 ± 0.03	28.5	27.0 ± 0.9
Height (km)	93.24 ± 0.07	72.5	69.38 ± 0.09
Latitude (° N)	50.1092 ± 0.0004	50.42	50.4718 ± 0.0005
Longitude (° E)	15.9837 ± 0.0011	16.14	16.1614 ± 0.0013
Abs. magnitude	− 4.1 ± 0.4	−14.3 ± 0.8	− 4.0 ± 0.4
Photomet. mass (kg)	13.5	8.6	none
Z R (°)	60.69 ± 0.05		61.07 ± 0.05

Fireball type: IIIB
Ablation coefficient: $(0.21 \pm 0.02)\ s^2/km^2$
PE coefficient: −6.18

Table 5 – Radiant data.

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	305.74 ± 0.03	304.63 ± 0.03	
δ (°)	− 9.09 ± 0.05	− 11.61 ± 0.05	
λ (°)			256.99 ± 0.04
β (°)			+ 05.28 ± 0.03
Initial velocity (km/s)	29.27 ± 0.03	27.16 ± 0.04	40.13 ± 0.03

Table 6 – Orbital data.

Orbit (2000.0)	
a	6.49 ± 0.10 AU
e	0.9182 ± 0.0013
q	0.5310 ± 0.0005 AU
Q	12.4 ± 0.2 AU
ω	269°.82 ± 0°.07
Ω	124°.2953 ± 0°.0001
i	7°.16 ± 0°.05

3. Slovakia, October 4, 1996, $2^h35^m00^s \pm 1^s$ UT

A bright fireball of −10 absolute magnitude was photographed by five Czech stations of the European Fireball Network. The six fish-eye records were obtained at the EN stations #16 Lysá hora, #14 Červená hora, #15 Telč, #9 Svratouch, and #20 Ondřejov (fixed and guided picture). The fireball traveled a 93.18-km luminous trajectory in 6.84 seconds and terminated at an altitude of 31.8 km. The beginning point was photographed at a height of 81.0 km over the Czecho-Slovak border near the Slovak town Nové Mesto nad Váhom and small meteorites of total weight under one kilogram could hit the ground in the vicinity of another Slovak town, Kremnica. The time of the fireball passage was determined from the combination of the records from the Ondřejov fixed and guided cameras, and it is in good agreement with several visual observations. The following results based on all available records have a very good precision.

Table 7 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	21.891 ± 0.005	20.9	8.8 ± 0.5
Height (km)	81.02 ± 0.14	49.4	31.8 ± 0.2
Latitude (° N)	48.7477 ± 0.0015	48.69	48.651 ± 0.002
Longitude (° E)	17.8676 ± 0.0012	18.54	18.923 ± 0.002
Abs. magnitude	− 3.3 ± 0.7	− 9.7 ± 0.8	− 3.1 ± 0.9
Photomet. mass (kg)	12.4	7.9	about 0.3
Z R (°)	57.80 ± 0.03		58.49 ± 0.03

Fireball type: I
Ablation coefficient: (0.0097 ± 0.0010) s^2/km^2
PE coefficient: −4.22

A very good solution (±19.6 meters) was found for a dynamic fragmentation at a height of 41 km under pressure of 12 Bars directly confirmed from two records. Moreover, this point coincides with a small flare in the brightest part of the luminous path.

Table 8 – Radiant data.

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	357.50 ± 0.04	353.44 ± 0.04	
δ (°)	+ 28.253 ± 0.011	+ 24.744 ± 0.011	
λ (°)			310.345 ± 0.014
β (°)			+ 12.630 ± 0.007
Initial velocity (km/s)	21.909 ± 0.004	19.179 ± 0.005	37.302 ± 0.009

Table 9 – Orbital data.

Orbit (2000.0)	
a	2.320 ± 0.004 AU
e	0.6902 ± 0.0004
q	0.7187 ± 0.0004 AU
Q	3.921 ± 0.008 AU
ω	251°89 ± 0°07
Ω	191°1993 ± 0°0001
i	14°389 ± 0°008

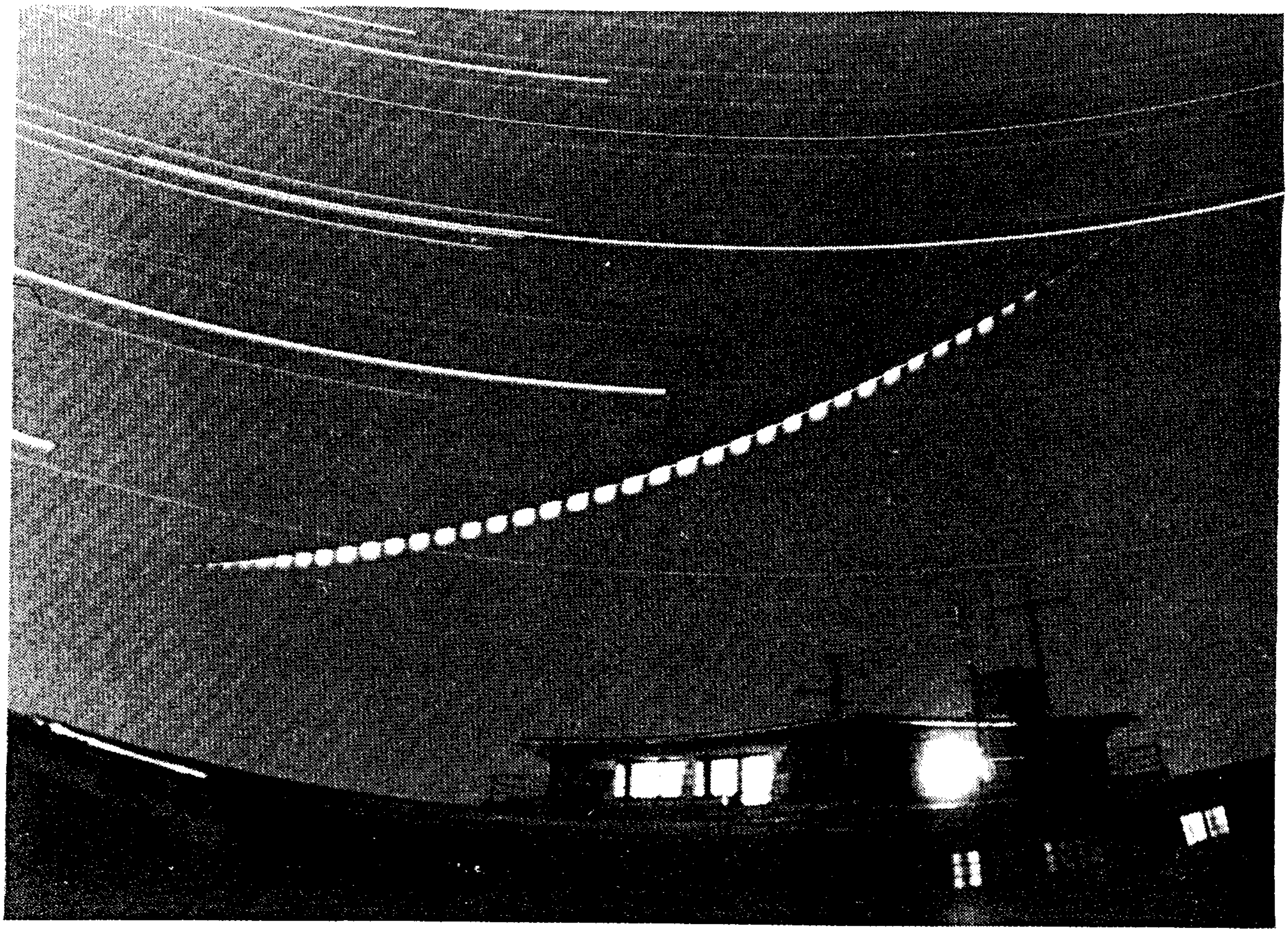

Figure 1 – Detailed view of the EN041096 "Kremnica" fireball photographed above the southern horizon from the closest Czech EN station #16, Lysá hora, by a fixed fish-eye camera (f = 30 mm, f/3.5, 10 shutter breaks per second). The direction of the fireball flight is from west to east.

4. Czech Republic, January 15, 1997, $17^h53^m03^s \pm 3^s$ UT

A fireball of −8 maximum absolute magnitude was photographed by three Czech stations of the European Fireball Network. The four fish-eye records were obtained at the EN stations #20 Ondřejov (fixed and guided picture), #9 Svratouch, and #15 Telč. The fireball traveled a 48.3-km luminous trajectory in 1.46 seconds and terminated at a large altitude of 68.89 km.

Table 10 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	34.00 ± 0.04	32.6	30.5 ± 0.9
Height (km)	96.333 ± 0.006	71.1	68.89 ± 0.03
Latitude (° N)	50.1393 ± 0.0001	49.82	49.7910 ± 0.0002
Longitude (° E)	15.2443 ± 0.0001	15.16	15.1494 ± 0.0004
Abs. magnitude	− 1.4 ± 0.7	− 8.2 ± 0.3	− 1.3 ± 0.7
Photomet. mass (kg)	0.08	0.02	none
Z R (°)	55.26 ± 0.02		55.61 ± 0.02

Fireball type: IIIA
Ablation coefficient: $(0.113 \pm 0.014)\ s^2/km^2$
PE coefficient: −5.19

Table 18 – Orbital data.

Orbit (2000.0)	
a	2.809 ± 0.004 AU
e	0.6522 ± 0.0005
q	0.9769 ± 0.0001 AU
Q	4.642 ± 0.008 AU
ω	169°266 ± 0°014
Ω	296°0784 ± 0°0001
i	36°482 ± 0°011

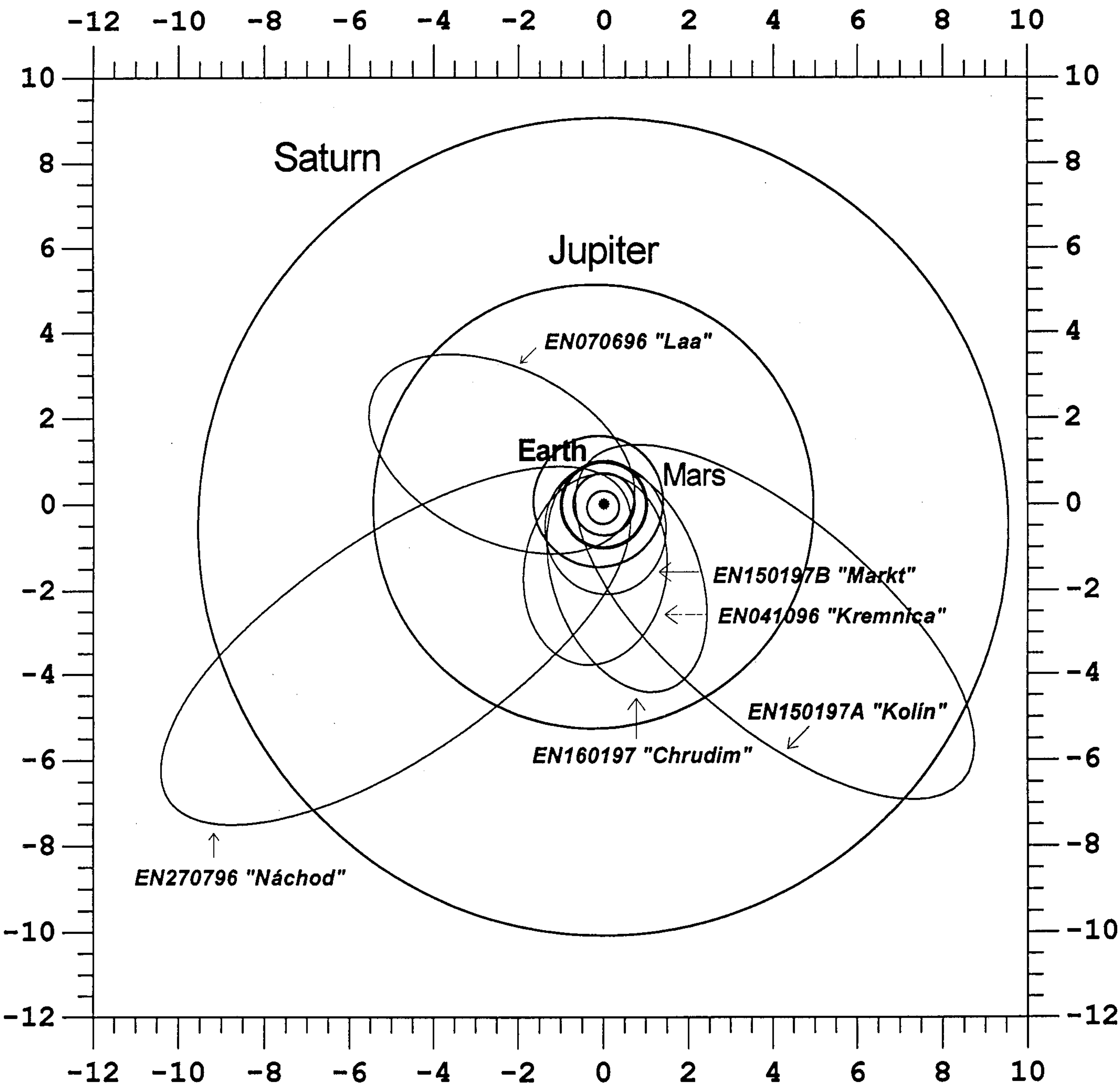

Figure 2 – Heliocentric orbits of the 6 EN fireballs discussed in this article projected onto the ecliptic plane. The axes show X and Y coordinates in AU.

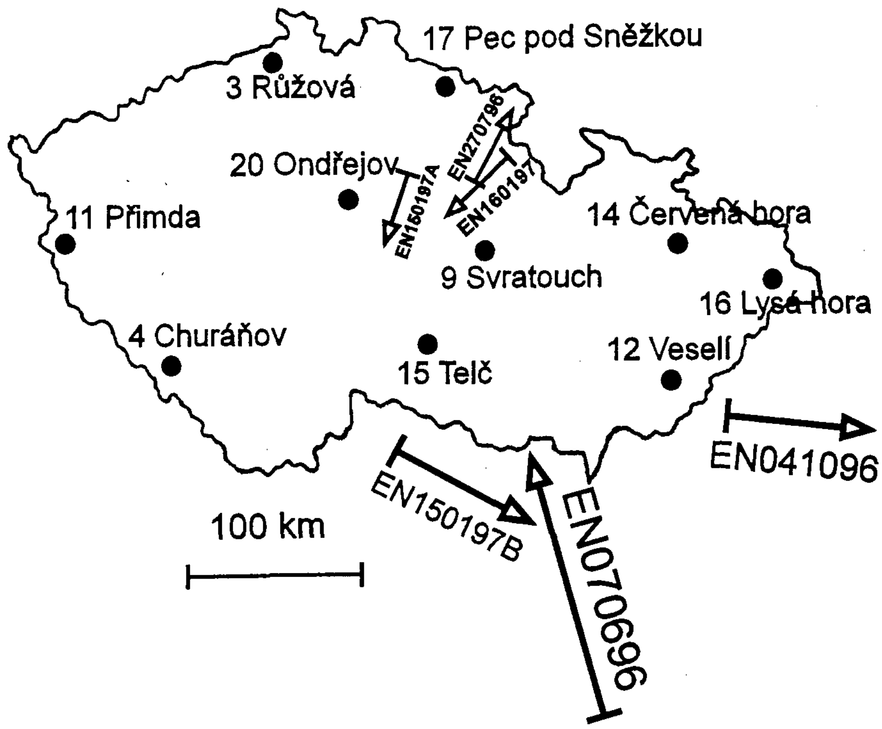

Figure 3 – Trajectories of the 6 EN fireballs discussed in this article. The border of the Czech Republic is outlined.

Reference

[1] P. Spurný, "Exceptional fireballs photographed in central Europe during the period 1993–1996", *Planet. and Space Sci.*, 1997, in print.

Observational Results

WAMS Observations in 1996

Michael J. Buhagiar

A selection of 248 radiants mainly on the southern hemisphere observed by members of the *Western Australian Meteor Search* (*WAMS*) in 1996 is given.

Meteor studies are presented from 1996 observations by the *Western Australian Meteor Search* (*WAMS*) that includes two original founding members (Jeff Wood and Michael Buhagiar), plus a few others (Shayne Francis, Michael Satraj, Aaron Clark, Joshua Wood, and Martin Coroneos), although about 90–97% of the year's records were secured by Michael Buhagiar. Therefore, despite the shortened list of observers, it so happens the one who contributed more is an experienced observer, therefore the quality and uniformity of the results is considerably more reliable than might have otherwise been the case, and when coupled to the extra-ordinary quantity of hours spent observing by the author (776 hours with 6500 meteors) what happens is an acceptable form of concentration, that more than compensates for the reduced number of contributors.

All columns in Table 1 are self-explanatory, except for the number of plots ("n, N"), that includes always two numbers, the first being the numbers of meteors delineating the given radiant, and the second one being the total number of plots on the appropriate chart; this added quantity is a means of estimating the dominance of the said radiant, and could even be used as a means of estimating the ZHR of the said intersection, bearing in mind the fact that each chart, on average, will have about 3 sporadics per hour. The limit for acceptance as a convergence point is about 6° diameter intersection, depending on the length of the plotting arcs.

This list may be offered as a separate annual summary; however, if any soul wishes to make investigations from it, in search of interpretations that go beyond the year's limitations, I add a note of warning here: All resultant radiants have already been correlated with my personal radiant lists spanning 1969–1995, and to deny the author credit will automatically enhance suffering from an unnecessary separation of my previous studies, or risk being greatly reduced in their value. Therefore, if the reader wants to make interpretations that seek stream behavior and reliability, I most vehemently suggest contacting me first to obtain a more fluid interpretation, or risk the consequences of being unscientific. If any desire exists to enquire about my further studies, all it takes is the written (or possibly) spoken word, to reach me for my further information to be readily made available.

A reasonably precise estimate of number of meteors that I have either observed or have been reported to me during 1996, is 7100 from about 800 hours under the stars. This (personal record breaking) year's dedication, has lifted my lifetime total of secured observations to about 29 000 from a total of about 2500 hours observing, covering 352 of the possible 366 days of the year, therefore the task that I somewhat set out in 1969 to achieve has now almost reached fruition, and the 27 years have seen me grow in "meteor wisdom," the only significant gap remaining in the coverage spanning the two nights August 26–27. There remain 12 other single uncovered nights.

The outstanding month for complete coverage is May, with 128 observing sessions recorded, naturally more so over the first half, peaking on the 2nd, 5th, 6th and 7th, although the peak of nine times (5th), is eclipsed by December 13th, with 10 sessions. The least covered month is September, with 56 observing sessions, although spread fairly uniformly throughout the month. The at times fine weather here has allowed the consecutive nights' observing records to tumble in 1996, with 20 nights (from February 18 to March 8) to be again eclipsed by 34 from November 30, 1996, to January 3, 1997.

The year 1996 has seen the addition of 500 individual radiants to the about 1500 from my previous observing sessions, with the listing of a consequent total of about 100 annual or occasional showers. However this communication is just concentrating on my 1996 observations, therefore it stands separate.

Table 1 – List of convergences in 1996. The column 'n, N' gives the number of meteors contributing to the convergence area and the total number on the respective chart. "Shw." gives an association with the *IMO* Working List of Visual Meteor Showers.

Date	α	δ	n, N	Shw.	Date	α	δ	n, N	Shw.	Date	α	δ	n, N	Shw.
Jan 03-04	170	−51	7/16		Mar 11-12	248	+35	10/40		Jun 05-06	263	−17	6/20	SAG
Jan 13-14	191	−07	6/6		Mar 13-14	221	−48	7/8		Jun 06-07	305	+30	6/10	
Jan 16-17	124	−48	6/10		Mar 16-17	209	−57	6/25		Jun 07-08	309	+38	6/6	
Jan 18-19	118	−48	6/10			221	−42	8/20		Jun 12-13	240	−09	6/28	
Jan 20-21	166	−59	6/15		Mar 18-19	196	−11	13/17	VIR	Jun 13-14	277	−30	7/15	SAG
Jan 28-29	210	−35	7/30			243	−50	6/19	GNO	Jun 14-15	282	−28	7/30	SAG
Jan 30-31	180	−33	7/15		Mar 19-20	247	−11	6/20			250	−33	9/50	
Feb 02-03	199	−57	10/34	ACE		200	−40	7/12			217	−29	6/50	
	110	−72	6/12		Mar 21-22	243	−39	6/10		Jun 21-22	289	+12	7/26	
	196	+18	7/10		Mar 23-24	198	−24	6/15		Jun 23-24	290	−30	7/20	SAG
Feb 03-04	193	−31	13/25		Mar 24-25	165	−60	6/20		Jun 24-25	272	−15	9/30	SAG
	250	−70	6/20		Mar 30-02	232	−29	7/30		Jun 25-26	260	−55	6/25	
Feb 09-10	122	−47	6/25		Apr 01-02	165	−66	8/20		Jun 26-27	281	−30	9/20	SAG
	98	−53	8/30		Apr 08-09	220	−17	7/12	SAG	Jun 27-28	330	−45	6/10	
	88	−16	7/20		Apr 09-10	162	−60	9/15		Jul 05-06	276	−30	11/25	SAG
	225	−81	11/30		Apr 13-14	252	−17	7/15		Jul 08-09	302	−10	10/20	

Table 1 – List of convergences in 1996 (continued).

Date	α	δ	n, N	Shw.	Date	α	δ	n, N	Shw.	Date	α	δ	n, N	Shw.
Feb 12-13	160	−76	8/10			257	−55	6/30			345	−17	6/40	
	98	−51	6/20			224	−50	8/30			285	−12	10/40	
	137	−22	6/20		Apr 14-15	201	−56	6/10			265	+45	8/20	
Feb 13-14	202	−52	7/40		Apr 15-16	305	−58	6/7		Jul 10-11	346	−33	10/30	
Feb 15-16	151	−15	8/30		Apr 16-17	201	00	6/22			300	−10	7/30	CAP
	232	−61	6/25	ACE		212	−26	7/20			3	−28	6/20	
Feb 16-17	239	+01	10/20		Apr 17-18	211	−23	6/30		Jul 11-12	302	−11	7/10	CAP
	195	−07	8/12			247	−49	8/30		Jul 24-25	2	−81	6/9	
Feb 18-19	254	−05	7/10			294	−58	7/20		Jul 26-27	302	−10	10/30	CAP
	222	−44	6/20			230	−60	6/20			334	−20	7/30	SDA
	152	−49	6/11			100	−26	6/10			342	−11	8/30	
Feb 19-20	248	−05	9/20		Apr 18-19	186	−72	7/50			300	−75	6/15	
	205	−43	11/30		Apr 20-21	315	−04	10/20		Jul 27-28	339	−15	10/20	SDA
	195	−15	8/30			223	−15	6/20	SAG	Jul 30-31	308	−01	7/24	
Feb 20-21	197	−17	10/30		Apr 21-22	211	−63	8/20			344	−11	6/25	SDA
	98	−56	6/11			229	−45	7/20		Jul 31-01	304	−13	6/20	CAP
Feb 21-22	162	−17	7/20		Apr 22-23	282	−20	8/25		Aug 02-03	345	−13	8/30	SDA
	314	−08	6/10			216	−50	8/30			314	+40	6/30	
Feb 22-23	135	−55	8/20		Apr 27-28	187	−56	7/20			295	−04	10/30	
	163	−16	19/40			267	−30	7/20			11	+13	8/30	
	260	−18	6/20		Apr 28-29	241	−17	11/30	SAG	Aug 05-06	304	+35	12/40	
Feb 23-24	247	+02	8/40			331	−05	9/20	ETA		308	−09	27/40	CAP
	221	−07	9/30			189	−65	8/20			338	−15	7/30	SIA
Feb 24-25	236	−44	6/30		Apr 29-30	234	−29	7/20			335	+01	6/20	
Feb 24-25	183	−28	6/30		May 01-02	332	−11	6/15			104	+24	6/10	
Feb 26-27	260	−48	7/30		May 04-05	336	−01	14/20	ETA	Aug 07-08	306	−09	10/25	CAP
	196	−18	8/30		May 10-11	350	+07	9/20			340	−29	13/40	
	173	−05	6/7	VIR	May 18-19	239	−19	11/30	SAG		203	−64	6/30	
	79	−31	6/20			282	−27	15/40		Aug 08-09	345	−30	6/10	PAU
Feb 27-28	224	+13	6/10			306	+16	6/20			345	+14	7/20	
	268	−05	6/15			194	00	10/12		Aug 09-10	40	−11	19/40	
	107	−26	8/20			343	+02	45/50	ETA		57	−28	10/40	
Feb 28-29	103	−38	8/20		May 21-22	344	+01	6/7			352	−09	9/50	SDA
	160	−43	11/30		May 22-23	252	−27	6/15	SAG		343	−30	10/40	
	163	−10	6/30		May 24-25	243	−32	7/20			345	+25	6/20	
	203	−68	10/20			342	−10	18/23		Aug 12-13	309	+14	8/20	
	10	−75	6/20		May 26-27	279	−30	17/50		Aug 13-14	261	−56	6/15	
Feb 29-01	204	−19	8/20			274	−58	10/50		Aug 14-15	48	+45	10/30	PER
Mar 01-02	226	−45	10/30			243	+18	8/12			250	−08	13/30	
Mar 04-05	238	−56	6/20	GNO		241	−23	8/25	SAG		250	−55	14/25	
	170	−20	6/10		May 27-28	242	−04	6/9			282	+23	11/40	
Mar 05-06	255	+15	6/20			261	−50	8/20			322	−15	10/40	
Mar 07-08	278	−50	7/9		May 28-29	349	−02	16/20			330	−38	12/40	
	118	−50	6/7			326	−38	9/30		Aug 17-19	350	−15	17/45	
Mar 11-12	195	+60	7/10			272	−29	7/30			55	+45	7/20	PER
	143	−40	6/11		Jun 04-05	0	+06	6/7			10	−73	6/15	
	200	−60	8/20			244	−20	7/25		Aug 24-25	5	−15	7/15	
	184	−20	8/30			268	−07	6/30		Aug 31-01	277	+24	6/10	
Sep 04-05	71	−72	6/20		Nov 16-17	155	+16	7/7	LEO	Dec 14-15	116	+33	20/44	GEM
Sep 10-11	70	−57	6/10		Nov 17-18	150	+20	13/20	LEO		80	+30	8/20	
Sep 24-25	96	−25	6/19		Nov 18-19	153	+23	8/20	LEO		126	−04	8/44	HYD
Oct 02-03	0	−78	7/20		Nov 20-21	82	00	6/20			131	−46	7/20	PUP
	120	−50	12/25			59	+21	10/20	TAU		100	−31	6/20	
Oct 06-07	20	+15	10/30	TAU	Dec 02-03	150	−22	6/10		Dec 15-16	146	−48	6/30	
Oct 10-11	43	+04	8/15		Dec 03-04	126	−47	6/20	PUP	Dec 16-17	155	+20	6/20	
Oct 13-14	50	+37	8/15		Dec 05-06	140	−18	11/20			96	+23	6/20	XOR
Oct 16-17	87	+12	6/6	ORI		80	−70	6/15		Dec 17-18	97	−54	9/20	
Oct 17-18	44	+02	11/20		Dec 06-07	131	−05	7/20		Dec 18-19	115	−39	8/20	
	121	−13	6/10			120	−40	6/20	PUP		80	−31	7/25	

Table 1 – List of convergences in 1996 (continued).

Date	α	δ	n, N	Shw.	Date	α	δ	n, N	Shw.	Date	α	δ	n, N	Shw.
Oct 18-19	92	+14	6/10	ORI	Dec 07-08	112	+32	9/20	GEM		141	−03	8/25	
Oct 19-20	92	+18	18/28	ORI		135	−54	8/20		Dec 20-21	156	−42	6/12	
Nov 06-07	83	−08	10/20		Dec 08-09	113	+33	7/20	GEM	Dec 22-23	155	−57	6/20	
	130	+08	7/25		Dec 10-11	106	+28	6/12	GEM	Dec 27-28	94	+18	6/10	
Nov 09-10	70	+20	16/30	TAU		156	−39	6/12		Dec 30-31	122	−48	14/25	
	60	−10	7/30		Dec 12-13	112	+38	10/20	GEM	Dec 31-01	185	−69	7/10	
	90	−50	6/30		Dec 13-14	109	+30	52/80	GEM		83	−39	6/20	
Nov 10-11	58	+14	7/20	TAU		162	−40	8/20						

Editor's postscript

The above list of convergence points is given here to encourage meteor studies on the southern hemisphere. The complete list contained convergence points made up by at least 3 meteors—we give only those with more than 5 meteors here in order to save space and present the more significant points only. The "Shw." column in Table 1 was added to indicate possible associations with meteor showers listed in the IMO*'s Working List of Visual Showers for the reader's convenience.*

SPA Meteor Section Results: July–August 1996

Alastair McBeath

Details on observations and comments sent to the *SPA Meteor Section* from July and August, 1996, are presented. Conditions were again unhelpful for many people, but August provided several better nights, and proved the more interesting of the two months for visual observers. Radio and visual data confirmed another good Perseid primary maximum on August 12, 1^h–2^h UT, and some further useful radio results were achieved in July.

1. Introduction

Skies in the entire first half of 1996 proved unexpectedly poor for many sites across Europe, and July was only somewhat better, though August brought an improvement, albeit locations across the southern UK and much of Germany and the Low Countries met with a dismal night on August 11-12, when the Perseid primary maximum was expected.

Indeed, it was only by traveling into Poland that a few of the German *Arbeitskreis Meteore* (*AKM*) observers managed to see anything of the Perseids that night at all! Watchers further east in Europe did much better then, as did those in northern England, north Wales, and southern Scotland, who all managed to snatch at least a few hours of clearer skies.

The observing tallies submitted to the Section are given in Table 1.

Radio observations came from Alan Heath and Steve Hudson, and Robert S. White in England, and Ilkka Yrjölä in Finland (these latter results submitted by Norman Fitch of the *Radio Society of Great Britain*, who also provided a summary of impressions of the Perseid shower by six other *RSGB* members). Robert ran his system for another lengthy spell between July 14–August 2, while Alan and Steve and Ilkka concentrated primarily around the Perseid maxima.

Our visual contributors included

> *AKM* members (Germany and Poland: data summaries provided by leading observer Jürgen Rendtel, with Rainer Arlt and nine others giving excellent support), *Ayr Astronomical Society* members (Scotland: results via observer Nick Martin), *Astroclub Canopus* members (Bulgaria: information from observer Eva Bojurova), Neil Bone (England: report via *The Astronomer*), Jay Brausch (North Dakota, USA), Ovidiu Cioroianu (Romania), John Coates (England), *Exeter Astronomical Society* members (England: data from Lawrence Beck), Dave Gavine and Jamie Shepherd (Scotland), Martin Gaskell (Nebraska, USA: report via *The Astronomer*), Shelagh Godwin (England and Czech Republic), Brian Kelly (Scotland), Richard Livingstone (Wales), Malta Astronomical Society members (Malta: results summary from observer Godfrey Baldacchino), Marisa March (on board an Irish Sea ferry: news via John Lambert), Tony Markham (England: he also provided all *The Astronomer* reports from his "Meteors" column there), Alastair McBeath (England), Tom McEwan (Scotland), Vasile Micu (Romania), Stewart Moore (report via *The Astronomer*), Graham Pointer (England), Gelu-Claudiu Radu (Romania), George Spalding (England), Stephen R. Weinman (Guam: data from Guy Ottewell).

Table 1 – Visual and radio hours' totals, and visual meteor numbers recorded in each month, including a partial breakdown of meteor types.

Month	Visual	PER	CAP	KCG	Meteors	Radio
July	$40\overset{\mathrm{h}}{.}57$	54	29		402	414^{h}
August	$251\overset{\mathrm{h}}{.}34$	4157	15	110	6115	$145\overset{\mathrm{h}}{.}44$

2. July

The majority of reports came from the third week of the month, revealing low activity from the various Aquarid and Capricornid showers, and a few early Perseids.

Rates were never high visually, but Robert White's radio data showed the build-up of meteor rates generally towards the end of July and into early August, as shown in Figure 1.

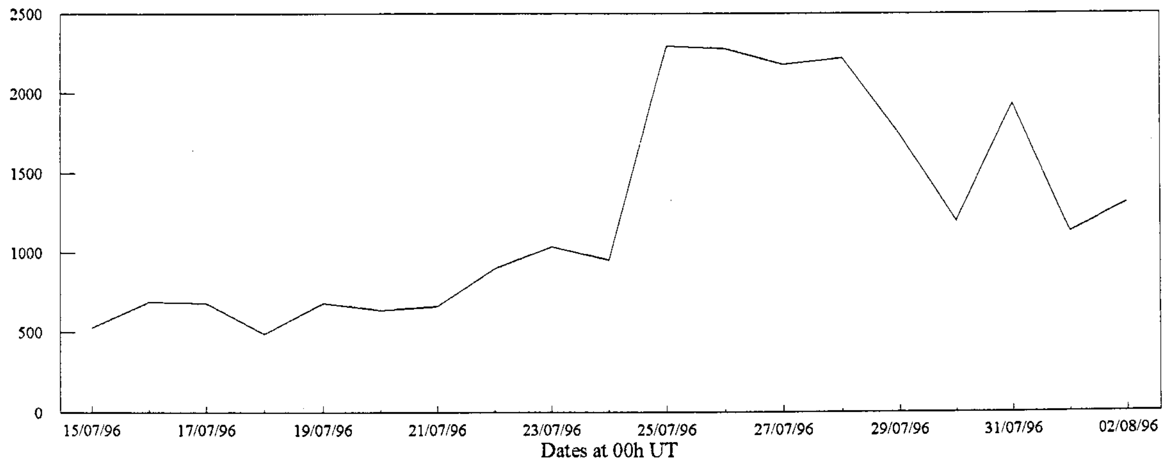

Figure 1 – Raw daily radio meteor echo counts from July 15 to August 2, 1996, from data collected by Robert S. White. The rise in overall meteor activity in late July, persisting into early August, due to increasing rates from the Capricornid and Aquarid streams near their maxima, is clearly visible.

The same pattern of activity was shown as found in Robert's data from 1995 July (see [1]), with a steep activity increase around July 24-25. The spike found on July 21-22 in 1995 did not repeat, however, in these data.

Following the 1996 *IMC* at Apeldoorn, the author obtained some observations from the Department of Mathematical Physics and Astronomy at Ghent University in Belgium which showed a lengthy period when no information was available from the radio system in the morning hours of 1995 July 22, either because of Sporadic-E, a temperature inversion, or because the system was not operating. This coincided with the time Robert detected a major activity spike. Although we cannot be certain, this new information makes it more likely it was probably due to a Sporadic-E event then. My thanks are due to Jean-Marc Wislez for drawing my attention to the Ghent University data on the WWW at the *IMC*, and also to Peter Ward for obtaining color copies for me very swiftly once back in England.

3. August

As often happens, August brought a particular concentration of observer activity, but observations were actually quite well-spread over the month, with someone out recording meteors on virtually every date between August 3 and 23. Naturally, there was a sharp increase in the number of watchers reporting data from nights around the Perseid maximum, so much so that it has been possible to derive a ZHR graph for the shower from August 9-10 to 14-15, as illustrated in Figure 2.

Highest individual ZHRs (single-observer) were between 120 and 160 in the period from 0^h50^m to 1^h50^m UT on August 12, with some values from the period around 1^h10^m to 1^h30^m UT exceeding 200. There are too few observations from this specific interval to confirm the accuracy of this latter figure, however, with early *IMO* results featuring ZHRs no higher than 120–160 for August 11-12, for instance (my thanks to Rainer Arlt for providing these figures).

Tables 2 and 3 give some further details on the overall Perseid and August sporadic magnitude and train figures. Not all observers reported complete magnitude and train data, and some data were unsuitable as it was collected either by inexperienced observers or under poor conditions (limiting magnitude worse than +5.5, cloud cover more than 20%). These results are thus based on reduced tallies, the numbers of people reporting train numbers still lower than those providing magnitude data. Overall, 40.3% of Perseids and 2.6% of August sporadics left persistent trains.

Many observers reported that there were lots of bright Perseids around, and indeed details on 25 fireball-class events were notified to the Section from August, along with many more such objects that no further notes (e.g., timings, positions, etc.) were available on. The vast majority were Perseids, more than three-quarters of which occurred on August 11-12 and 12-13. However, there were very few exceptionally impressive events reported, even from the Perseids, where the brightest meteor was "only" of magnitude −8, with an 18-second persistent train.

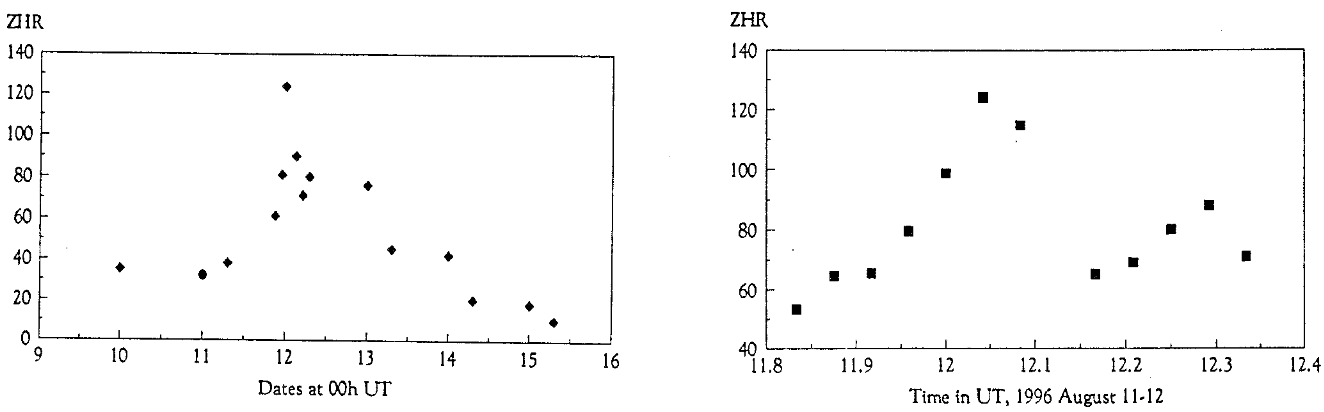

Figure 2 – *Left: SPA Meteor Section* 1996 Perseid ZHRs between August 9-10 and 14-15. The errors on individual data points are of the order of 3–5 for August 10-11 to 12-13 inclusive, but between 7–10 for other nights. Perseid ZHRs were computed using $r = 2.1$ for August 11-12, $r = 2.5$ on other nights, based on the magnitude distributions for separate nights. *Right:* Peak ZHRs, for the hours closest to the primary maximum, but also showing early signs of the normal peak, on August 11-12. Data points are at hourly intervals. Errors on individual points are about 8–10 before 2^h UT (August 12.08), 10–13 after this time, when fewer observers reporting data were active.

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

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$	Tot	Lm	$\overline{m}_{6.5}$
Perseids	108.5	108	165.5	291.5	371.5	436	376.5	282.5	108	2248	6.04	1.92
Sporadics	4.5	9	19.5	42.5	74.5	113.5	165	192.5	289	910	6.04	3.88

Table 3 – Global train percentages and mean duration in seconds per magnitude class for the Perseids and August sporadics. Train details were only available for 652 Perseids and 505 sporadics of the reported totals.

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4^+$
Train % PER	47	71	50	52	42	33	5	0
Duration PER	7.8	3.4	2.8	2.1	1.8	1.2	1.2	
Tain % SPO	0	100	0	20	11	0	1	0
Duration SPO		6		2	0.6		1	

Despite this, most observers were well satisfied with what they saw, judging by the correspondence to the Section, although the American watchers, who missed the primary peak and much of the ordinary one from the shower, sometimes expressed disappointment. Jay Brausch in North Dakota, for instance, commented that he felt the *shower overall this year was "anemic,"* while on Guam, better-placed to view the normal Perseid peak, Stephen R. Weinman enjoyed *two nights of major meteors* over the maxima. Those people in Europe fortunate enough to witness the main maximum were all very impressed, and observed rates of 4–6 Perseids a minute were relatively common between 1^h10^m and 1^h30^m UT on August 12. For some watchers, this brought with it a hint of panic, as they tried to keep all the details in mind before recording them! Others found it a little reminiscent of the wonderful α-Monocerotid peak the previous November, but better, as the Perseids kept up a constant performance throughout the night, as well as yielding high rates at their best.

Ilkka Yrjölä's radio results between August 11–15 picked up the best Perseid activity beautifully around 1^h UT on August 12, and activity overall was higher that day than any other nearby in his data. UK radio amateurs, more interested in using the meteor-scatter propagation mode than just observing the activity, gave mixed reactions to the shower, but the majority view was that the event had been at least average to good. Frequently, their impressions of a shower are geared by which and how many new areas they are able to communicate with, which will be heavily influenced by the shower's peak timing in relation not only to their own aerial geometry and radio set-up, but those of the others they hope to contact.

4. Conclusion

Overall, a better session than most so far this year, with a pleasingly good Perseid return quite well observed. As has become customary, my heartfelt thanks go to everyone who has provided data, comments, suggestions and notes to the Section from the period covered, and to wish all and sundry every success for their future work. Clear skies!

Reference

[1] R.S. White, A. McBeath, "An Automatic System for Monitoring Forward Scatter Radio Signals", in *Proceedings 1996 IMC*, A. Knöfel, P. Roggemans, eds., IMO, 1997, pp. 133–138.

SPA Meteor Section Results: September–October 1996

Alastair McBeath

A resumé of data presented to the *SPA Meteor Section* from September and October, 1996, is given. September proved quite quiet, with few observers active, but low rates of δ-Aurigids/September Perseids, part of the minor Aurigid-Cassiopeid-Perseid complex of showers, and from a radiant in Triangulum/Perseus, were readily detected around September 7–12. A brilliant fireball was also noted from sites in Northern England on September 8. In October, observations clustered around the Orionid maximum, from October 15-16 to 23-24, but several, mostly negative, Draconid watches were carried out too. Peak Orionid ZHRs were around 30 on both October 20-21 and 21-22. Two hugely impressive fireballs, on October 3 and 17, were also reported, and on October 24, Jürgen Rendtel made the first-ever photographic observations of moving ripples in a solar halo. One main highlight of both months was a fresh input of radio data from several new observers, allowing a particularly detailed look at radio meteor activity in September and October.

1. Introduction

It is never easy for observers to keep their enthusiasm running after the excitements of mid-August have passed, and September is often a quiet month as a result. In 1996, again, weather conditions particularly across Europe assisted little, a problem which persisted into October, though with somewhat better skies around the Orionid maximum in places. Certainly more observers were active then, taking advantage of whatever clearer nights did chance by.

The main observed totals sent to the Section for the various techniques are summarized in Table 1.

Table 1 – Visual, photographic, and radio hours' totals, and visual meteor numbers recorded in each month, including a partial breakdown of meteor types.

Month	Visual	SPI	DAU	ORI	TAU	Meteors	Photo	Trails	Radio
September	$29\overset{h}{.}94$	28	34			252	$185\overset{h}{.}66$	0	$1401\overset{h}{.}0$
October	$69\overset{h}{.}14$	0	6	522	80	1068	$334\overset{h}{.}18$	3	$2335\overset{h}{.}3$

Most of the photographic results were provided by members of the German *Arbeitskreis Meteore* (*AKM*) European Fireball Patrol Network contributors, and were submitted together with the *AKM*'s visual data, by leading photographic and visual observer Jürgen Rendtel, to whom go many thanks. The remainder of the photographic hours (averaging 16.2 hours each month) were provided by Valentin Grigore in Romania, who caught 3 Orionid trails during October.

Radio data was received from

> Peter Bus (Netherlands, RMOB), Maurice de Meyere (Belgium, RMOB), Werfried Kuneth (Austria, RMOB), Kimio Maegawa (Japan, RMOB), Chikara Shimoda (Japan, RMOB), Kazuhiro Suzuki (Japan, RMOB), Jeroen Van Wassenhove (Belgium, RMOB), Robert S. White (England), Ilkka Yrjölä (Finland, RMOB and via RSGB), and Wim Zanstra (Netherlands, RMOB).

My thanks for the above go especially to the observers involved, but also to Christian Steyaert for providing copies of the *Radio Meteor Observation Bulletins* (*RMOBs*) containing much of the data, and to Norman Fitch of the *Radio Society of Great Britain* (*RSGB*) for part of the data and discussions on the topic from the radio amateurs' point of view. Equipment details not given here for the *RMOB* observers can be found in [1–3] (this latter for Kimio Maegawa and Wim Zanstra only during this period), while Robert S. White's set-up is discussed in [4].

In analyzing the radio results, the procedures outlined in [5] for dealing with unprocessed data have been followed, and the graphs selected for display here are representative of the radio results as a whole, generally backed up by the rest of the data not so shown.

Finally, but by no means least, we come to those people providing visual meteor watch observations:

> *AKM* members (Rainer Arlt, André Knöfel, Sirko Molau, Jürgen Rendtel, Germany), Eva Bojurova (Bulgaria), Jay Brausch (North Dakota, USA), Shelagh Godwin (England), Valentin Grigore (Romania), Brian Kelly (Scotland), Nick Martin (Scotland), Alastair McBeath (England), Tom McEwan (Scotland), Vasile Micu (Romania), Adrian Negoescu (Romania), duToit Prinsloo (South Africa), George Spalding (England), Magda Streicher (South Africa), Peter van Blommenstein (South Africa), Graham Winstanley (England).

As ever, these people too receive many grateful thanks for their input, along with Tim Cooper in South Africa, who provided details on all the observations from that country.

2. September

Full Moon in late August put paid to most visual observers' attempts to cover the α-Aurigid maximum around September 1, and no shower meteors were seen. Radio data from Chikara Shimoda, Kazuhiro Suzuki (see Figures 1 and 2) and Ilkka Yrjölä (who carried out a 96-hour observing run from August 31 to September 3) revealed no especial enhancement in raw echo counts then. Radio data did show slightly higher echo counts from around September 2–6, borne out too in results from Maurice de Meyere (not illustrated here), but the difference is marginal and is not confirmed by all sets of data. The relatively high peak of September 4-5 seen in Figure 1 does not appear elsewhere, for example, though regrettably, Maurice de Meyere was not operating his set-up then.

Highest δ-Aurigid rates—ZHRs of around 5 ± 2—were seen on September 8, a date which shows a small enhancement in the available radio data sets too. Maurice de Meyere's data and those of Chikara Shimoda both show further enhancements on September 9-10. The only other active radio observer then was Kazuhiro Suzuki, and his data may not always reveal such peaks, as his data sampling method is slightly different, and, for example, actually showed a drop in detected echo counts during the main 1996 Leonid epoch (see [5]). A visual report forwarded by Rainer Arlt indicated Koen Miskotte in the Netherlands had noted enhanced September Perseid rates around September 7-8, and Jay Brausch in the USA also casually detected an unusual number of meteors radiating from the Auriga-Perseus-Triangulum region as well during September 9–12, although he did not keep full records as he was making auroral observations on these nights. This certainly suggests the opening fortnight of September, at least, should receive more attention from observers, as already suggested in, for example, [6] and [7]. Despite the Section's Aurigid and Taurid meteor plotting project being operational at the time, too few plots were received during September to confirm these visual reports.

September 8 also provided three casual witnesses in Northern England with views of a spectacular magnitude -15 (?) fireball, at about $21^{h}24^{m}$ UT. The meteor was seen from sites near Alston, Cumbria ($\lambda \approx 2°25'$ W, $\varphi \approx 54°50'$ N; unnamed witness), Hexham, Northumberland ($\lambda \approx 2°08'$ W, $\varphi \approx 54°55'$ N; by Ron Cook) and North Gosforth, Newcastle ($\lambda \approx 1°35'$ W, $\varphi \approx 55°05'$ N; by Mario Sammut), with all observers noting the object as being in the southern to south-western skies, moving east to west. No accurate positions were available from any of the sites, but the object was within 20° to 30° of the south-west horizon as seen from Hexham (Ron Cook had been looking at Jupiter just before the meteor appeared) and North Gosforth (from where the meteor was seen *just below Aquila ... to Scutum*). These two observers independently estimated the visible flight as lasting about 7 s, and with a 12°–14° path length suggested by Mario Sammut, a $1\overset{\circ}{.}7$/s to 2°/s angular velocity is implied. The rough direction and approximate velocity might indicate a very late Northern ι-Aquarid, or possibly a Piscid, but in both cases the velocity is perhaps too low, and a sporadic seems the more likely. Thanks are due to John Lambert and Don Simpson for encouraging the observers to provide reports to the Section.

Radio reports show a small upturn in activity on September 13-14 and 15-16, also coincident with some higher Piscid rates detected visually (ZHRs of $4–7 \pm 2–3$), but whether this was the main Piscid peak is unknown.

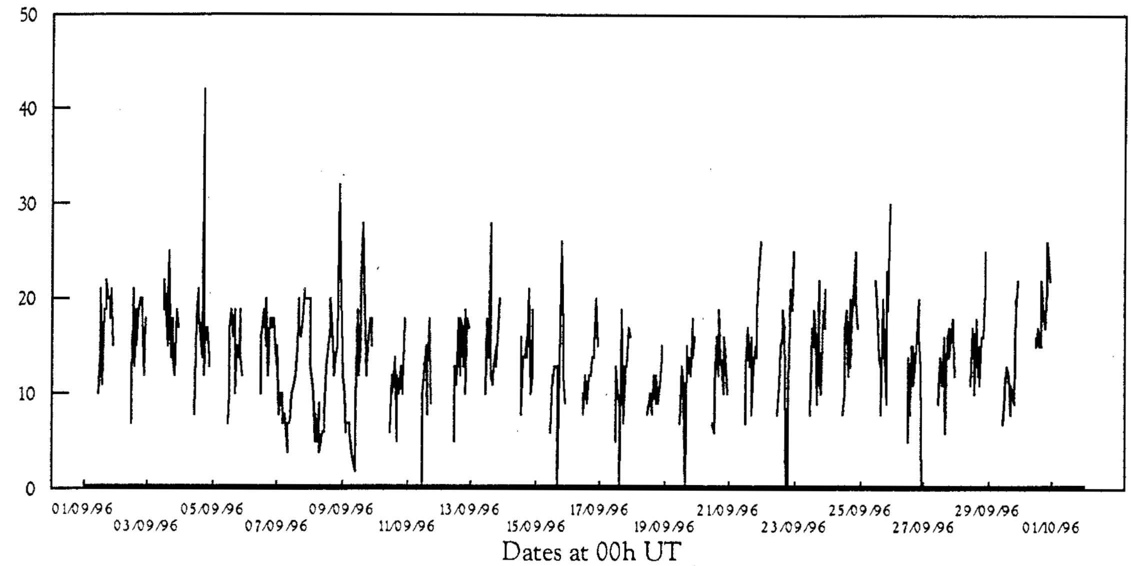

Figure 1 – Raw hourly radio meteor echo counts from September 1 to 30, 1996, from data collected by Chikara Shimoda in [1] and [2]. In general, except for between September 6–10, coverage was restricted to about 12 hours a day, and variations in day-to-day activity are quite minor. Note that in Figures 1–4, the vertical and horizontal scales vary from graph to graph.

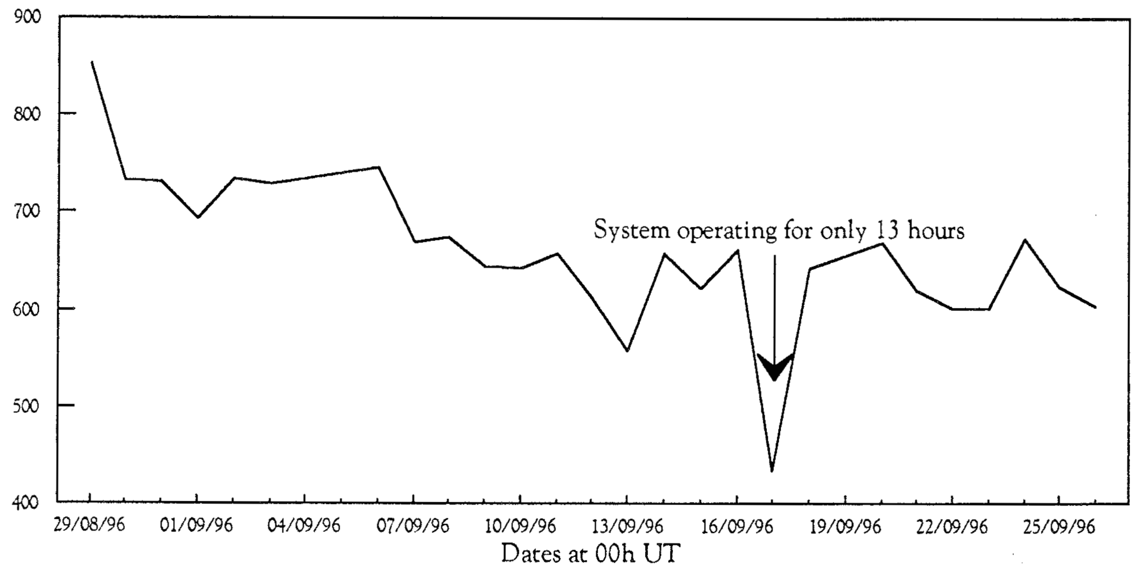

Figure 2 – Raw daily radio meteor echo counts from August 29 to September 26, 1996, from data collected by Kazuhiro Suzuki in [1]. After an initial apparent activity drop in late August, variations are generally small, but rates do seem to be slightly higher up to September 6-7 or so.

An alternative solution is suggested by the radio peaks previously found around September 16, with a possible radiant in Orion-Gemini [8], and which Dirk Artoos estimated reached a maximum close to $\lambda_{\odot} = 172\overset{\circ}{.}91$ (eq. 1950.0), which equates to a time around 3^{h}–4^{h} UT on September 16, 1996. Only Maurice de Meyere and Kazuhiro Suzuki were operating their radio equipment then, and, for Japan, a radiant in Orion-Gemini would have set by around 4^{h} UT on September 16, hence nothing unusual was detected at that time by Suzuki. De Meyere's data do show a distinct enhancement at this time, but it is fair to say that his data also show other daily peaks of comparable magnitude at around the same time on at least five other days in September between 1-2 to 24-25, so it is difficult to be sure if the September 16 event is significant, especially as sporadic activity reaches its diurnal maximum at about this time too. The fact that enhanced peaks were detected in several radio data sets around this date does imply something slightly unusual was occurring, however.

Radio rates were again marginally enhanced around September 20-21, in line with the expected Piscid peak, although the shower has been suspected previously of having more than one maximum and a multiple radiant. No visual reports are available after September 19 for correlation, as Full Moon approached. Higher raw echo counts in three radio data sets on September 24-25 may perhaps indicate a slight shift in the peak time of the daytime Sextantids, although only Chikara Shimoda's data are available for dates around September 27, the predicted maximum, and these show no possible enhancement again until September 28-29 (Figure 1). Dirk Artoos also drew attention to the period around September 26–30 in [8] as being an interesting time for radio observations, but too few radio reports from then in 1996 allowed any correlation with the possible Aurigid or Sextantid radiants he proposed.

3. October

Early October brought an unusual "orbital" meteoroid, or possibly a small fireball "procession." According to reports received, an object entered the Earth's atmosphere over New Mexico, USA, around 4^h01^m UT on October 4 (8^h01^m p.m. on October 3, local time) at a shallow angle, creating a brilliant fireball and partially fragmenting, before bouncing out and orbiting the Earth once. It is suggested it then re-entered the atmosphere a second time around 1^h44^m later over California, USA, producing a second superbly bright meteor, and possibly dropping meteorites, as sonic booms were heard, and seismic shock waves recorded by Caltech and US Geological Survey stations in Southern California. The object was seen to fragment severely as well. Investigations as to what actually happened are still on-going as this is written, and a more likely explanation may be that two brilliant fireballs following similar tracks occurred over the south-western USA during the evening hours of October 3. Thanks are due to all who sent press cuttings and notes on this, particularly Dave Newton, who provided information from the WWW on the event shortly after its occurrence.

Although most visual observations for the month were made around the expected Orionid main maximum on October 21, despite problems from an increasingly bright Moon, several watches were carried out earlier in the month too, with observations from the UK and Bulgaria (a brief summary report of a special observing camp at Avren village, from Eva Bojurova), around October 8–10, suggesting no obvious Draconid activity then. The two radio operators who were active through this period, Maurice de Meyere and Chikara Shimoda (see Figures 3 and 4) did find a slight enhancement around October 9, but activity in the opening days of October, when no particular shower activity was expected, was at least as high. Another radio operator, Peter Bus, ran for a short time on both October 6 and 8, as did Wim Zanstra on October 8 and 11, but neither data set shows any obvious echo-count peaks.

Another brilliant fireball came down in daylight over Europe on October 17 at 11^h35^m UT, as seen from the Netherlands. The track seems to have been across Northern Germany and Denmark, but few sightings of the meteor have been reported to date. Of the European radio operators providing data, only Werfried Kuneth and Robert White were operating their systems at the time, and neither reported anything unusual.

The chief event of October was, however, the Orionids, and most visual and radio observers were active during the shower's main phase. The radio operators had rather a disappointing time, with the shower showing up as only a quite small enhancement in echo counts overall, but coverage was very good from European and Japanese sites, so we can be reasonably confident that nothing particularly unexpected happened with the shower in 1996. Visual observations from the USA, the main gap in radio cover in these data, certainly suggest nothing untoward was recorded there either. So far, none of the radio observers has produced rates of long-echo counts, which, bearing in mind how successful these were in enabling the Japanese radio operators in particular to detect the Leonids in 1996 [5], might be worth examining for the Orionid epoch too in future years. The Orionids have similar visual characteristics to the Leonids—swift moving, sometimes bright, and often leaving persistent trains.

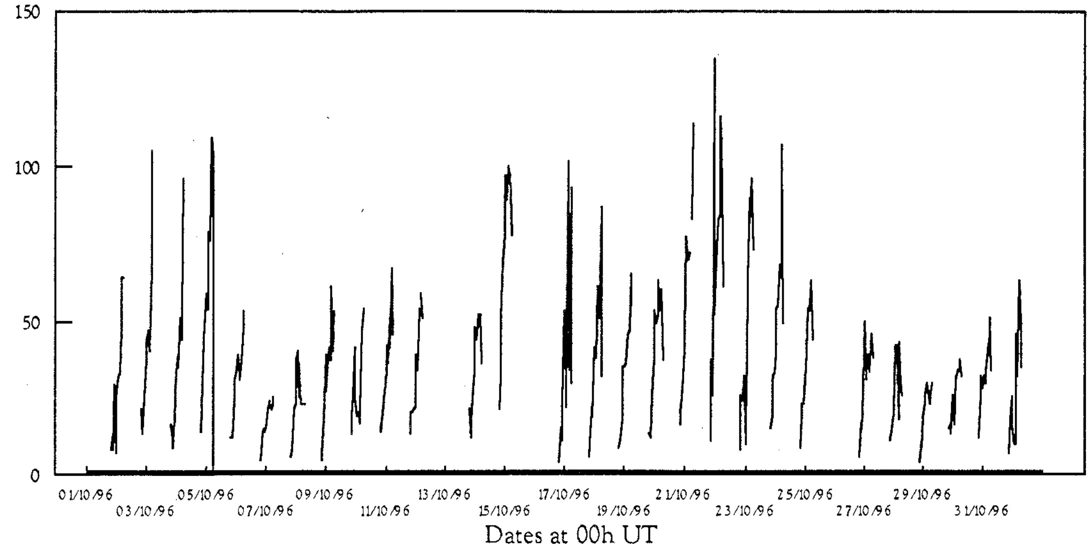

Figure 3 – Raw hourly radio meteor echo counts from October 1 to November 1, 1996, from data collected by Maurice de Meyere in [2]. The Orionids are visible as the "bulge" from October 20–25. Radio auroral problems were reported by Finnish observers on October 18-19 and 19-20, but not at times when this equipment was operational.

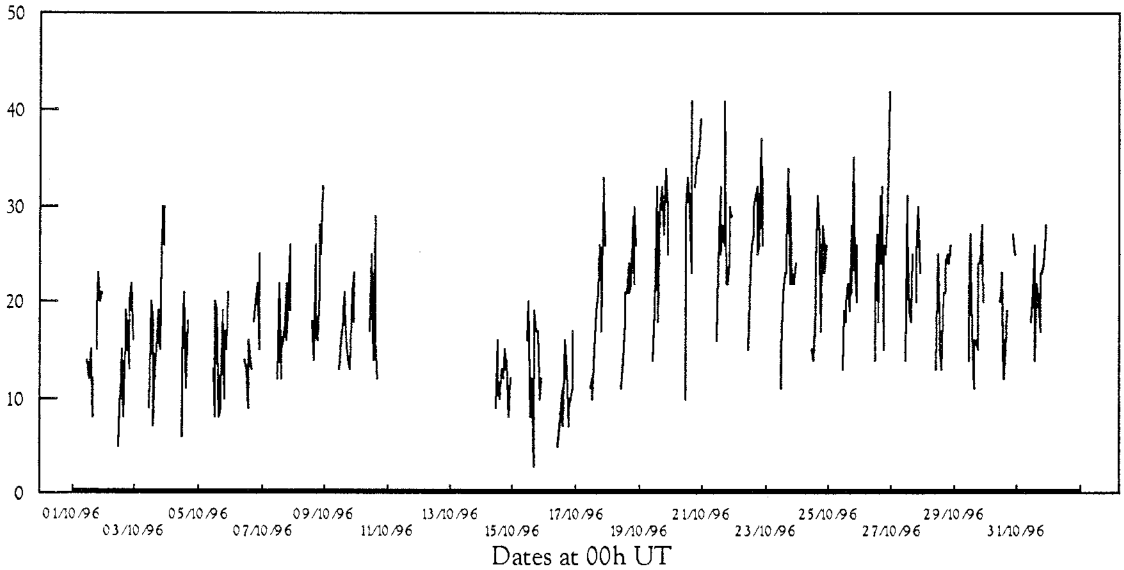

Figure 4 – Raw hourly radio meteor echo counts from October 1 to 31, 1996, from data collected by Chikara Shimoda, given in [2]. As in Figure 3, the Orionids are noted as a slight "bulge" centered on October 21 and 22, with occasional activity peaks also seen early in the month. The set-up was non-operational from October 11–13.

Radio and visual data confirms that the highest activity was detected on October 20-21 and 21-22, with visual ZHRs of the order of 30 ± 6 on both nights, as shown in Figure 5.

Although individual visual workers were generally unable to watch for more than two to three hours on a given night—with shorter watches as time progressed due to increasing moonlight problems—most watchers commented that they had been quite favorably impressed with the Orionid activity seen, though some commented that there had been a paucity of bright Orionids.

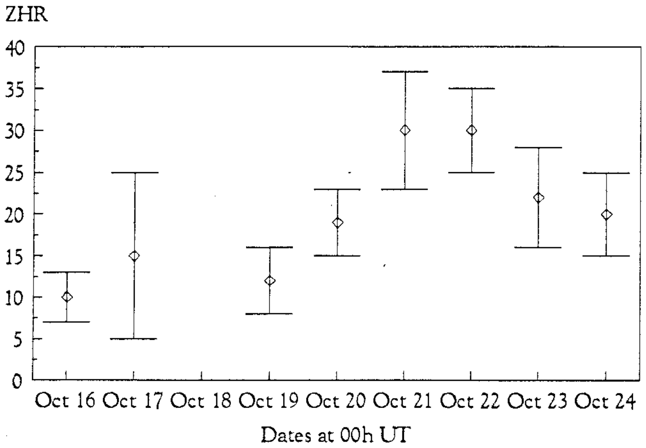

Figure 5 – Mean visual Orionid ZHRs between October 15-16 and 23-24. All results from a given date have been combined into a single daily data point, as variations were found to be quite minor. The shape and character of the graph compares surprisingly closely with the Orionid "bulge" shown in the radio data of Figures 3 and 4.

A breakdown of Orionid and October sporadic magnitudes is given in Table 2. As this table demonstrates, just one Orionid fireball was seen, a magnitude −5 blue event with a 10 s train at 0^h23^m UT on October 21, observed by Adrian Negoescu at Targoviste in Romania.

Table 3 gives a survey of the Orionid and October sporadic train details. The overall percentages are much as found for this period in previous years, though there are some differences in detail, as might be expected where the numbers of meteors dealt with are relatively small.

Towards the end of October, the radio echo count numbers began to rise again, perhaps because of increasing Taurid rates. Some of the radio data from November suggested activity was indeed generally somewhat higher around the October-November boundary, as will be discussed in a later paper.

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

Magnitude	-3^-	−2	−1	0	+1	+2	+3	+4	$+5^+$	Tot	Lm	$\overline{m}_{6.5}$
Orionids	1	7	13	28.5	58	57.5	64	38.5	12.5	280	6.02	2.44
Sporadics	1	1.5	14.5	14.5	27.5	40	57	51.5	35.5	243	5.99	3.17

Table 3 – Global train percentages and mean duration in seconds per magnitude class for the Orionids and October sporadics. Train details were only available for 113 Orionids and 178 sporadics of the reported totals.

Magnitude	-3^-	−2	−1	0	+1	+2	+3	$+4^+$	Tot	%
Train % ORI		0	100	73	66	42	21	16	44	39
Duration ORI			1.6	1.4	2.0	1.3	0.8	0.5		
Train % SPO	100	0	63	33	7	13	10	5	22	12
Duration SPO	17		1.2	1.5	0.5	1.3	0.8	0.5		

4. New sightings of moving ripples in solar haloes

In a letter dated October 24, Jürgen Rendtel detailed how, earlier that day, he had seen and photographed a series of six or seven moving ripples crossing through the right 134° parhelion of a major all-day solar halo display. This is almost certainly the first photographic record of these ripples ever made. Such ripples are extremely rare, and may be due to sound waves from meteors, as discussed in [9], but this is actually Jürgen's second sighting of them. The first was in 1988, as commented upon in [10], where two other sightings were also mentioned. His latest observations are described in detail in [11]. Jürgen also drew attention to the fact that one further sighting of these ripples has been made recently, on November 20, 1995, by Holger Seipelt, who saw six ripples cross a left 22° parhelion, again part of a much larger display, from the dramatic setting of the Grand Canyon in Arizona, USA! Full details of this sighting can be found in [12], bringing the tally of ripple observations to nine in just over 50 years. Any further such sightings should be reported to the author or Jürgen Rendtel immediately.

5. Conclusion

It is good to find more radio work being made and submitted for analysis, since this is an area which promises particularly interesting findings, while setting its own unique challenges. At the same time, other techniques are also essential to ensure we continue to build up a more complete picture of the meteoroid flux encountered by the Earth. The complementary nature of radio and visual work has been especially highlighted here during the Orionids, and no observer should feel that their data have not contributed, since all results, no matter how short the watch, are of potentially inestimable value. Clear skies!

References

[1] C. Steyaert, *Radio Meteor Observation Bulletin* 38, October 1996.

[2] C. Steyaert, *Radio Meteor Observation Bulletin* 39, November 1996.

[3] C. Steyaert, *Radio Meteor Observation Bulletin* 41, January 1997.

[4] R.S. White, A. McBeath, "An Automatic System for Monitoring Forward Scatter Radio Signals", in *Proceedings 1996 IMC*, A. Knöfel, P. Roggemans, eds., IMO, 1997, pp. 133–138.

[5] A. McBeath, "SPA Meteor Section Preliminary Radio Results: 1996 Leonids", *WGN* 25:1, February 1997, pp. 45–53.

[6] G.W. Kronk, "A September Radiant in the Aries-Triangulum Region?", *WGN* 21:6, December 1993, pp. 261–263.

[7] M.J. Currie, "The September α-Triangulid Shower: Recent Telescopic Results", *WGN* 22:6, December 1994, pp. 220–223.

[8] D. Artoos, "Possible Radio Activity in September 1990", *WGN* 18:3, June 1990, pp.101–102.

[9] G.H. Archenhold, "Moving ripples in solar haloes: are they caused by sound waves from meteors?", *Quarterly Journal of the Royal Astronomical Society* 25, 1984, pp. 122–125.

[10] A. McBeath, "Moving Ripples in Solar Haloes—Update", *WGN* 22:4, August 1994, pp. 134-136.

[11] J. Rendtel, "Halophönomen und 'Moving Ripples"', *Mitteilungen des Arbeitskreises Meteore* 21, 1996, pp. 181–182.

[12] H. Seipelt, "USA-Südwest—Ein atmosphärischer Reisebericht", *Mitteilungen des Arbeitskreises Meteore* 21, 1996, pp. 33–35.

The 1996 Geminid Maximum in Bulgaria

Valentin Velkov

Impressions are given of the 1996 Geminid maximum as observed by members of *Astroclub Canopus* in Avren Village, Bulgaria.

Participants of our Geminid expedition in 1996 were Dilyana Porozhanova, Galin Genchev, Hristo Kemanadjiev, Ivan Gradinarov, Lina Rashkova, Plamen Stoychev, Valentin Velkov, and Veselin Stoyanov. Our observing data from 1993 have shown that the maximum of the Geminids should occur at $\lambda_\odot = 262\overset{\circ}{.}15$ (eq. 2000.0). For 1996, this corresponded to 20^h00^m UT or 22^h00^m our local time in the night of December 13-14.

After a two-week spell of bad weather on the day of December 13 as if by magic the clouds began to break and in the evening the sky cleared up. In the early night, the observers enjoyed a dark sky and the Milky Way crossing the Summer Triangle above the western horizon. The meteor watch started at 18^h30^m UT. The shower activity was not very high at first, but, in contrast to previous years, the unusually great number of bright meteors was impressing. This concerns especially the interval between 19^h30^m and 21^h15^m. At 21^h20^m, the sky conditions suddenly worsened. The limiting magnitude dropped to 5.1. This did not affect too much the observed hourly rates, however, and for the interval 21^h20^m–22^h00^m UT the calculated ZHRs reach values up to 345. At local midnight (22^h00^m UT), clouds prevented us from further observing.

Table 1 – Geminid ZHRs on December 13-14, 1996, from Avren Village, Bulgaria. The ZHRs are calculated with population index $r = 2.41$ determined from our data. For this purpose, we used the magnitude classes from −5 to +1 of the collective magnitude distribution of the meteors seen by all participants in the expedition.

Period (UT)	Obs	F	Lm	$T_{\rm eff}$	Gem	ZHR	$z_{\rm rad}$
18^h30^m–18^h45^m	STOPL	1.00	6.4	$0^h.25$	7	70	64°
	VELVA	1.00	6.2	$0^h.25$	8	96	
18^h45^m–19^h00^m	STOPL	1.00	6.4	$0^h.25$	12	110	62°
	VELVA	1.00	6.2	$0^h.25$	8	88	
19^h00^m–19^h15^m	STOPL	1.00	6.4	$0^h.25$	18	153	59°
19^h15^m–19^h30^m	STOPL	1.00	6.4	$0^h.25$	17	134	56°
	VELVA	1.00	6.2	$0^h.17$	5	71	
19^h30^m–19^h45^m	STOPL	1.00	6.4	$0^h.25$	23	170	54°
	VELVA	1.00	6.2	$0^h.25$	21	185	
19^h45^m–20^h00^m	STOPL	1.00	6.4	$0^h.25$	26	181	51°
	VELVA	1.00	6.2	$0^h.25$	21	174	
20^h00^m–20^h15^m	STOPL	1.00	6.4	$0^h.25$	22	145	48°
	VELVA	1.00	6.2	$0^h.25$	22	172	
20^h15^m–20^h30^m	STOPL	1.00	6.4	$0^h.25$	27	169	46°
	VELVA	1.00	6.2	$0^h.25$	20	149	
20^h30^m–20^h45^m	STOPL	1.00	6.4	$0^h.25$	22	131	43°
	VELVA	1.00	6.2	$0^h.25$	21	149	
20^h45^m–21^h00^m	STOPL	1.00	6.3	$0^h.25$	10	62	40°
	VELVA	1.00	6.2	$0^h.25$	16	109	
21^h00^m–21^h15^m	STOPL	1.00	6.2	$0^h.25$	31	186	38°
21^h15^m–21^h30^m	STOPL	1.00	6.1	$0^h.25$	19	120	35°
	VELVA	1.00	5.3	$0^h.25$	20	280	
21^h30^m–21^h45^m	VELVA	1.00	5.1	$0^h.25$	17	275	32°
21^h45^m–22^h00^m	VELVA	1.00	5.1	$0^h.25$	22	345	29°
00^h00^m–00^h15^m	VELVA	1.00	6.1	$0^h.17$	14	121	10°
00^h15^m–00^h30^m	VELVA	1.00	6.1	$0^h.17$	17	148	10°
00^h30^m–00^h45^m	VELVA	1.00	6.1	$0^h.25$	21	122	12°
02^h00^m–02^h15^m	VELVA	1.00	6.3	$0^h.25$	34	179	25°
02^h15^m–02^h30^m	VELVA	1.00	6.3	$0^h.25$	30	162	28°
02^h30^m–02^h45^m	VELVA	1.00	6.3	$0^h.25$	18	100	31°
02^h45^m–03^h00^m	VELVA	1.00	6.3	$0^h.25$	29	165	33°
03^h00^m–03^h15^m	VELVA	1.00	6.1	$0^h.25$	15	105	36°
03^h15^m–03^h30^m	VELVA	1.00	6.1	$0^h.25$	24	175	39°
03^h30^m–03^h45^m	VELVA	1.00	6.1	$0^h.25$	28	212	42°

After a good supper, one of the most experienced observers (Plamen Stoychev) unfortunately fell asleep in expectation of better conditions and did not wake up till the morning. At 0^h UT, it cleared up, and we began to observe again, but soon after that two more observers dropped out. Around 1^h UT, fatigue defeated me also, and, at 1^h30^m UT, the last of the experienced observers (Dilyana Porozhanova) fell asleep as well. Only one person went on watching: the student Ivan Gradinarov. At 1^h50^m, I woke up. I was surprised by by the still high shower activity. I continued my watch till 3^h45^m UT. Although there were no more bright meteors, the number of Geminids remained high. Series of 3–4 simultaneously appearing meteors were followed by about one-minute "calms." At dawn, although the radiant began to go down toward the horizon and the predicted moment of the maximum had been already passed long time ago, the number of bright Geminids increased again. Between 3^h45^m and 4^h05^m UT, we saw two meteors of magnitude −3.5. The second of them appeared at about 10° from Venus and had the same brightness as the planet. If reduced for zenith distance, its magnitude would be −7.3. The show ended with a daytime fireball resembling a signal rocket, which was seen by one of the young observers (Veselin Stoyanov) around 5^h–5^h15^m UT, when we were leaving the observing site.

Based on the obtained ZHR values for the consecutive time intervals, the only conclusion we can make is that no systematic trend in the ZHR variations can be seen. We ignore the unrealistically high ZHRs calculated for the time interval 21^h30^m–22^h00^m UT when too high correction factors ensuing from the bad limiting magnitudes were applied. Remarkable is the increase of the shower activity towards dawn observed at very good sky conditions, with quite a high number of bright meteors. It is possible that a secondary maximum occurred or that the maximum shifted compared with previous years.

High Activity of the 1996 Geminids in Spain

Josep M. Trigo

An overview of the 1996 Geminid observations of the author is given.

The observations have been made by Josep M. Trigo-Rodriguez (*SOMYCE*, *IMO*) from Benicássim ($\lambda = 0°$, $\varphi = +40°$, near Castelló) on December 13. The activity was high. Clouds prevented observations during the second half of the night. For the same reasons, it was not possible to observe on other nights.

Table 1 – The author's Geminid observations on December 13. All data were obtained using the counting method.

Period (UT)	T_{eff}	Field center	Lm	F	Gem	χ – Ori	Spor
21^h08^m–21^h38^m	$0^h\!.48$	$\alpha = 15°$, $\delta = +30°$	5.60	1.11	12	0	0
21^h38^m–22^h00^m	$0^h\!.35$	$\alpha = 30°$, $\delta = +15°$	5.80	1.11	11	0	0
22^h00^m–22^h05^m	$0^h\!.08$	$\alpha = 60°$, $\delta = +15°$	6.10	1.05	5	0	1
22^h05^m–22^h10^m	$0^h\!.08$	$\alpha = 60°$, $\delta = +15°$	6.15	1.00	3	0	0
22^h10^m–22^h15^m	$0^h\!.08$	$\alpha = 60°$, $\delta = +15°$	6.20	1.00	5	0	1
22^h15^m–22^h20^m	$0^h\!.08$	$\alpha = 60°$, $\delta = +15°$	6.20	1.00	6	0	0
22^h20^m–22^h25^m	$0^h\!.08$	$\alpha = 60°$, $\delta = +15°$	6.20	1.05	5	0	0
22^h25^m–22^h30^m	$0^h\!.08$	$\alpha = 60°$, $\delta = +15°$	6.10	1.05	8	1	0
22^h30^m–22^h35^m	$0^h\!.08$	$\alpha = 60°$, $\delta = +15°$	6.00	1.11	11	0	1
22^h35^m–22^h40^m	$0^h\!.08$	$\alpha = 75°$, $\delta =$ 00°	5.80	1.17	5	0	1
22^h40^m–22^h45^m	$0^h\!.08$	$\alpha = 75°$, $\delta =$ 00°	5.60	1.53	2	0	1

Table 2 – Magnitude distribution of the observed Geminids. The average magnitude of the sporadic meteors seen was +3.3.

Magnitude	−2	−1	0	+1	+2	+3	+4	+5	Trained
Geminids	4	3	3	6	15	27.5	12.5	2	2

BAA Observations of the 1996 Geminids: A Preliminary Report

Neil Bone

An overview is given of *BAA* observations of the 1996 Geminids.

Meteor observers in the British Isles suffered another poor autumn in 1996, with few clear nights. The redeeming exception, for those in the south, was on Geminid maximum (Friday, December 13-14), when a cold front clearing from the north brought fine conditions to most locations by mid-evening. Observers in the northern UK enjoyed their best conditions during the Geminids on December 12-13. This preliminary report covers observations received up to mid-January 1997.

In all, the 51 individual observers and two groups listed below contributed some 103^h38^m of watch time, amounting to 3703 meteors (430 sporadics, 3253 Geminids, and 20 others). The majority of results were obtained on December 13-14. The following observers contributed:

J. Abbott, S. Beaumont, D. Beesley, H. Bennett, J. Bingham, N. Bone, G. Boots, R. Bowen, C. Bradley, S. Evans, R. Fails, M. Flowers, H. Ford, R. Gillingwater, P. Girard, M. Green, R. Grover, C. Hall, T. Hopwood, M. Houston, J. Hubble, R. Johnson, G. Johnstone, G. Jones, N. Kiernan, J. Lang, A. McBeath, T. McEwan, A. McEwan, T. Markham, N. Martin, B. Mizon, P. Mollinari, N. Morrison, C. Newman, B. O'Halloran (Ireland), G. Oksa, J. Olesen (Denmark), J. Owen, G. Parsley, N. Quinn, J. Rogers, R. Schmude (USA), G. Spalding, C. Steele, D. Storey, M. Taylor, P. Thomsett, J. Tipping, A. Vincent, P. Yates, Macclesfield AS, Worthing AS.

As previously [1,2], the results have been analyzed in hourly bins to yield sky- and radiant altitude-corrected Zenithal Hourly Rates. Population index $r = 2.44$ was used for Geminids, $r = 3.42$ for sporadics. The derived values for sporadic corrected rates and Geminid ZHRs are presented in Table 1.

On the basis of previous years' results [3–5], Geminid maximum was expected to occur around $\lambda_\odot = 262\overset{\circ}{.}0$—$16^h$ UT on the afternoon of December 13 [6].

Table 1 – Geminid data from members of the *BAA* in December 1996. The columns list the date in December 1996, the time (UT), the solar longitude ($\lambda_\odot$), the observing time ($T_{\rm eff}$), the limiting magnitude (Lm), the cloud correction factor (F), the number of sporadics (Spor) and Geminids (Gem), the CHR of the sporadics, the radiant altitude ($h_{\rm rad}$), and the ZHR of the Geminids. Values of F smaller than 1 are caused by a correction made for group observations.

Dec	Time	$\lambda_\odot$	$T_{\rm eff}$	Lm	F	Spor	Gem	CHR	$h_{\rm rad}$	ZHR
5	23^h33^m	$254\overset{\circ}{.}17$	3.00	6.00		28	3	17.3 ± 3.3	$52\overset{\circ}{.}1$	2.0 ± 1.2
12	21^h02^m	$261\overset{\circ}{.}18$	1.88	5.50	0.56	15	45	15.2 ± 3.9	$34\overset{\circ}{.}5$	57.7 ± 8.6
13	01^h25^m	$261\overset{\circ}{.}37$	1.00	5.80		5	35	13.4 ± 6.0	$65\overset{\circ}{.}2$	72.0 ± 12.2
13	02^h25^m	$261\overset{\circ}{.}41$	1.00	5.80		3	38	8.0 ± 4.6	$65\overset{\circ}{.}6$	77.9 ± 12.6
13	03^h54^m	$261\overset{\circ}{.}48$	1.00	5.80		7	36	18.7 ± 7.1	$58\overset{\circ}{.}6$	78.7 ± 13.1
13	05^h21^m	$261\overset{\circ}{.}54$	3.50	5.97	1.03	22	86	12.4 ± 2.6	$48\overset{\circ}{.}1$	54.6 ± 5.9
13	19^h16^m	$262\overset{\circ}{.}13$	3.00	5.57		13	40	13.6 ± 3.8	$19\overset{\circ}{.}9$	89.8 ± 14.2
13	20^h16^m	$262\overset{\circ}{.}17$	2.50	5.60		14	61	16.9 ± 4.5	$28\overset{\circ}{.}1$	115.6 ± 14.8
13	21^h36^m	$262\overset{\circ}{.}23$	10.21	5.35		37	212	14.9 ± 2.4	$39\overset{\circ}{.}6$	90.9 ± 6.2
13	22^h43^m	$262\overset{\circ}{.}27$	9.10	5.41	0.95	38	261	15.2 ± 2.5	$49\overset{\circ}{.}9$	94.2 ± 5.8
13	23^h30^m	$262\overset{\circ}{.}31$	10.50	5.42	0.99	41	312	14.6 ± 2.3	$56\overset{\circ}{.}8$	92.1 ± 5.2
14	00^h26^m	$262\overset{\circ}{.}35$	13.36	5.46	0.93	64	569	16.0 ± 2.0	$64\overset{\circ}{.}1$	111.3 ± 4.7
14	01^h29^m	$262\overset{\circ}{.}39$	8.00	5.53	0.89	33	413	12.1 ± 2.1	$69\overset{\circ}{.}4$	116.6 ± 5.7
14	02^h31^m	$262\overset{\circ}{.}43$	6.67	5.51	1.06	25	177	13.4 ± 2.7	$69\overset{\circ}{.}0$	72.9 ± 5.5
14	03^h36^m	$262\overset{\circ}{.}47$	4.52	5.32	0.92	19	201	16.5 ± 3.8	$62\overset{\circ}{.}9$	131.7 ± 9.3

It is of interest to note Geminid ZHR already approaching its usual peak value in the early-morning hours of December 13, as indicated by reports from Scotland and the north of England.

Observations of 1993 [5] showed a long "tail" of high activity in the Geminids, extending past the expected $\lambda_{\odot} = 262^{\circ}.0$ peak. This was again found in 1996; Geminid ZHR remained close to peak levels well into the early morning hours of December 14, 1996, some 12 hours (approximately $0^{\circ}.5$ of solar longitude) after the expected maximum.

This activity contrasts with the sharper Geminid maxima reported in, for example, 1980 [7], perhaps reflecting a change in the character of Geminid activity over the past couple of decades. It may be of interest to more closely examine extensive un-analyzed data in the *BAA Meteor Section* archives from the 1980s to see whether any putative systematic change in the Geminids' activity can be followed over time.

Bright events were numerous on December 13-14. Overall, the Geminids showed a mean magnitude of +1.60 ($N = 2689$), compared with +2.52 ($N = 379$) for sporadics. Several noteworthy fireballs were reported on maximum night, including events at 23^h58^m, 00^h10^m, 01^h38^m, 02^h18^m, and 03^h42^m UT.

Few Geminids showed persistent trains (105/2123=4.9%). It is notable, however, that a lower-than-usual frequency of sporadic trains (15/379=4.0%) was also reported.

Photographically, the Geminids proved very rewarding, and many trails suitable for accurate positional measurement were recorded. Analysis of these is in progress by Steve Evans, with the aim of adding the 1996 data to the *BAA Meteor Section*'s long-term analysis of the Geminid radiant's structure and motion since the 1950s [8].

Activity around the peak of the 1996 return reaffirmed the Geminids' reputation as the year's most consistently productive shower. Those fortunate to have clear skies on December 13-14 logged large numbers of meteors—one group of four observers in the English Midlands logged almost 700 meteors in 5.5 hours!

Acknowledgments

Thanks are, as always, expressed to all who contributed observations.

References

[1] N. Bone, "BAA Observations of the 1993 Geminids—A Preliminary Report", *WGN* 22:2, April 1994, pp. 77–79.

[2] N. Bone, "Preliminary Report on BAA Observations of the 1994 Geminids", *WGN* 23:2, April 1995, pp. 67–68.

[3] S.J. Evans, N.M. Bone, "Visual and Photographic Observations of the Geminid Meteor Shower in 1990", *J. Br. Astron. Assoc.* 103:2, 1993, pp. 19–26.

[4] S.J. Evans, N.M. Bone, "Visual and Photographic Observations of the Geminid Meteor Shower in 1991", *J. Br. Astron. Assoc.* 103:6, 1993, pp. 300–304.

[5] S.J. Evans, N.M. Bone, "Visual and Photographic Observations of the Geminid Meteor Shower in 1993", *J. Br. Astron. Assoc.* 106:5, 1996, pp. 253–256.

[6] *BAA Handbook*, 1996.

[7] G.H. Spalding, "The Geminid Meteor Stream in 1980", *J. Br. Astron. Assoc* 92:5, 1982, pp. 227–233.

[8] S.J. Evans, "An Evaluation of the Geminid Meteor Stream Radiant from Photographic Observations", *J. Br. Astron. Assoc.* 107:1, 1997, pp. 34–35.

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