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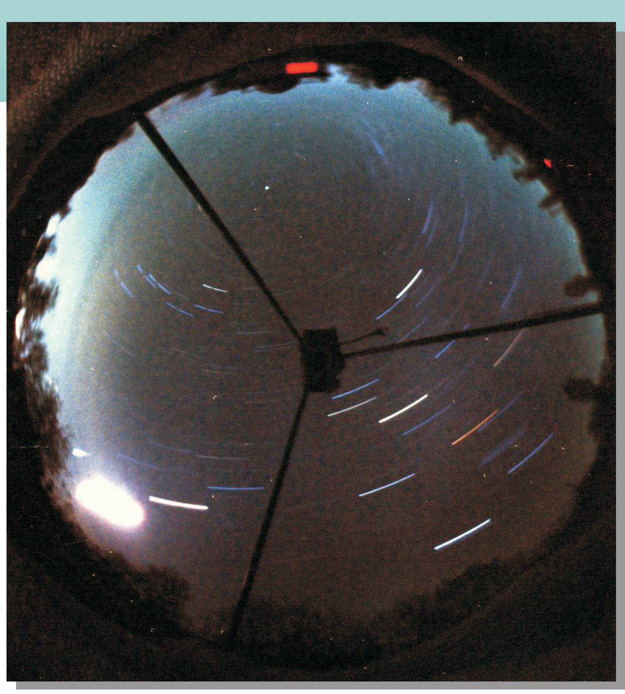

Lyrids
IMC 2005
Southern showers
CCD observations

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WGN Vol. 33, No. 3, June 2005, pp. 67 – 92

Administrative

Conferences

Lyrids

Ongoing meteor work

History

Front cover photo

An all-sky photograph taken with a fireball camera. The camera, mounted on a tripod, looks down at a convex mirror and sees the entire sky reflected. The camera is reflected in the centre of the shot; the tripod legs can be seen and, to the right, the shutter release.
The bright oval on the lower left is the Moon. A bolide, a 2003 Leonid, is just visible slightly above it. Photograph by Valentin Velkov.

Writing for WGN This Journal welcomes papers submitted for publication. All papers are reviewed for scientific content, and edited for English and style. Instructions for authors can be found in WGN **31:4**, 124–128, and at http://www.imo.net/articles/writingforwgn.pdf .

Cover design Rainer Arlt

Editorial — LaTeX citations in WGN papers

Chris Trayner

WGN is edited in a text processing format called LaTeX, and many authors write their papers in this. Other people use other forms, such as Microsoft Word, and we translate these into LaTeX. For those who use LaTeX, we can now offer a simpler way of referring to other work in the papers you write. For the moment this scheme only applies to references to WGN articles.

Referring to a paper involves two things: the Citation in the text and the Reference at the end. If I want to refer to Rainer Arlt's table of Solar Longitudes in the last WGN, for instance, I call it (Arlt, 2005): this is the Citation. If you look at the end of this Editorial, you will see the details listed: this is the Reference.

When writing a paper conventionally, you must type both of these into your paper. To take the Reference first, in LaTeX you would type something like

```
\bibitem{ArltSolong}
        Arlt, R. (2005) ``Solar longitudes for 2005'',
        WGN, \textbf{33:2}, 33--34.
```

The formatting (double quotes round the title, volume and issue in bold face) has to conform to the conventions of the Journal being written for, here WGN. The identifier in curly brackets (`ArltSolong` in this example) is one you choose yourself. The References are all typed in this form at the end of your paper.

Citations in the text can be entered manually, as `(Arlt, 2005)`, or they can be entered as `\cite{ArltSolong}`, where the identifier in curly brackets is the one you chose for the `\bibitem`. This will automatically be translated into `(Arlt, 2005)`, or whatever the correct Citation is.

There is a further refinement of this, called BibTeX, where you keep all your References in a database rather than typing them for every paper you write. With BibTeX, you just use the Citations plus a couple of lines at the end of your paper to access your database. These lines include a specification of the format required by the Journal you are writing for, and everything is formatted automatically. WGN uses its own format, but if you use `\bibliographystyle{apalike}` you will get something very close; the Editors will correct it.

This much is conventional, and further details can be found in standard LaTeX textbooks such as (Lamport, 1986; Goossens et al., 1994).

When I edit WGN, I find that a high proportion of references are to papers in earlier issues of WGN. When you write your paper, you have to enter all these References by hand at the end of your paper. When I edit your paper, I have to re-format them all; I use BibTeX to format all References in WGN. We are now introducing a scheme to save us both the effort.

It is now possible to refer to WGN papers by merely providing the Citation in the text, without providing the Reference at the end. The Citation must be in the `\cite{}` form, not entered explicitly as `(Name, Date)`. The Reference will be added automatically by the WGN Editorial staff, using a database of all WGN papers. Initially this database will only exist for this issue and future ones; later it will be extended to previous WGNs. It is also hoped to add IMC Proceedings and IMO publications such as the Handbook for Visual Meteor Observers.

All this requires the author to know what indentifier to put inside the `\cite{}`, as this must match the one in our database. Starting with this issue, WGN is printing these identifiers with each paper. We are calling these IMO bibcodes, in line with the name bibcode that NASA-ADS (the Astrophysical Database Service, http://adswww.harvard.edu/) uses. Henceforth you will see this printed at the bottom of the first page of every WGN paper. If you wished to refer to this Editorial, for instance, you could just enter `\cite{WGN-333-editorial}` and the rest would be automatic. If you look at the IMO bibcodes in this issue, you will realise that most of them have a simple format: WGN-<Volume><Issue>-<Author>-<Title>, where <Author> is the first author (if more than one), and <Title> is an abbreviation, all in lower case. There are a few exceptions, such as the Editorial with no author given.

Multiple citations can be combined as `\cite{WGN-333-shamir-ccd,WGN-333-mularczyk-lyrids}` to refer to these two papers from the present issue. Sometimes you want to refer to the author as a person, with just the year in brackets, as in "Einstein (1905) showed that …". This can be achieved with `\citeyear{}`, which acts like `\cite{}` but only places the year: `Einstein \citeyear{Einstein1905} showed that ...` The useful forms are listed below with, under them, the results of using them for (Arlt, 2005).

`\cite{}`	`\citeNP{}`	`\citeyear{}`	`\citeyearNP{}`
(Arlt, 2005)	Arlt, 2005	(2005)	2005

If all else fails, you can enter your Citations by hand and use the `\nocite{}` command. This acts like `\cite{}` but places no Citation; it merely causes the Reference(s) to be added at the end. For instance, if you wanted

IMO bibcode WGN-333-editorial

to say that "Rainer Arlt (1997–2005) has been publishing tables of Solar Longitude for the past nine years", you could enter this as `Rainer Arlt (1997-2005) \nocite{WGN-251-arlt-solong, ... WGN-332-arlt-solong} has been publishing ...` (with all nine bibcodes in the `\nocite{}`, of course). The Citation would appear as above, and all nine References would appear at the end of your paper.

For present and future WGN papers, the IMO bibcode can be found on the paper itself. For earlier ones, of course, it was not printed. Note that it is not possible to guess at the bibcode. In due course we will introduce an on-line index which allows you to look these up. We will announce more about this, and other new on-line IMO services, in future issues of WGN.

References without IMO bibcodes must be provided conventionally, either with `\bibitem`s or by providing us with a `.bib` file (which is perfectly acceptable).

Using this system should save save time for both authors and the editorial team. If you have any queries, you can email me at `wgn@imo.net`; as always, remember to include the word 'meteor' in the subject line to get past our anti-spam filters.

References

Arlt R. (2005). "Solar longitudes for 2005". *WGN* **33:2**, 33–34.

Goossens M., Mittelbach F., and Samarin A. (1994). *The LaTeX Companion.* Addison-Wesley, Reading, Massachusetts.

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Call for Candidates for the IMO Council 2006–2009

The IMO Council

The IMO exists through the voluntary work of the IMO Council. A large Council allows the workload to be spread out so that no one member is overburdened. Therefore we encourage members seriously interested in meteor science to join the IMO Council. The only condition to be a candidate for Council membership is that you must be a Voting Member. The positions of President, Vice-President and Treasurer come up for election this year. There are also positions of General Council Member available for other people who want to get involved.

Candidates should have considerable experience and knowledge in the specific field of meteor astronomy, be capable of organizing themselves and others, and should point out which special fields of meteor work they wish to develop and improve.

To submit your candidacy, simply send a short curriculum vitae of your astronomical work and the position (President, Vice-President, Treasurer or General Council Member) of interest to you. These may be sent to the Secretary-General Robert Lunsford by email at `lunro.imo.usa@cox.net` or by regular mail to 161 Vance Street, Chula Vista, CA 91910-4828, USA. The Secretary-General is also available to answer questions concerning specific tasks of each position. Submissions must be received by 2005 August 31. Applicants will be reviewed at the 2005 International Meteor Conference and successful applicants will be placed on the ballot in the first available issue of WGN following the conference.

As well as members of the Council there are Commissioners, who deal with specific areas of interest. The current Commissions are the FIreball DAta Center (FIDAC), Photographic Commission, Telescopic Commission, Video Commission and Visual Commission. If you feel you have a contribution to make in one of these fields, please contact the Secretary-General. For instance, the Radio Commission has been vacant for many years and needs someone to resurrect and popularize this valuable observing method. There is no election for Commissioners — they are selected by the Council.

IMO bibcode WGN-333-imo-elections

Conferences

International Meteor Conference 2005 September 15–18, Oostmalle, Belgium

The IMC 2005 Committee

The first time

For the first time since the foundation of IMO, the International Meteor Conference will be held in Belgium, on September 15–18, 2005. Oostmalle is a Belgian village located 30 km northeast of the beautiful city of Antwerp, second largest city of Belgium, fourth largest port in the world, and the world capital of diamonds. Urania, the Public Observatory of Antwerp, has maintained regular contacts with IMO since 1988. Actually, Urania is IMO's official seat, and its meteor section is very proud to organize this IMC.

Go Belgian

The conference center 'Provinciaal Vormingscentrum' lies in a green area, and offers accommodation for 100 people or more (rooms for 1 to 6 persons). There is one big lecture hall and some smaller well-equipped rooms with Internet access. The evenings can be spent in the two cosy bars we have at our disposal. Beer lovers can taste a selection of the finest Belgian beers there.

The weather

The temperature is typically around 15–20 degrees Celsius (60-70 degrees Fahrenheit) in September.

Currency

The official currency in Belgium is the Euro. Foreign currency can be exchanged in banks and exchange offices.

Guest Lecture: 'The Impact of Impacts'

On Friday September 16 at 16^{h}, Prof. Dr. Philippe Claeys (Vrije Universiteit Brussel) will talk about 'The Impact of Impacts'. Professor Claeys is a geologist whose active research interests include the bio-geo-evolution of the Earth, global changes, rapid climatic changes and mass extinction events, effects of asteroid and comet impacts on the global Earth system, isotope geochemistry, stratigraphy/geochronology, sedimentology and sedimentary petrography, and planetary science. He is currently involved in some exciting research on the Chicxulub crater (Yucata'n, Mexico). See `http://we.vub.ac.be/~dglg/Web/Claeys/Claeys.htm`.

The excursion

A traditional part of the program is the excursion, which will lead us to the nice and small characteristic city of Lier, famous for its beguinage and the 'Zimmertoren'. Even Albert Einstein was impressed by this old tower in which Louis Zimmer built a whole range of high-quality astronomical clocks in the 1930s.

Participation fee

If you wish to register, please fill out the registration form on the next page or register online at the IMC 2005 website (see below). The participation fee for the IMC 2005 is €120 for people who register before July 1st and €130 for those who register later. This fee includes lodging, meals, excursion and the Proceedings. Either a prepayment of €60 or the total amount should be sent to IMO treasurer Ina Rendtel (details inside back cover and IMC 2005 website).

Visas and invitations

We will gladly send official invitations to people who need these to get a visa, provided that they inform us about this in due time. You can find out on the IMC website whether visa are required for citizens of your country.

IMO bibcode WGN-333-imc-advert

Radio meteor school 2005

We proudly present the 'Radio Meteor School 2005', a five-day tutorial (Oostmalle, September 10 till 14) in which Prof. Dr. Oleg Belkovich, Russian eminence grise in meteor astronomy, will lecture on the physical and mathematical theory of radio meteor observations. We stress the fact that this is not an easy course, and it will be helpful only to devoted radio observers highly skilled in mathematics and willing to get the utmost data out of their observations. For these people, it is very worthwhile to arrive in Belgium five days before the IMC to participate in the Radio Meteor School. The additional price will be around €150, and should only be paid upon arrival. However, you must register for this school before July 1st. Contact the organizers in order to register.

Contact information

For more information, check the IMC 2005 website at http://www.imo.net/imc2005 or contact the organizers by e-mail at imc2005@imo.net. You can also write to us: IMC 2005 — Jan Verbert, Public Observatory Urania, Jozef Mattheessensstraat 60, B-2540 Hove, Belgium.

Financial Support to Participants of the IMC 2005

As last year, *IMO* is making funds available to support attendance at the *IMC* 2005, but the deadline for applications has now passed. Those who have applied will be informed of the result in due course.

International Meteor Conference Oostmalle, Belgium, September 15–18, 2005
Registration form

Each individual participant should fill out a form and return it to IMC 2005 — Jan Verbert, Public Observatory Urania, Jozef Mattheessensstraat 60, B-2540 Hove, Belgium, as soon as possible. Your registration will be guaranteed only after Ina Rendtel has received the minimum pre-payment of €60. 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: ______________________ Date of birth (YYYY-MM-DD): __________

Address: ______________________

____

____

Phone: __________ Fax: __________ E-mail: __________

- I wish to register for the IMC 2005 from September 15 to 18.
- I intend to participate, cannot yet register, but wish to stay on the mailing list.
- I intend to travel by ______, together with ______________________
- I need travel information from __________ to Oostmalle.
- I wish to stay in Belgium before and/or after the IMC and would like additional information.
- Vegetarian.

T-shirt: Size (S-M-L-XL): ______ Gender: ______

For participants wishing to contribute to the program:
Lecture: ______________________ Duration: ______ minutes

Workshop or discussion: ______________________

Poster presentation: ______________________ Space: ______ m^2

Required equipment: ______________________

Comments:

Either the entire fee of €120 or a pre-payment of €60 should be sent to IMO treasurer Ina Rendtel. Follow the payment instructions inside the back cover or on the IMC 2005 website `http://wwww.imo.net/imc2005` . Participants making a pre-payment only have to pay the remaining €60 in cash upon arrival in Oostmalle. The registration fee increases to €130 for participants registering after July 1st.

The following payment options are available.

- **International bank transfer** payments should be made to Ina Rendtel, Mehlbeerenweg 5, D-14469 Potsdam, Germany, BIC bank code: PBNKDEFF, IBAN code: DE86 1001 0010 0547 2341 07. When paying, always state BIC bank code and IBAN code together. Always contact your local bank to verify charges for international transfers.
- **German postal giro** Pay in euros to the German postal giro account 547234-107 of Ina Rendtel, Postbank Berlin. Bank code 100 100 10. The bank code and 'Postbank Berlin' should be mentioned together with account number.

Lyrids

2004 Lyrids in CMW's visual observations

Krzysztof Mularczyk [1]

The results of the Polish Comets and Meteors Workshop (CMW) visual observations of the 2004 Lyrids are presented. Observations show that the maximum started near $\lambda_\odot = 32.^\circ05$. Combined CMW and IMO data show a clear maximum at $\lambda_\odot = 32.^\circ16$. It is possible that a minimum appeared between $\lambda_\odot = 32.^\circ0$ and $32.^\circ1$.

Received 2005 May 8

1 Introduction

The Lyrids are active between 16 and 25 April. Dubietis & Arlt (2001) show that the Lyrid maximum occurs from $\lambda_\odot = 32.^\circ0$–$32.^\circ45$.

The preliminary results of the 2004 Lyrids were presented by Rainer Arlt (2004). Unfortunately, the analysed data did not cover the whole maximum and did not contain observations before $\lambda_\odot = 32.^\circ16$. Presumably, the main peak occurred near $\lambda_\odot = 32.^\circ16$ (00^h00^m UT, April 22) with ZHR=21±3.

2 Observations

The analysis includes observations from the period 2004 April 14/15–26/27 (Table 1). The effective time was 86.66 hours. In all, 94 Lyrids and 586 other meteors were found.

3 Analysis of activity

The analysis of activity was made using the ComZHR program (Olech & Jurek, 2003). The ZHR profile was calculated by the standard procedure (e.g. Dubietis & Arlt, 2003):

$$\mathrm{ZHR} = \frac{NFr^{6.5-\mathrm{lm}}}{T_{\mathrm{eff}}(\sin h)^\gamma}\,, \qquad \Delta\mathrm{ZHR} = \frac{\mathrm{ZHR}}{\sqrt{1+N}}$$

where T_{eff} is the effective observing time, lm and F are the limiting magnitude and cloudiness coefficient, N – the number of meteors, r – the population index ($r = 2.1$ (Arlt, 2004)), h – the radiant height and γ – the zenith exponent, here set to 1. The results are presented in Figure 1. The right panel shows observations around the maximum. The point at $\lambda_\odot \approx 32^\circ$ and ZHR≈ 5 on the left panel is the average of the cluster of observations from $\lambda_\odot \simeq 31.^\circ9$ to $32.^\circ1$, i.e. all except the rightmost point at $\lambda_\odot \approx 32.^\circ13$, ZHR$\approx$14, which also appears on the left panel.

The Polish data are not sufficient to define the maximum of the peak. The reason is insufficient observations during the maximum and too wide a period applied (about one hour). However, we can see the activity profile before and after the maximum. At the beginning it is almost flat. The profile after the maximum was exponential in (Dubietis & Arlt, 2003). Our data only show a decrease. A minimum with ZHR~ 3 is shown in the right panel.

Neither the Polish nor the IMO's observations cover all the activity period, so we decided to combine them. The result is shown in Figure 2.

The combined data show a clear profile with a maximum at $\lambda_\odot = 32.^\circ16$. The main peak reached ZHR $= 21 \pm 3$. This agrees with (Arlt, 2004). We do not have observations from the period $\lambda_\odot = 31.^\circ3$–$31.^\circ9$ and we cannot say what happened then. It is possible that another maximum appeared at that time. It is very interesting that in the Polish observations a minimum is visible at $\lambda_\odot \approx 32.^\circ05$ before the main peak, shown in the right panel of Figure 1. The first point is the average of observations performed by three persons, the second and fourth points represented one observer and the rest of points were produced by two persons. Observers applied 1 and 0.5 hour intervals and each of them included at least two meteors. These data were produced by experienced observers so we may assume minimal errors in performed observations. However we have to consider that the observations at $\lambda_\odot = 31.^\circ99$ were made when the Lyrid radiant was only 20° above the horizon. This can introduce large errors in observations and in the computed ZHR.

4 Conclusion

Thanks to CMW's and IMO's data we got a clear profile of the 2004 Lyrids. The maximum at $\lambda_\odot = 32.^\circ16$ reached ZHR=21±3. Polish observations show a minimum in Lyrid activity at $\lambda_\odot \approx 32.^\circ05$. The data also show another maximum before the main peak, but we had too few observations to say what exactly had happened then.

Acknowledgments

I would like to thank to all the observers who send us their data and Dr Arkadiusz Olech for his valuable remarks. This paper was supported by the BST grant to the Warsaw University Observatory.

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IMO bibcode WGN-333-mularczyk-lyrids

Table 1 – Lyrid observations made by members of CMW. N_{plot} - number of plotted meteors, N_{notpl} - number of un-plotted meteors, N_{Lyr} - number of Lyrids

Observer	$T_{eff}[h]$	N_{plot}	N_{notpl}	N_{Lyr}
Ewa Zegler (ZEGEW)	33.43	288	2	10
Anna Lemiecha (LEMAN)	17.50	137	11	19
Dariusz Dorosz (DORDA)	15.00	78	69	55
Przemysław Żołądek (ZOLPR)	11.16	35	0	3
Kamil Złoczewski (ZLOKA)	5.57	37	1	2
Tomasz Fajfer (FAJTO)	2.00	13	3	5
Dominika Łacheta (LACDO)	2.00	6	0	0
	86.66	594	86	94

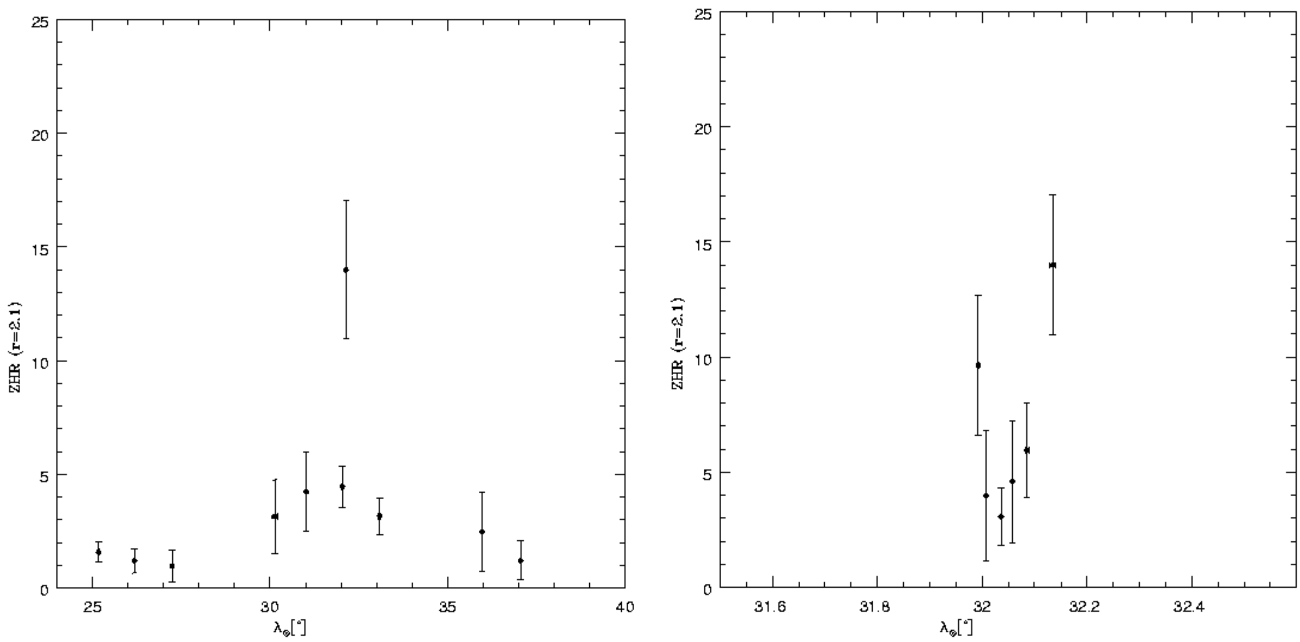

Figure 1 – Lyrids activity profile in the CMW data. Left panel – all activity. Right panel – near the maximum.

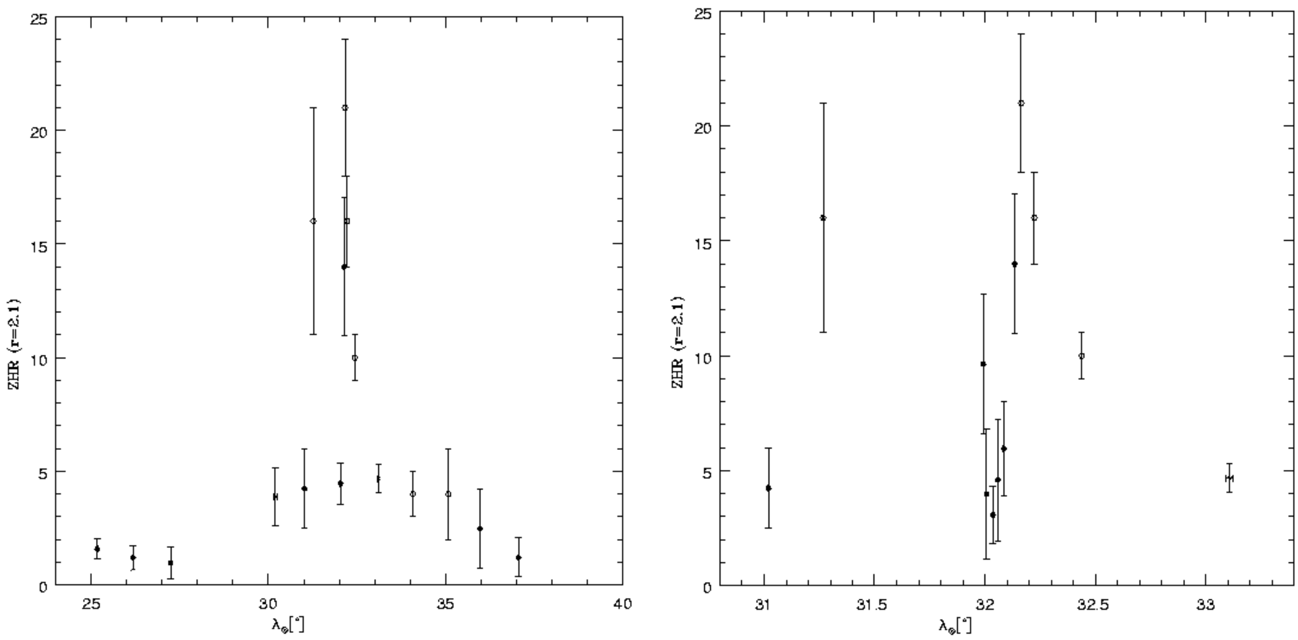

Figure 2 – Lyrids profile in CMW and IMO's data. Left panel – all activity. Right panel – near the maximum. Open circles – CMW's observations, black circles – IMO data, crosses – average of CMW and IMO's data.

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Dubietis A. and Arlt R. (2003). "The Lyrids in 2003". *WGN*, **31:3**, 97–98.

Olech A. and Jurek M. (2003). "Looking for weak meteor showers using ComZHR software". In Olech A., Złoczewski K., and Mularczyk K., editors, *Proceedings of the IMC 2002, Frombork, Poland, 26-29 Sept.*, pages 109–116. IMO, Potsdam, Germany.

Ongoing meteor work

Analysis of meteor trails using the Night Sky Live network of panoramic CCD cameras

Lior Shamir [1]

The analysis of meteor trails using a publicly accessible array of two panoramic all-sky CCD cameras is presented. Located at Mauna Kea and Haleakala, Hawaii, the array captures meteor showers as well as sporadic meteors, and provides information regarding meteor atmospheric trajectories and light curves. The system also allows light curve analysis using the FITS data and the absolute distances between specific points of interest in the trail. Data collected by the system are available to the public in real-time, and can be accessed using a simple internet browser.

Received 2005 March 31

1 Introduction

Observing meteors is commonly done using arrays of cameras (Ceplecha, 1986; Ceplecha et al., 1999). These arrays can consist of narrow-field optics allowing imaging of faint meteors, or wide-field optics that capture only the brighter meteors, but cover a larger portion of the sky.

By using two (or more) cameras located far enough from each other, a 3D analysis of the meteor trail is obtained by using parallax (Molau, 1995; Koten et al., 2004; Spurný et al., 2004). However, while meteor research is a field of scientific interest, deploying and operating on-going arrays of cameras is a logistically demanding task. In this paper, a technique of using the Night Sky Live (Nemiroff & Rafert, 1999) network for the purpose of meteor science is presented. The twin all-sky CCD cameras constantly operated at Mauna Kea and Haleakala observatories are used for obtaining altitude, absolute length and light curves of meteors. Archived and real-time data collected by the Night Sky Live network are available to the public.

In Section 2 we briefly present the Night Sky Live network, in Section 3 the analysis of meteor trails is presented, in Section 4 the estimated error is discussed and Section 5 presents the analysis of meteor light curves.

2 The Night Sky Live Network

The Night Sky Live (Nemiroff & Rafert, 1999) consists of 10 nodes called CONCAM located at some of the world's premier observatories. Each node incorporates an SBIG ST-8 or ST-1001E CCD camera, a Nikon FC-E8 or SIGMA F4-EX 8mm fish-eye lens and an industrial PC. Each CONCAM takes one 1024×1024 180-second exposure all-sky image every 3 minutes and 56 seconds. The FITS files are then transmitted to the main server where they are copied to the public domain and can be accessed at `http://nightskylive.net` . The Night Sky Live network provides features such as bright star monitoring (Shamir & Nemiroff, 2004) and all-sky opacity maps (Nemiroff & Shamir, 2003). FITS frames are stored in the main server for two months, after which they are archived on DVDs and removed from the server, but are still available upon specific request.

Currently there are 10 CONCAM nodes located in Mauna Kea and Haleakala - Hawaii, Cerro Pachon - Chile, Kitt Peak - Arizona, Mt. Wilson - California, Rosemary Hill - Florida, Siding Spring - Australia, Wise Observatory - Israel, Canary Islands and South Africa. Among the operating CONCAMs, the ones discussed in this paper are the twin CONCAMs located at Mauna Kea and Haleakala, which are close enough to capture the same meteors.

3 Analysis of Meteor Trails

Mauna Kea CONCAM is located at Longitude $-155°28'8''.7$, Latitude $+19°49'21''.1$, and Haleakala CONCAM is located at Longitude $-156°15'21''.2$, Latitude $+20°42'25''.9$. The distance between the two stations is 128.14 km. In order to analyze the trajectory of a meteor trail, the celestial coordinates of the start and end of the meteor trail are required. These coordinates are obtained by manually finding the image (X, Y) coordinates of the start and end of the light curve in both images, and then converting the image coordinates into (Alt,Az) topocentric celestial coordinates using a fuzzy logic-based transformation formula (Shamir & Nemiroff, 2005). The source code of the computer program that implements the transformation formula can be downloaded from `http://nightskylive.net/wolf/source/`, and the algorithm is thoroughly discussed in (Shamir & Nemiroff, 2005).

Figures 2 and 3 show the same meteor recorded by Haleakala and Mauna Kea CONCAMs at 2004 October 18, $13^h36^m07^s$ UT. Enlargements of the meteors themselves are shown in Figure 1.

The image coordinates of the meteor are given in Table 1.

The topocentric celestial coordinates calculated by applying the fuzzy logic-based transformation formula are given in Table 2.

The azimuth of Haleakala from Mauna Kea is

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IMO bibcode WGN-333-shamir-ccd

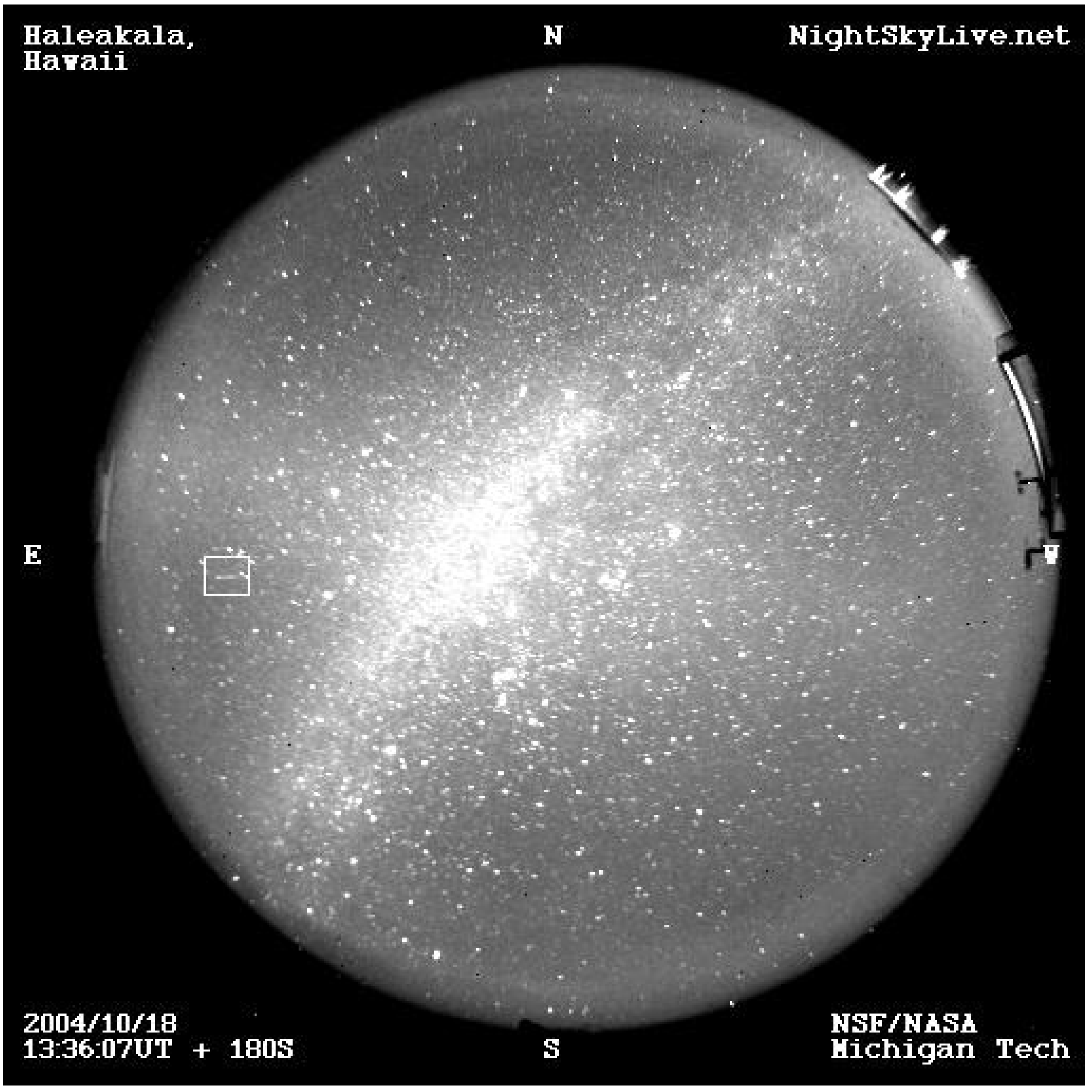

Figure 2 – A meteor (in the white rectangular frame) recorded at Haleakala. This may be seen enlarged on the back cover.

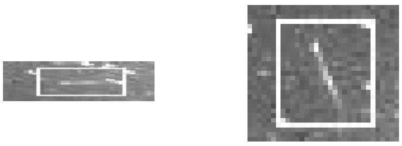

Figure 1 – Details of the meteors photographed from Haleakala (left) and Mauna Kea (right).

Table 1 – Image coordinates (in pixels) of the start and end of the meteor trail in the images taken at Mauna Kea and Haleakala

	Mauna Kea	Haleakala
Start	(339,670)	(219,483)
End	(329,695)	(203,483)

$320^\circ\!.35$. Given the distance from Mauna Kea to Haleakala and the azimuths of the meteor from both stations, the horizontal distance of the end of the meteor trail from Mauna Kea can be easily obtained by calculating the side y in Figure 4.

Table 2 – Topocentric coordinates of the start and end of the meteor trail

	Mauna Kea	Haleakala
Start	Az=$\phi = 44^\circ\!.30$	Az=$\gamma = 99^\circ\!.84$
	Alt=$44^\circ\!.24$	Alt=$32^\circ\!.70$
End	Az=$\beta = 41^\circ\!.84$	Az=$\alpha = 99^\circ\!.66$
	Alt=$39^\circ\!.72$	Alt=$28^\circ\!.47$

The horizontal distance of the end of the meteor trail from Mauna Kea can be calculated using Equation 1.

$$y = \frac{x \cdot \sin(180 - \delta - \alpha)}{\sin(\alpha - \beta)} \tag{1}$$

Given that $x = 128.14$ km, $\alpha = 99^\circ\!.66$, $\beta = 41^\circ\!.84$, and $\delta = 39^\circ\!.65$, y can be calculated to be 98.7 km. The horizontal distance z from Haleakala to the end of the meteor trail can be calculated using Equation 2:

$$z = y \cdot \frac{\sin(\delta + \beta)}{\sin(180 - \delta - \alpha)} = 149.72 \text{ km} \tag{2}$$

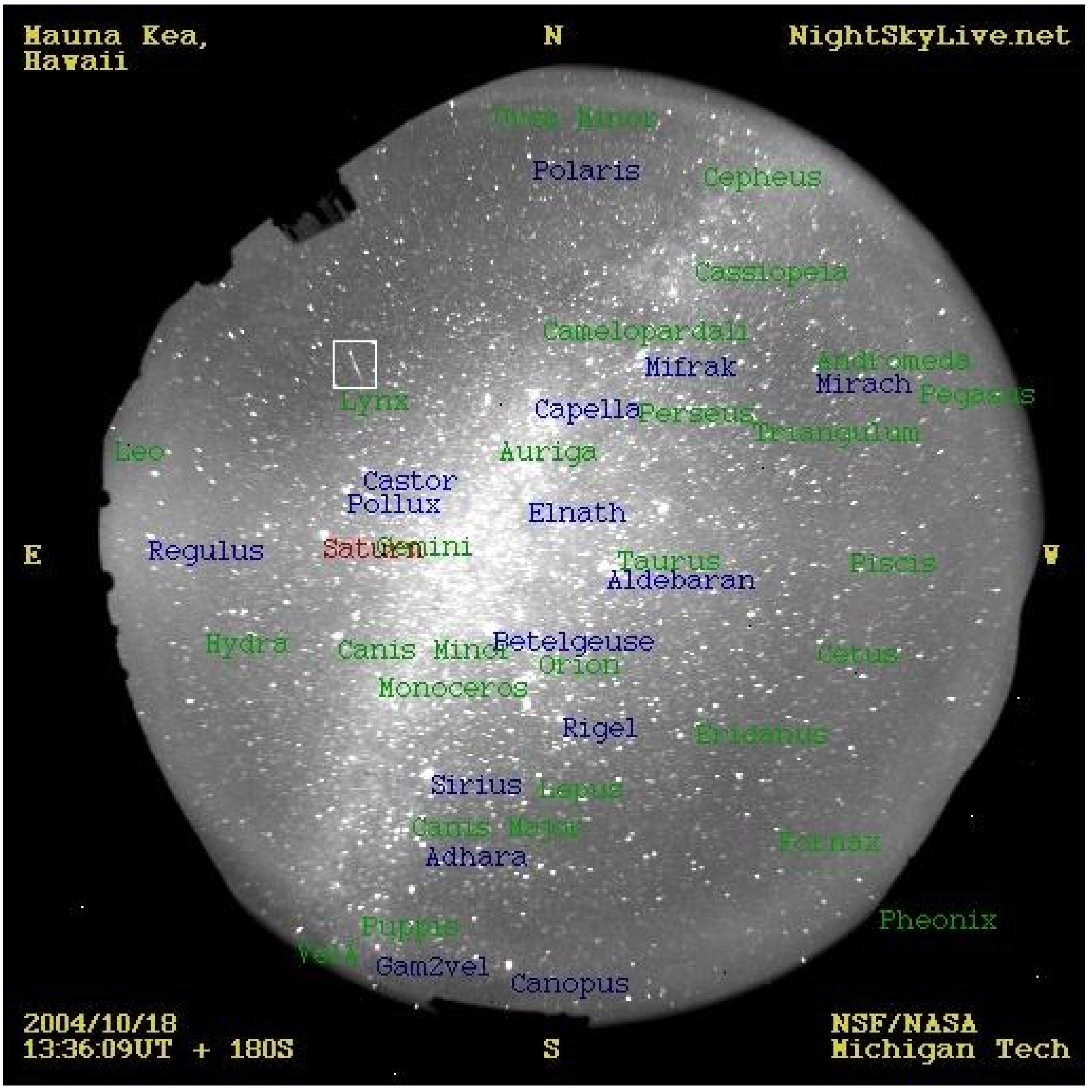

Figure 3 – A meteor (in the white rectangular frame) recorded at Mauna Kea.

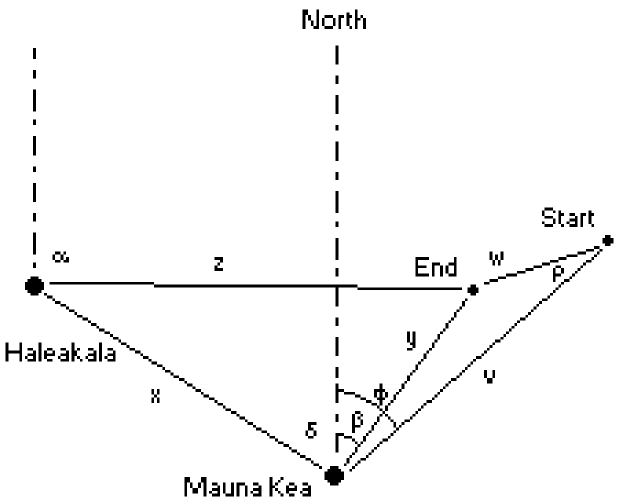

Figure 4 – Illustration of the meteor trail as seen from above. α is the azimuth of the end of the meteor trail from Haleakala, β is the azimuth of the end of the meteor trail from Mauna Kea, x is the distance from Mauna Kea to Haleakala and δ is the azimuth of Haleakala from Mauna Kea.

Using the angular altitude of the end of the meteor trail measured in Mauna Kea (which is $39\overset{\circ}{.}72$), the altitude of the end of the meteor trail is $H_{\text{end}} = \tan(39.72) \cdot y = 81.9$ km above the Mauna Kea.

Using the altitude and the horizontal distance, the absolute distance of the end of the meteor trail from Mauna Kea is $D_{mk} = \sqrt{H_{\text{end}}^2 + y^2} = 128.25$ km

Similarly, the horizontal distance of the start of the meteor trail from Mauna Kea can be obtained using Equation 3.

$$v = \frac{x \cdot \sin(180 - \delta - \gamma)}{\sin(\gamma - \phi)} \tag{3}$$

where γ is the azimuth of the start of the meteor trail from Haleakala and ϕ is the azimuth of the start of the meteor trail from Mauna Kea. Using the values from Table 2, $\gamma = 99\overset{\circ}{.}84$ and $\phi = 44\overset{\circ}{.}30$, giving $v = 100.9$ km.

The horizontal distance from Haleakala to the start of the meteor trail can be calculated using Equation 4.

$$v \cdot \frac{\sin(\delta + \phi)}{\sin(180 - \delta - \gamma)} = 154.5 \text{ km} \tag{4}$$

Using the angular altitude of the start of the meteor trail measured in Mauna Kea (44°24), the altitude of the start of the meteor trail is $H_{\text{start}} = \tan(44.24) \cdot v = 98.2$ km above the Mauna Kea.

The horizontal length of the meteor trail can be obtained by calculating the side w using Equation 5.

$$w = \sqrt{(\sin(\phi - \beta)y)^2 + (v - \cos(\phi - \beta)y)^2} \quad (5)$$

where ϕ is the azimuth of the start of the meteor trail measured in Mauna Kea, y is the horizontal distance of the end of the meteor trail from Mauna Kea and v is the horizontal distance of the *start* of the meteor trail from Mauna Kea. Given that $\phi = 44\overset{\circ}{.}30$, $\beta = 41\overset{\circ}{.}84$, $y = 98.7$ km and $v = 100.9$ km, the horizontal length of the meteor trail is 4.7 km.

Given the altitudes of the start and end of the trail and the horizontal length, the absolute length of the trail (assuming linear trajectory) can be calculated simply by $L = \sqrt{(98.2 - 81.9)^2 + 4.7^2} = 16.96$ km.

4 Estimated Error

The fuzzy logic-based transformation formula is accurate to a level of 3.2 pixels (Shamir & Nemiroff, 2005). Since each pixel in a Night Sky Live frame is approximately 10′, the maximum difference between the computed celestial coordinates and the true celestial coordinates would be $3.2 \cdot 10' = 32'$. Due to sub-pixel positioning, an extra error of $0.5 \cdot 10'$ should be added so the total error is $32' + 5' = 37' \simeq 0\overset{\circ}{.}617$.

The coordinates of the meteor trail with the estimated error are given in Tables 3 (in degrees) and 4 (in radians).

4.1 Estimated Error of the End of the Meteor Trail

The horizontal distance y of the end of the meteor trail from Mauna Kea is calculated based on α and β (the azimuths of the end of the meteor trail measured in Mauna Kea and Haleakala) using Equation 1.

Let $y_n = x \cdot \sin(\pi - \delta - \alpha)$ and σ_α be the estimated error of α specified in Table 4. The estimated error in y_n is defined by Equation 6.

$$\begin{aligned}\sigma_{\text{yn}} &= x \cdot \cos(\pi - \delta - \alpha) \cdot \sigma_\alpha \\ &= 128.14 \cdot \cos(\pi - 0.692 - 1.7394) \cdot \tfrac{0.0108}{\cos(0.4969)} \\ &\simeq 1.193\end{aligned} \quad (6)$$

Let $y_d = \sin(\alpha - \beta)$. The estimated error σ_{yd} in y_d is defined by Equation 7.

$$\begin{aligned}\sigma_{\text{yd}} &= \cos(\alpha - \beta) \cdot \sqrt{\sigma_\alpha^2 + \sigma_\beta^2} \\ &= \cos(1.7394 - 0.7302) \cdot \\ &\quad \sqrt{\left(\tfrac{0.0108}{\cos(0.4969)}\right)^2 + \left(\tfrac{0.0108}{\cos(0.6932)}\right)^2} \\ &\simeq 0.0099\end{aligned} \quad (7)$$

Using the estimated error provided by Equations 6 and 7, the estimated error σ_{y} in y is defined by Equation 8.

$$\sigma_{\text{y}} = \frac{x \cdot \sin(\pi - \delta - \alpha)}{\sin(\alpha - \beta)} \cdot \sqrt{\left(\frac{\sigma_{\text{yn}}}{y_n}\right)^2 + \left(\frac{\sigma_{\text{yd}}}{y_d}\right)^2} \simeq 1.82 \quad (8)$$

The estimated error σ_{y} introduces an error of $1.82/98.7 \simeq 1.84\%$ in y.

Let $t = \tan(\psi)$, where ψ is the altitude of the end of the meteor trail measured in Mauna Kea. The estimated error in t is defined by Equation 9.

$$\sigma_{\text{t}} = \sigma_\psi \cdot \cos^{-2}(\psi) = 0.0108 \cdot \cos^{-2}(0.6932) \simeq 0.0183 \quad (9)$$

Let σ_{He} be the estimated error in H_{end}, defined by Equation 10.

$$\sigma_{\text{He}} = \tan(\psi) y \cdot \sqrt{\left(\frac{\sigma_{\text{y}}}{y}\right)^2 + \left(\frac{\sigma_{\text{t}}}{\tan(\psi)}\right)^2} \simeq 2.35 \quad (10)$$

σ_{He} introduces an estimated error of $2.35/81.9 \simeq 2.87\%$ in H_{end}.

4.2 Estimated Error of the Start of the Meteor Trail

Let $v_n = x \cdot \sin(\pi - \delta - \gamma)$. The estimated error σ_{vn} in v_n is defined by Equation 11.

$$\begin{aligned}\sigma_{\text{vn}} &= x \cdot \cos(\pi - \delta - \gamma) \cdot \sigma_\gamma \\ &= 128.14 \cdot \cos(\pi - 0.692 - 1.7425) \cdot \tfrac{0.0108}{\cos(0.5707)} \\ &\simeq 1.25\end{aligned} \quad (11)$$

Let $v_d = \sin(\gamma - \phi)$. The estimated error in v_d is defined by Equation 12.

$$\begin{aligned}\sigma_{\text{vd}} &= \cos(\gamma - \phi) \cdot \sqrt{\sigma_\gamma^2 + \sigma_\phi^2} \\ &= \cos(1.7425 - 0.7732) \cdot \\ &\quad \sqrt{\left(\tfrac{0.0108}{\cos(0.5707)}\right)^2 + \left(\tfrac{0.0108}{\cos(0.7721)}\right)^2} \\ &\simeq 0.0112\end{aligned} \quad (12)$$

Using the estimated error provided by Equations 11 and 12, the estimated error in v is defined by Equation 13.

$$\sigma_{\text{v}} = \frac{x \cdot \sin(\pi - \delta - \gamma)}{\sin(\gamma - \phi)} \cdot \sqrt{\left(\frac{\sigma_{\text{vn}}}{v_n}\right)^2 + \left(\frac{\sigma_{\text{vd}}}{v_d}\right)^2} \simeq 2.04 \quad (13)$$

σ_{v} introduces an error of $2.04/100.9 \simeq 2.02\%$ in v.

Let $q = \tan(\xi)$, Where ξ is the altitude of the start of the meteor trail measured in Mauna Kea. The estimated error in q is defined by Equation 14.

Table 3 – Topocentric coordinates (in degrees) of the start and end of the meteor trail and their estimated error

	Mauna Kea	Haleakala
Start	Az=ϕ=44.30$\pm\frac{0.617}{\cos(44.24)}$	Az=γ=99.84$\pm\frac{0.617}{\cos(32.70)}$
	Alt=44.24$\pm$0.617	Alt=32.70$\pm$0.617
End	Az=β=41.84$\pm\frac{0.617}{\cos(39.72)}$	Az=α=99.66$\pm\frac{0.617}{\cos(28.47)}$
	Alt=39.72$\pm$0.617	Alt=28.47$\pm$0.617

Table 4 – Topocentric coordinates (in radians) of the start and end of the meteor trail and their estimated error

	Mauna Kea	Haleakala
Start	Az=ϕ=0.7732$\pm\frac{0.0108}{\cos(0.7721)}$	Az=γ=1.7425$\pm\frac{0.0108}{\cos(0.5707)}$
	Alt=0.7721$\pm$0.0108	Alt=0.5707$\pm$0.0108
End	Az=β=0.7302$\pm\frac{0.0108}{\cos(0.6932)}$	Az=α=1.7394$\pm\frac{0.0108}{\cos(0.4969)}$
	Alt=0.6932$\pm$0.0108	Alt=0.4969$\pm$0.0108

$$\sigma_{\rm q} = \sigma_\xi \cdot \cos^{-2}(\xi) = 0.0108 \cdot \cos^{-2}(0.7721) \simeq 0.0210 \quad (14)$$

Let $\sigma_{\rm Hs}$ be the estimated error in $H_{\rm start}$, defined by Equation 15.

$$\sigma_{\rm Hs} = \tan(\xi)v \cdot \sqrt{\left(\frac{\sigma_{\rm v}}{v}\right)^2 + \left(\frac{\sigma_{\rm q}}{\tan(\xi)}\right)^2} \simeq 2.90 \quad (15)$$

This introduces an estimated error of $2.90/98.2 \simeq 2.95\%$ in $H_{\rm start}$.

The procedure described in Section 3 was tested by measuring the altitude of known satellites such as the International Space Station and several Iridium satellites with accuracy of less than 1%.

5 Meteor Light Curves

FITS frames provide an effective infrastructure for pixel-by-pixel analysis of meteor light curves (Campbell et al., 2001; Cordell et al., 2004; Brosch & Manulis, 2002; Brosch et al., 2004). A 3D plot of the pixel values of the meteor recorded in Figure 3 is illustrated in Figure 5.

The light curve presented in Figure 5 has two peaks of maximal brightness. The first peak is at image coordinates (334,681) and the second is at the end of the trail at (329,695). Using the analysis presented in Section 3, the first peak is at altitude of 91.2 km above Mauna Kea and occurred when the meteoroid was 7.29 km away from where it started its luminous trail. The second peak is at altitude of 81.9 km above Mauna Kea and 16.96 km away from where the luminous trail started.

The limiting stellar magnitude of CONCAM is approximately 6.8. Assuming a meteor duration is 0.4 seconds and the length of the trail is 20 pixels on the CCD chip (such as the meteor in this paper), the duration on each pixel would be $\frac{0.4}{20} = 0.02$ seconds, and the limiting magnitude of the meteor would be $6.8 + 2.5\log_{10}\frac{0.02}{180} \simeq -3.08$.

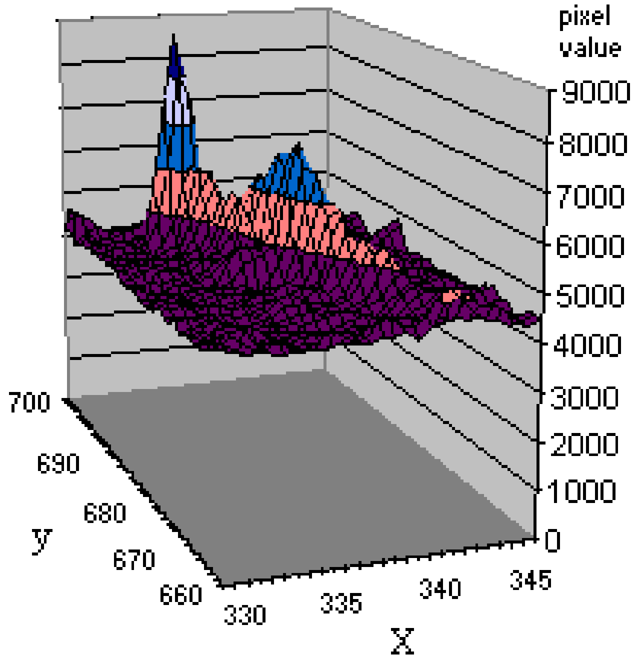

Figure 5 – Light curve of the meteor recorded in Figure 3.

6 Conclusion

The twin CONCAM stations located at Mauna Kea and Haleakala provide data that can be used for the purpose of meteor research without the need to set up and operate a dedicated array of cameras. The fish-eye images cover the whole 2π steradian view of the night sky, and the stations are active 24/7 all year round. Data recorded in real-time, as well as archived data, are copied to the public domain and can be accessed and used easily. The analysis presented in this paper allows one to obtain the altitude and total length of meteor trails, which can be used for light curve analysis.

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SPA Meteor Section results: October–December 2002

Alastair McBeath[1]

Results and information from SPA Meteor Section data during October–December, 2002, are presented and discussed, excepting those from November during the Leonids, which were handled earlier. Leading the main events of the quarter was a widely-seen, magnitude −12/−15 fireball at 04^h53^m UT on October 5/6, which passed over west Belgium and northern France. The Draconid epoch in October may have produced some low rates, but this is not certain. The Orionids gave a relatively weak showing, with an ill-defined radio maximum around October 19–22. The radio results suggested the pre-maximum October 17/18 peak may have recurred. In December, a visual Geminid peak at circa 10^h–11^h UT on December 14 was found ($\lambda_\odot$ (eq. 2000.0) = 262°.20–262°.24), with EZHRs $\sim 200 \pm 12$, probably inflated by the moonlit sky. The radio data also supported a strong peak on this date, but possibly slightly later, between 11^h–14^h UT ($\lambda_\odot$ = 262°.24–262°.37). Another fireball, of magnitude −4/−8, was reported from parts of central to southern England on December 17/18, at $16^h51^m \pm 1^m$ UT. Details on its probable trajectory over south-east England to the Channel off the Isle of Wight are given. No evidence was found supporting anything other than a normal, minor, Ursid return, despite a prediction of possibly enhanced activity for December 22.

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1 Introduction

This quarter saw the last predicted Leonid storm of the current group, associated with the return of the shower's parent comet, 55P/Tempel-Tuttle, in 1998. Details on the Section's view of that event have already been published (McBeath, 2003a, 2003b), so are not repeated here. This article concentrates instead on the other main events of the 2002 October to December period. These should have included the Moon-free Taurid peaks in November, the Geminids, and the belatedly-predicted, if badly-moonlit, possible Ursid outburst (Lyytinen & Nissinen, 2002) in December. However, as at other times during the year, these predicted events were overtaken by several unexpected bright fireballs.

Table 1 gives the observed totals for the quarter. In addition, 1^h.1 of photographic data, with 6 trails, were reported from the Leonid epoch in November.

In the following observers' lists, only those who contributed data from outside the November 16–21 period already discussed, or whose data arrived too late to be included in those earlier reports, are named.

Radio results were received directly from

> Dirk Artoos (Belgium), Gilberto Klar Renner (Brazil), Ton Schoenmaker (Netherlands), and Ivan Sergey (Belorussia; data via Rainer Arlt),

plus the following Radio Meteor Observation Bulletin reporters (*RMOB*; website: `www.rmob.org`; provided to the Section by editor Chris Steyaert):

> Enric Fraile Algeciras (Spain), Mike Boschat (Nova Scotia, Canada), Walter Boschin (Italy; with Luca Donato in October; with Diego Ganzini, Alessandro and Giuseppe Candolini in December), Jeff Brower (Colorado, USA), Eisse Pieter Bus (Netherlands), Maurice de Meyere (Belgium), Thierry Duhagon (France), Minoru Ehara (Japan), Didier Favre (France), Valter Gennaro (Italy), Ghent University (Belgium), Patrice Guérin (France), Rafael Haag (Brazil), Steve Hansen (Massachussetts, USA), Kazuyoshi Kanatsu (Japan), Michael Krocil (Czech Republic), Toshihide Miayake (Japan), Naoki Moriwaki (Japan), Stan Nelson (New Mexico, USA), Robert Obraz (Croatia), Hiroshi Ogawa (Japan), Sadao Okamoto (Japan), Robert Savard (Quebec, Canada), Hironobu Shida (Japan), Dave Swan (England), Istvan Tepliczky (Hungary), Pierre Terrier (France), Yung Cheich Tsao (Taiwan, China), Takashi Usui (Japan), Bruce Young (Queensland, Australia), Ilkka Yrjölä (Finland).

Ton Schoenmaker's data were also in *RMOB* 112 (November 2002), while the various *RMOB* reports were extracted from *RMOB*s 111–113 (October-December 2002) inclusive. The raw observations were dealt with as usual, using the modified procedure outlined in (McBeath, 2004).

Video observations came exclusively from the Arbeitskreis Meteore (AKM; website: `www.meteoros.de`) summaries in their monthly journal Meteoros. As with the other AKM data used here, they came from Meteoros 5:11 and 5:12 (2002), 6:1 and 6:2 (2003), sent in by Ina Rendtel. The video observers involved were:

> Orlando Benitez-Sanchez (Canary Isles), Steve Evans (England), Detlef Koschny (Netherlands), Sirko Molau (Germany), Mirko Nitschke (Germany), Steve Quirk (Australia), Jürgen Rendtel (Germany & Canary Islands), Ulrich Sperberg (Germany), Rosta Stork (Czech Republic), Jörg Strunk (Germany), Ilkka Yrjölä (Finland).

Visual reports came from:

> American Meteor Society observers (AMS; website: `www.amsmeteors.org`; extracted from summaries in 'Meteor Trails' 18 and 19, March and June 2003 respectively, provided by observer and editor Bob Lunsford (California, USA); note all locations are states in the USA where no separate country is given): Ed Cannon (Texas), Mark Fox (Missouri), George Gliba (West Virginia), Robin Gray (Nevada), Robert Hays (Indiana), Carl Johannink (Netherlands), Edwin Jones (Arkansas), Roseann Johnston (Alabama), Javor Kac (Slovenia), Gene Kispert (Minnesota), Thomas Lazuka (Indiana), Mike Linnolt (Hawaii), Pierre Martin (Ontario, Canada), Paul Martsching (Iowa), Bert Matous (Kansas), Jim

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Table 1 – Visual, video and radio hours' totals, visual and video meteor numbers recorded (with a partial breakdown of visual types), per month.

Month	Visual						Video		Radio
	Hours	Counts					Hours	Counts	Hours
October		NTA	STA	ORI	–	Total			
	104	42	43	127	–	1 073	641.1	2 728	5618
November		NTA	STA	ORI	LEO	Total			
	400.4	164.5	97.5	41	27 885	28 572	356.1	1 935	9621
December		GEM	URS	–	–	Total			
	198	2 775	49	–	–	4 367	–	–	10474

McGraw (Iowa), Robert Morgan (Nevada), Michael Morrow (Hawaii), Dale Niedfeldt (Minnesota), David Stine (Texas), David Swann (Texas); AKM members (in Germany, unless noted): Pierre Bader, Frank Enzlein, Christoph Gerber, Martin Hörenz, Ralf Koschack, Hartwig Lüthen, Sven Näther, Jürgen Rendtel (Germany and Canary Islands), Roland Winkler, Oliver Wusk (Queensland, Australia); Russell Cockman (Scotland), Alastair McBeath (England), Jonathan Shanklin (England), George Spalding (England), Enrico Stomeo (Italy), Richard Taibi (Maryland, USA; data also recorded in AMS summaries).

In addition, Richard Taibi helpfully forwarded notes on Ursid data he had collected during the shower from himself and:

Mike Boschat (radio), George Gliba, Alan Hilburn (North Carolina, USA), Ike Lysell (Sweden), Grigorios Maravelius (Greece), and Paul Martsching.

2 October

The first point of meteoric interest in the month was expected to be checking the Draconid epoch, with its possible maximum sometime on October 8 or 9. Before then though, a cluster of fireballs had appeared on October 4/5 and 5/6. The first two were seen only by single witnesses, at roughly $19^{h}00^{m}$ UT on October 4/5 from near the city of Worcester, and at about $01^{h}10^{m}$ UT on October 5/6 from north-east England.

The third event was much more widely seen, at $04^{h}53^{m}\pm1^{m}$ UT on October 5/6, as spotted from places in southern England up into the Midlands, and across Belgium. A total of 16 sightings from England and Belgium gave some useful details on the fireball. Several other reports, mostly from media sources or unrecorded phone-calls to observatories or the emergency services, were received; but no information on the fireball's timing, appearance, or sky position could be extracted from these — only notes that the event had been seen, and sometimes a rough observer's location. Figure 1 shows the approximate locations of the main observers and the meteor's likely projected surface track.

Best estimates for the fireball's brilliance indicated a magnitude range of $-12/-15$, enough to alert observers indoors, light up the sky, the clouds, or the ground, depending on where the observers were at the time. Two witnesses reported seeing the event begin with a bright flare, and two more commented the end-flare was spectacularly violent as well. Seven observers said fragmentation was seen along the track and near the end, and these small pieces were typically described as red in colour. The bolide itself was noted as having a blue or green colour dominant for at least part of the trail by eleven of the twelve witnesses who gave such information, though red or orange was a relatively common secondary colour (in 6 of the 12 colour reports). No sonic effects were reported by any of the observers, with several commenting specifically on this absence.

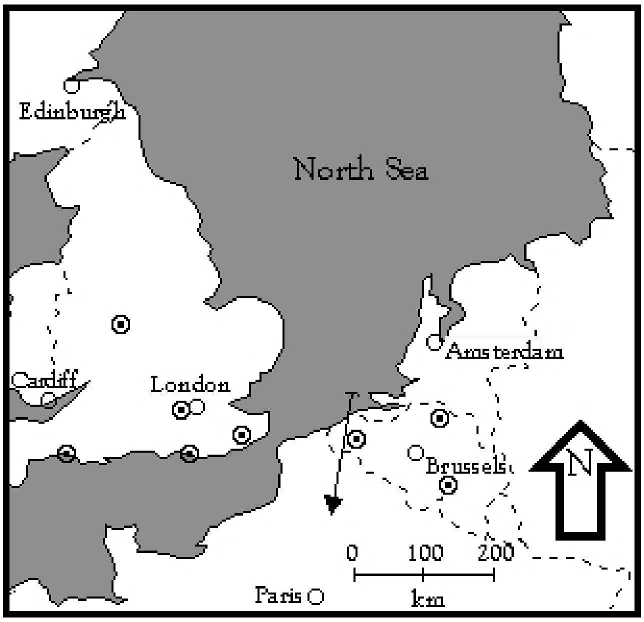


Figure 1 – A sketch map showing the probable surface track of the October 5/6, $04^{h}53^{m}$ UT fireball (the arrowed line) across west Belgium and north France. Capital cities are shown as named open circles. Locations from where at least rough details on the fireball's sky position were secured are indicated by the small target symbols. Note some of these represent several observers whose sites were too close together to illustrate separately at this scale. The outlying four symbols (two in England, two in Belgium) clockwise from the south-western one denote sites at: Lyme Regis (Dorset); Tamworth, (Staffordshire) and Coventry (West Midlands); motorway between Mol and Geel (Antwerpen); and Andenne (Namur).

As no photographic or video images were secured showing the trail, and as morning twilight was underway at the time, the accuracy of the positional information on the fireball's trajectory was often poor, and only three reports gave enough data to closely establish the projected surface track shown in Figure 1. The most probable best-fit approximations for the atmospheric trajectory from an analysis of these were as follows.

The start of the visible trail was at around 130 km altitude over the southern North Sea, roughly 30 km offshore north of Blankenberge, Belgium (more or less due west of the western tip of the Zeeland peninsula in the Netherlands), at $\simeq 51.^\circ6$ N, $3.^\circ1$ E. The visible end was at about 80 km altitude over Picardy, northern France, about 20 km east-north-east of Amiens, at $\sim 49.^\circ9$ N, $2.^\circ6$ E. This gave a shallow, probably near-grazing, entry angle of circa 15° from the horizontal, and a visible atmospheric path length of ~ 195 km.

The assumption that several independent estimates for the full-trail duration of around 20–30 s were close to the truth gave a mean atmospheric velocity of some 6–10 km/s, which had most likely significantly decelerated during the flight from an original (probably in the bottom end of the meteoric range) of the order of 11–15 km/s or a little more. In the absence of detailed imaging data, which would be necessary for definite confirmation, this deceleration, and the potential problems the very low intra-atmospheric velocity may have created (for example, a possible non-rectilinear atmospheric path, due to the Earth's gravitational attraction), have been ignored. The velocity range thus established suggested the bolide was due to a natural, large, meteoroid, and was not a man-made re-entry event as had been earlier suspected.

Projecting a straight-line path along this atmospheric trajectory from the visible end point, implied a maximum-distance impact point for any surviving meteorites about 20 km north-east of Orléans, France, at $\sim 48°$ N, $2.^\circ1$ E, although any meteoritic fragments might have fallen earlier in the dark flight stage, some way south of Paris. No reports of any possible meteorites associated with this bolide have been found, however. The near-grazing high-altitude track, and the long duration and heavy fragmentation observed in the meteor ablation zone, reduce the possibility of any surviving pieces large enough to be easily found at the surface, unfortunately.

Moving on to the potential Draconid period, a scattering of very weak visual rates were suggested by some, but not all, active observers. These were often so low as to be simply sporadics lining up with the general Draconid radiant area by chance. Hiroshi Ogawa (2002) reported Draconid ZHRs of about 6 on October 9 and 10 over Japan, although other visual data on those nights failed to show any comparably clear activity elsewhere.

The radio results seem to have provided a rather more conclusively negative view. Although weak radio maxima happened in several datasets on October 8, 9 or 10, the one factor confirmed in all cases was that the strongest response was found when the Draconid radiant was at about its lowest for the day — in some cases when it was below the horizon. A minor peak around $\lambda_\odot = 195°$–$196°$ was one of the events found in the Forward Scatter Meteor Year analyses from the start (the most recent update was (McBeath, 2001)). The 2002 results suggest that, except in 1998 and 1999, the peak around this time has not been generally due to the Draconids. Recent discussions indicate it may be due to late Sextantid activity instead (personal communications with Dirk Artoos, 2003). However, a close inspection of the data infers some of the activity between approximately 22^h UT on October 8 and 15^h UT on October 10 might be because of weak Draconid rates after all. These findings are not certain, but it would be beneficial to have more, and fuller, visual monitoring of the whole Draconid epoch — possibly through to October 11 — in future, just in case.

Examination of the radio results near the Orionid maximum discovered a generally weak recurrence of the shower. It was at its best at some vague time between October 19 and 22. The expected maximum should have fallen on October 21 (McBeath & Arlt, 2001, p. 11), but no consensus to that effect was apparent. There was some evidence that the pre-maximum peak sometimes found on October 17/18 recurred in the radio results in 2002, though probably yielding slightly weaker rates than the main maximum, if so.

In the visual data, weak Orionid ZHRs (assuming $r = 2.9$) ≤ 6, were followed from October 5/6 through to 14/15 at least, by when the waxing gibbous Moon was becoming a significant problem virtually all night. After this, computed ZHRs were increasingly less accurate. Data from October 17/18 suggested ZHRs were $\sim 14 \pm 4$, with a similar $\sim 16 \pm 6$ the following night, but these values were not reliably calculated because of the bright sky. The lack of viable data means confirming the possible radio Orionid pre-maximum peak on October 17 and 18 was not practical. No watches were carried out close enough to the probable main maximum to confirm it or its radio-weak strength either. Dubietis (2003) indicated rates should have been relatively low from the source this time, a concept to which the radio observations at least could be fitted.

There was little radio evidence, and none from the scant visual reports, to support significantly enhanced Taurid activity in late October, as was last seen in 1998 (McBeath, 1999; Arlt, 2000). There was a minor peak in radio activity around October 31, which has been quite commonly seen before (McBeath, 2001).

3 November

Most of the visual data during the month was concentrated around the Leonids, as has already been detailed elsewhere. Some coverage of the Taurid peaks was achieved too, earlier in the month, indicating that shower rates were of their typical character then (ZHRs ~ 5 from each branch of the stream over the maxima). This impression was borne out in a brief examination of the radio observations. No unexpected radio spikes were found during the α-Monocerotid near-peak time, on November 21, either. As this was full Moon night, it is scarcely surprising there were virtually no visual sightings of shower meteors then, none at all indicating any unusual rates.

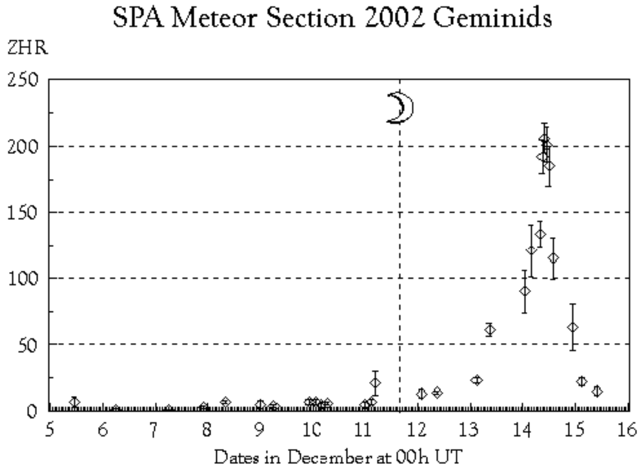


Figure 2 – Geminid ZHRs in December 2002 from SPA Meteor Section results, computed assuming $r = 2.6$. The time of first quarter Moon is also marked, indicating that the datapoints to the right of the line are likely to be numerically less reliable the later in December they are. In particular, the maximum rates on December 14 may well be somewhat inflated.

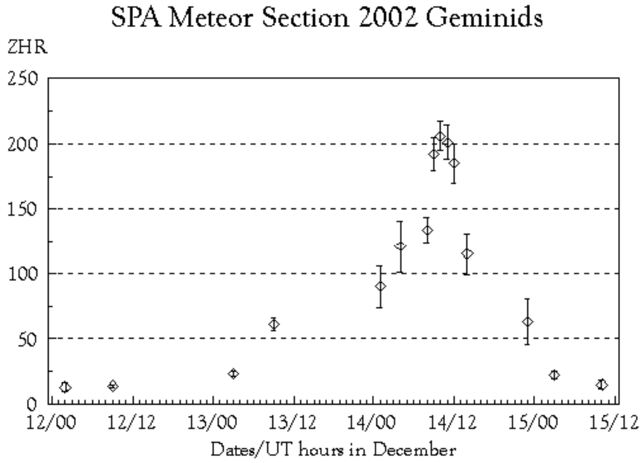


Figure 3 – A close-up of the Geminid near-peak results, extracted from Figure 2.

4 December

Before the Geminids got underway, a bright fireball of probably magnitude $-5/-8$ had already shot across the southern UK, on December 4/5. Six observers in central to southern England reported details on it, several of whom were out to spot the International Space Station's pass at around the same time. This led to a degree of scatter in the timings for the event, with outlying estimates between 19^h15^m–19^h25^m UT. The mean was $19^h17^m \pm 2^m$ UT. This also led to few accurate sky-positions for the visible trail being received, and it was not possible to derive even an approximate surface track from those that were. The fireball probably passed high above the general area of south Wales to the Severn Valley/Bristol Channel, possibly on a roughly north-west to south-east trajectory, but this is uncertain. Two of the observers noted fragmentation took place, probably late in its flight, and almost all agreed it was bright green in colour.

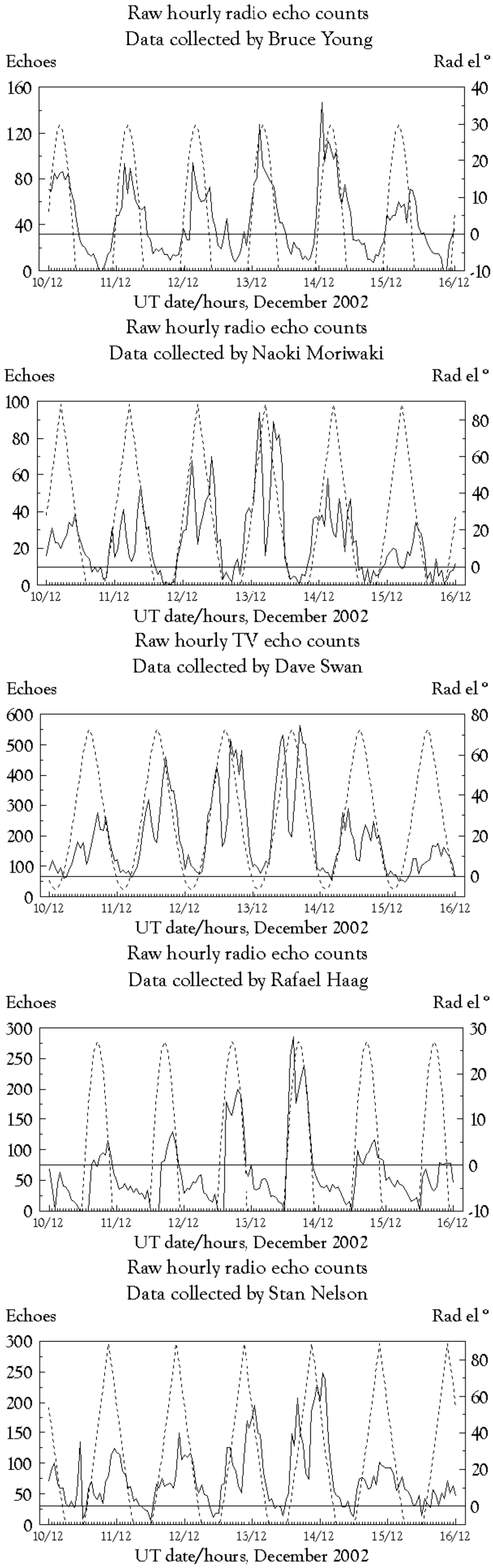
Once the Geminids began to appear, coverage throughout the shower was remarkably good, as Figure 2 shows. While some possible activity was claimed on December 5 and 6, it is clear this only reached visually detectable levels for more than an isolated observer by the UT evening hours of December 7. This is what has been typically found before. After first quarter Moon, the computed ZHRs became increasingly less reliable, as the correction factors mounted. The moonlit maximum rates of $\sim 200 \pm 12$ achieved around 10^h–11^h UT on December 14 ($\lambda_\odot = 262.^\circ20$–$262.^\circ24$), more clearly seen in Figure 3, are almost certainly inflated above the real level. However, the general character of the peak is more likely to be accurate, if not the precise numerical values. The 2+ day rise to the peak, and the very rapid fall afterwards, are well-established features of past Geminid returns.

In the radio data, a typically strong Geminid peak response was seen in the more reliable results, as the sample graphs in Figure 4 suggest. An examination of these, allowing for the radiant elevation, indicated the most probable peak timing was on December 14, between 11^h–14^h UT ($\lambda_\odot = 262.^\circ24$–$262.^\circ37$), with the strongest counts around 13^h UT ($\lambda_\odot = 262.^\circ32$). This might imply the radio maximum was a little later than the visual one. The predicted peak was due between 07^h45^m–12^h30^m UT ($\lambda_\odot = 262.^\circ1$–$262.^\circ3$) on December 14, more likely towards 10^h UT ($\lambda_\odot = 262.^\circ2$) (McBeath & Arlt, 2001, p. 19). The maximum times found in the visual and radio results seem in-line with these predictions at least.

Between the Geminids and Ursids came another curious, loosely-defined, fireball 'cluster' over the UK, on December 17/18 and 18/19. One fireball on each night was seen from multiple sites, as detailed below. In addition, at least two other fireballs occurred on December 17/18, seen by single observers, at 20^h42^m UT (from north-west England), and about 00^h30^m UT (from indoors in South Wales). Such a relative grouping of fireballs on December 17/18 is unusual, though not unprecedented, and from the analysed details, it is very unlikely that they all derived from a single source. A casual report of four faint binocular meteors in only two or three seconds around 05^h30^m UT on December 17/18 was received too, but this was probably unrelated to the fireballs.

The chief event on December 17/18 was at $16^h51^m \pm 1^m$ UT. Eight reports on it were received from Lancashire southwards across England. Figure 5 shows these locations, and the probable projected ground track. As with the December 4/5 fireball, there was some scatter in the timing estimates of between 16^h40^m and 16^h53^m UT, but the majority were closer to the mean value adopted here. Despite details on the object's appearance and apparent flight path being hampered by the presence of the almost-full Moon, there was a reasonable degree of consistency between most of the sightings, allowing the approximate surface track and atmospheric trajectory to be defined.

Derived details based on the track in Figure 5 were as follows. The meteor probably started at about 130 km altitude above the River Crouch area north of



Southend in Essex, at roughly latitude 51°38′ N, longitude 0°47′ E, both positions with errors of at least ±10′. Its visible flight carried it south-westwards from here, high over south-east England and the Isle of Wight, to end approximately 20 km offshore south of Brighstone, Isle of Wight, at $\sim$ 90 km altitude above the Channel waters (latitude $\sim$ 50°26′ N, longitude $\sim$ 1°25′ W, again both parameters with a minimum ±10′ error). This gives a surface track length of some 210 ± 20 km, and a slightly longer atmospheric trajectory of $\sim 213 \pm 20$ km, at an angle to the horizontal of just $11° \pm 1°$, very nearly grazing the atmosphere, if correct. The best estimates for the fireball's entire visible duration were between 3 and 3.5^s, which equates to a mean atmospheric velocity, not allowing for deceleration, of $\sim 66 \pm 11$ km/s. Such a very high velocity is consistent with the higher than average start and end heights for so bright a meteor.

The observers generally agreed that the meteor had been a very bright green colour, and that it flared to around magnitude $-4/-8$, breaking up into several fragments, perhaps two to four main pieces, late in its flight. Some people described the fragments as being orange in colour. Given such a high speed, fragmenting, atmospheric flight, it is most unlikely that any sizeable meteorites would survive to reach the surface, but any that continued to follow the same mean path as the fireball would have splashed-down into the Atlantic Ocean around 150 km west of the south-west tip of Brittany, the Pointe du Raz.

December 18/19 yielded a single main fireball event, at $06^h29^m \pm 1^m$ UT. It was probably of magnitude -5 to -10. Eleven sightings were received on it, but only two observers were able to give reasonably accurate sky-positions for the trail, and it was not possible to derive a plausible surface track from these, as the pair were too close to one another in southern England. There were two main clusters of observers, in Berkshire-Surrey and Hampshire-Wiltshire-Dorset, plus outlying single witnesses in Worcestershire and Cardiff, south Wales. The meteor most likely passed high over the Cotswold Hills of south-west England on an east to west, perhaps north-east to south-west, trajectory, but this is only a best guess. Several observers mentioned the meteor was golden-yellow in colour, and it seems to have been quite slow-moving. For once, the majority of timings were within one minute of 06^h29^m UT, however.

The last main event of the year was the Ursids, suggested as possibly capable of producing an enhanced outburst of uncertain proportions (Lyytinen & Nissi-

Figure 4 – (On left) – Five sample raw radio or TV echo count graphs, over the 2002 Geminid maximum. The echo count lines are the irregular ones, keyed to the left-hand y-axes. The daily-symmetrical lines, keyed to the right-hand y-axes, show the Geminid radiant elevation at each site. The graphs are intended to demonstrate how the shower was radio-viewed from different parts of the world. Top to bottom: a) Australia (Bruce Young); b) Japan (Naoki Moriwaki); c) Europe (Dave Swan); d) South America (Rafael Haag); and e) North America (Stan Nelson). Drops to zero in the echo count lines generally show times when interference prevented accurate data collection.

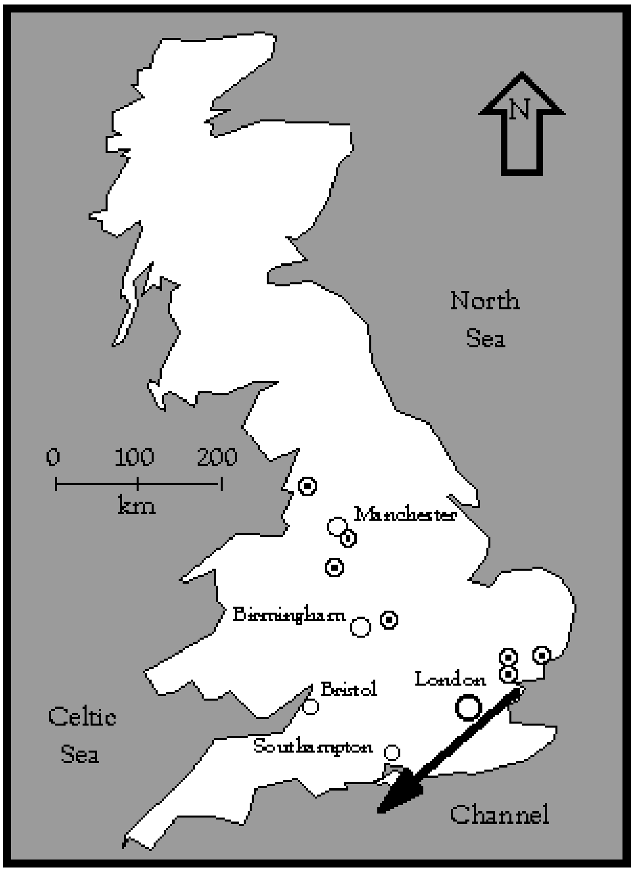


Figure 5 – A sketch map of mainland Britain showing the distribution of observers (the small target symbols) for the December 17/18, 16^h51^m UT fireball. Note some symbols represent more than one observer/location too close together to separate at this scale. Selected cities are shown as named open circles, while the most likely position for the fireball's surface track is given as the arrowed line.

nen, 2002) at their December 22/23 maximum, despite the near-full Moon. The weather was a further problem for many prospective watchers, but those few who did enjoy better skies for the shower found no evidence for anything beyond the normal minor rates (ZHRs $\sim$ 5–10). The radio data too showed nothing other than the normal weak Ursid maximum on December 22.

5 Acknowledgements

My final pleasant duty is, as always, to express my thanks to all our correspondents, contributors, and observers. Please keep your data coming, and good luck for your next efforts.

In regard to the October 5/6 bolide, I particularly wish to thank Clive Down and Andy Salmon of the SPA, Mike Dale of Royal Observatory Edinburgh, and Mike Feist of Foredown Tower Astronomy Group for forwarding details from reports they collected. Especial thanks go to Hendrik Vandenbruaene of the Belgian VVS group for providing summaries of all the data he received on this event, without which the analysis on this event could not have been completed. Details on these sightings can be found on the VVS website at `www.gamma-andromeda.be` .

In respect of the December fireballs, I must especially thank John Lambert of Newcastle and Northumberland Astronomical Societies for rounding up several of the December 4/5 and 17/18 sightings, Paul Sutherland of the SPA , Mike Dale again, and John L Roberts, for forwarding additional observations of the December 18/19 fireball.

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LIADA results of the 2005 γ-Normids

Josep M. Trigo-Rodríguez [1,2], *Pavel Balderas* [2,3], *Rosario Moyano* [4], *Viviana Bianchi* [2,5], *and Iván Javora* [2,6]

The first results of a program to study meteoroid streams in the framework of the Interplanetary Matter Section of the Liga Iberoamericana de Astronomía (LIADA) are presented. Observers from several Latin American countries are performing common campaigns on minor showers following the IMO reduction procedures. On March 2005 our research was focused on the activity of the 2005 γ-Normids. Meteor activity of this meteoroid stream was detected between March 8 and 16 showing Zenithal Hourly Rates (ZHR) of over 10 meteors/hour in the solar longitude interval between 347 and 351°.

1 Introduction

The Liga IberoAmericana De Astronomía (LIADA) tries to organize, train, and promote observations performed by amateur astronomers in Latin America. This organization uses Spanish and Portuguese as official languages in order to share experiences and create a school of semiprofessional members. The main target of this initiative is to look for mechanisms to develop astronomy in Central and South America by combining all available efforts. Research is performed under the criteria of professional astronomers; these criteria are distributed by the LIADA Council. Several astronomy areas are being covered in working groups (sections) where amateurs play an important role. Inside the Interplanetary Matter section of LIADA we are training meteor observers in the IMO procedures of observation and reduction of meteor shower observations.

In January 2005 we decided to establish a common project in order to keep meteor observations from different Latin American countries in conformity with IMO standards. During the first months of our initiative we have put special effort into the translation into Spanish of IMO procedures for observing minor and major showers, the development of observing campaigns and workshops on reduction procedures, etc. Studying meteors in the Southern Hemisphere is particularly necessary in order to improve our knowledge of southern meteor streams whose activity continues to be scarcely studied. We are presenting here the results of these first months of work. We hope that new observers will join us in the near future.

2 Reduction procedure

All observations included here were obtained following the IMO method, and selected from several experienced observers. All meteors were plotted in order to study their association to the different meteor showers after every observation. Plotting allows distinguishing members of showers from sporadic meteors intersecting the radiant by chance.

Zenithal Hourly Rates (ZHRs) were calculated using periods of about one hour, by using the well known formula:

$$\mathrm{ZHR} = \frac{N \cdot r^{6.5-\mathrm{Lm}}}{(\sin h)^{\gamma} \cdot T_{\mathrm{eff}}}$$

where N is the number of stream meteors observed in time T_{eff}, Lm is the limiting magnitude in the observational interval, h is the radiant's altitude, r is the population index, and γ is the factor added by Bellot Rubio (1995), to account for observing biases at large ranges ($\gamma = 1.4$). The population index was estimated from the number of observed meteors. No personal correction factors were applied because their values were undefined.

3 2005 γ-Normid results

Our group considered the study of this stream under the excellent 2005 Moon conditions to be a priority. However, the study of this shower requires excellent limiting magnitudes and observing experience due to the faintness of the meteors and their fast angular velocity that can easily cause confusion with sporadic meteors. Consequently, we took into account plotted observations made under good sky conditions (Lm≥5.5) and by experienced observers. Two observers from Bolivia contributed all the observations in this campaign which met all these criteria (Table 1). Their excellent coverage makes it possible to obtain some interesting results.

By using the population index typically reported in the literature ($r = 2.4$) we obtained the activity profile shown in Figure 1. Averaged ZHR values are given in Table 2. We found that the activity level was higher than expected (Jenniskens, 1994) even considering casual interception of the radiant by occasional sporadic meteors. Just at the end of the campaign, on March 17, the activity of the radiant was probably close to its end because the observed ZHRs were virtually undetectable above the background rate. Consequently, we cannot corroborate high activity on March 17, as previously reported in 1999 by independent observations in Australia and South Africa (McBeath, 2004). We encourage other groups to continue the coverage of this interesting meteor shower.

The estimated population index (r) of the stream on the basis of the 35 observed meteors was 4.2±0.5, which

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Table 1 – LIADA visual observations of the 2005 γ-Normids (GNO). Only observations with Lm≥5.5 were considered in this study. Observers — BALPA: Pavel Balderas, MOYRO: Rosario Moyano.

Date	Tb (UT)	Te (UT)	$\lambda_\odot$	Teff (h)	F	Lm	GNO	SPO	Observer
3/8/05	05^h00^m	06^h00^m	347.67	0.83	1	6.05	3	7	BALPA
3/8/05	06^h00^m	07^h00^m	347.72	0.81	1	6.05	2	9	BALPA
3/10/05	05^h15^m	06^h15^m	349.68	0.75	1	6.25	5	10	BALPA
3/10/05	06^h45^m	07^h45^m	349.75	0.80	1.11	6.15	5	7	BALPA
3/11/05	05^h30^m	06^h40^m	350.70	0.88	1.25	5.85	3	4	BALPA
3/11/05	06^h40^m	07^h45^m	350.75	0.86	1.25	6.10	2	6	BALPA
3/12/05	07^h30^m	08^h30^m	351.78	0.85	1	6.30	2	7	BALPA
3/15/05	05^h30^m	06^h30^m	354.69	0.78	1	6.10	3	10	BALPA
3/15/05	06^h25^m	07^h25^m	354.73	0.98	1	5.50	1	2	MOYRO
3/15/05	07^h25^m	08^h25^m	354.77	0.98	1	5.50	1	2	MOYRO
3/16/05	06^h00^m	07^h00^m	355.70	0.86	1	6.00	3	5	BALPA
3/16/05	06^h04^m	07^h04^m	355.71	0.98	1	5.50	1	0	MOYRO
3/16/05	07^h04^m	08^h05^m	355.75	0.99	1	5.50	0	1	MOYRO
3/17/05	05^h30^m	06^h30^m	356.68	0.81	1	6.0	1	10	BALPA
3/17/05	06^h45^m	07^h45^m	356.73	0.88	1	6.0	1	6	BALPA
3/17/05	06^h33^m	07^h45^m	356.72	1.17	1	5.5	0	3	MOYRO
3/17/05	07^h45^m	08^h58^m	356.76	1.25	1	5.5	2	3	MOYRO
TOTAL				15.46		5.84 (Average)	35	92	

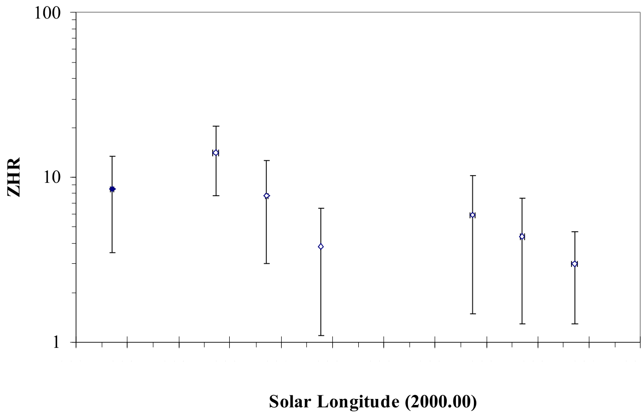

Figure 1 – Averaged ZHRs for the 2005 γ-Normids.

is far from the value usually accepted (Jenniskens, 1994; McBeath, 2004). Later on we realized that such a high value is probably wrong as a consequence of a bias in the magnitude distribution of faint meteors. The observers had not assigned meteors to the faintest magnitude classes (+5 and +6). Consequently, they overestimated the number of meteors in magnitude classes +3 and +4, which had the repercussion of increasing the population index value. When we noticed this problem it was too late, but it was a learning experience for the observers. Consequently, we decided to ignore the estimated population index and adopt the population index given in the literature. We are working together in order to correct these biases in future visual observations of our group.

Table 2 – Averaged values for the 2005 γ-Normids.

Date (2005 March)	$\lambda_\odot$ (°)	ZHR±Error
8.25	347.70	9 ± 5
10.27	349.72	14 ± 6
11.27	350.72	8 ± 5
12.33	351.78	4 ± 3
15.29	354.73	6 ± 4
16.27	355.70	4 ± 3
17.30	356.72	3 ± 2

4 Conclusions

The first detailed meteor observations from LIADA following IMO standards are presented. The γ-Normid meteor shower was clearly detectable over the sporadic background between March 8 and 16. A peak was observed on March 10 at $\lambda_\odot$=349.7° reaching ZHR=14±6, but the traditional peak at $\lambda_\odot$=352.3±0.5° (Jenniskens, 1994) was unfortunately not covered by the observations. Our activity pattern is a little bit different to that described by Jenniskens (1994), but the maximum was clearly advanced several days from the one suggested by Kronk (1988). However, our data is not extensive and future observations are required to study the activity and behavior of this interesting minor shower.

We hope that our results will encourage new observers to study meteor showers which are rarely observed. Among them, the γ-Normid meteor shower well deserves being the focus of future campaigns by other IMO Southern Hemisphere groups. Finally, we wish to mention that in the LIADA Interplanetary Matter homepage (`http://www.liada.net/meteoros.htm`) monthly information about our campaigns is being posted. Other groups are welcome to contact us in order to plan future common research.

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History

Meteor Beliefs Project: Notes from our correspondents

Alastair McBeath[1] *and Andrei Dorian Gheorghe*[2]

Several brief sections of prose and poetry with relevance to past beliefs in meteors are presented, from an eclectic selection provided to the Project by correspondents Guy Ottewell and Roy Watson.

1 Introduction

When we began this Project (McBeath & Gheorghe, 2003), we stressed the importance of contributions from people other than ourselves to make the whole work. As the Project has continued, we have been able to present various such contributed items more or less thematically. This time, we have decided to present a more random choice of quotations sent in to us, harking back to the inaugural article, which also presented a series of mostly unconnected items of meteoric interest. The pieces used here were found by two correspondents, Guy Ottewell (GO) and Roy Watson (RW), both from Britain.

Guy lived and worked for many years in the USA, and it was there he first began publishing his now-legendary, large format, annual Astronomical Calendar, sponsored by the Physics Department at Furman University (Greenville, South Carolina) in cooperation with the Astronomical League, currently distributed by Sky Publishing Corporation. All of his quotations were previously used as points of interest in the Calendar. For more information, see `www.universalworkshop.com`.

Roy's choices have come from his fascination with English literature, despite his being a Scot, coupled with his turning to advantage a protracted period of very severe illness during the last six years. Roy began visual meteor observing seriously in 1992, and has continued to do so ever since, when his circumstances have permitted in later years at least. He has also been working on some additional material for the Project, which we hope can be published in the relatively near future.

We have presented the quotations in approximate datal order, as far as this can be established, and have given a specific source for each, so anyone wishing to do so can confirm the information or, ideally, enjoy reading more, if non-meteoric, material from the same place.

2 An old Arab saying

wa-mâ l-mar'u illâ ka-sh-shihâbi, wa-ḍaw'ihi yaḥûru ramâdan ba'da idh huwa sâṭi' (Sabbagh, 1983, p. 21)

What is man but a meteor, and his light is reduced to ashes after he has been shining. (Quote provided and translated by GO).

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3 Middleton & Rowley's *The Changeling*

The play The Changeling was first performed in 1622, although the manuscript was unpublished until 1653, long after Thomas Middleton (1580–1627) and his somewhat less well-known co-author, William Rowley (circa 1585– circa 1625), both Englishmen, were dead. The quoted piece was provided by RW and is from near the play's end, in Act V, Scene iii, lines 154–155. The lines are spoken by Beatrice-Joanna, the play's leading lady ('lady' can be taken in a somewhat loose sense here, but 'heroine' would be hugely inaccurate, as the play revolves around her initiating the murder of those who stand in the way of her desires):

> Beneath the stars, upon yon meteor
> Ever hung my fate, 'mongst things corruptible;

(Thomson, 1971, p. 90.)

4 Herrick's *The Night-Piece*

This is another of RW's selections, from the poems of Englishman Robert Herrick (1591–1674). The text in question is in '*The Night-Piece, to* Julia', among his collected works published by John Williams and Francis Eglesfield in London in 1648, entitled 'Hesperides: Or, The Works Both Humane & Divine Of Robert Herrick *Eſq.*' Although Anglican clergyman Herrick spent his life unmarried, this poem is one of a considerable number of love poems written 'to Julia', some of which have a considerably more explicit erotic content than this lighter item. Lines 1–5 run:

> HER Eyes the Glow-worme lend thee,
> The Shooting Starres attend thee;
> And the Elves also,
> Whose little eyes glow,
> Like the sparks of fire, befriend thee.

(Martin, 1965, p. 217.)

5 Byron's *Manfred*

The final item from RW comes from George Gordon, Lord Byron's (1788–1824) play 'Manfred', Act I, Scene I, written in 1816–1817. The quote comes from lines 192–201, voiced by an unseen character at the start of a long incantation, which closes the Scene. Manfred has been alone in a gothic gallery at midnight, conversing with seven spirits, all of whom have departed, and Manfred has fallen to the floor senseless:

When the Moon is on the wave,
And the glow-worm on the grass,
And the meteor on the grave,
And the wisp on the morass;
When the falling stars are shooting,
And the answered owls are hooting,
And the silent leaves are still
In the shadow of the hill,
Shall my soul be upon thine,
With a power and with a sign.

(Coleridge, 1905, p. 399.)

Byron's usage of various nocturnal light effects, from the days long before serious man-made light pollution, is dramatically effective, as one would expect with a poet of his calibre. The 'meteor on the grave' is of the St Elmo's fire kind, as demonstrated by his subsequent reference differentiating it from 'falling stars' shooting across the sky.

6 Whitman, recalling Lincoln's memories of the 1833 Leonids

The remaining three quotes were all provided by GO. The first concerns some recollections of what was probably the Leonid meteor storm of 1833 by Abraham Lincoln, during his time as President of the United States of America, throughout the American Civil War. The War was fought between the predominantly northern USA, and the chiefly southern Confederate States of America, in 1861–1865. The comments come from a piece in American Walt Whitman's 'Specimen Days & Collect', first published in 1882 (here from (Whitman, 1909, p. 331, 'A Lincoln Reminiscence')). As Whitman never personally met Lincoln, though they both lived through the Civil War (Whitman's dates are 1819–1892, while Lincoln was assassinated just after the Civil War ended, in 1865), the quote must be at second-hand, though there is no reason to think that the majority of it is not accurately expressed. Abraham Lincoln was speaking to a delegation of bank presidents during the gloomiest part of the war, who had asked him whether his confidence in the permanency of the Union was not beginning to be shaken:

'When I was a young man in Illinois,' said he, 'I boarded for a time with a deacon of the Presbyterian church. One night I was roused from my sleep by a rap at the door, and I heard the deacon's voice exclaiming, "Arise, Abraham! the day of judgment has come!" I sprang from my bed and rushed to the window, and saw the stars falling in great showers; but looking back of them in the heavens I saw the grand old constellations, with which I was so well acquainted, fixed and true in their places. Gentlemen, the world did not come to an end then, nor will the Union now.'

7 Hopkins' record of the 1872 Andromedids

Gerard Manley Hopkins (1844–89) was an English poet of considerable religious experience. He left behind a large collection of religious and secular papers, lectures and notes, of which it is his 'Journal' we are most interested in here. He recorded often minute details of things he had seen and experienced in his travels or in places he stayed, and had a particular fascination with describing weather phenomena, especially clouds, and wildlife. The section below is from 1872 November 27:

Nov. 27–Great fall of stars, identified with Biela's comet. They radiated from Perseus or Andromeda and in falling, at least I noticed it of those falling at all southwards, took a pitch to the left halfway through their flight. The kitchen boys came running with a great todo to say something redhot had struck the meatsafe over the scullery door with a great noise and falling into the yard gone into several pieces. No authentic fragment was found but Br. Hostage saw marks of burning on the safe and the slightest of dints as if made by a soft body, so that if anything fell it was probably a body of gas, Fr. Perry thought. It did not appear easy to give any other explanation than a meteoric one. Br. Starkey saw and heard also but was odd and close about it.
(House & Storey, 1959, pp. 227–228.)

The editors' footnotes to this segment indicate that Father Perry was Stephen Joseph Perry, a Jesuit priest and an astronomer of international reputation, at the time Director of the Stonyhurst Observatory. Brother Hostage was Joseph Hostage, Perry's assistant at the Stonyhurst Observatory during his directorship. Hostage was formerly a railway engineer, and subsequently improved many of the Observatory's instruments, some of which improvements were adopted by the Meteorological Office. Brother Henry Starkey was a carpenter, and at the time of this Andromedid event was in charge of the Refectory at Stonyhurst.

8 Frazier's *Cold Mountain*

Cold Mountain was American Charles Frazier's first novel, published in 1997, since made into a successful film. It was set during the American Civil War, and chronicled the journey of a wounded Confederate soldier, Inman, as he tried to make his way back to his home, Cold Mountain in North Carolina, across a war-ravaged land. The quote comes from the third chapter, 'The Color of Despair', in which the time is probably August:

The night just passed had been the worst. The clouds had broken open and revealed meteors flinging themselves out of an empty point of sky. They had shot in on whizzing trajectories that Inman took to be aimed decidedly himward. Little projectiles flung from on high. Later, a great fireball had come roaring out of the dark, moving slow but aimed to land directly atop Inman. Before it had reached him, though, it simply disappeared like a candle flame pinched out with spittled finger and thumb.
(Frazier, 1998, pp. 66–67.)

9 Conclusion

As we began both the Meteor Beliefs Project and this article, so we end here by reminding everyone reading this that interesting snippets or quotations regarding past or present beliefs in meteors are always welcomed. We may not be able to use everything that is sent to us, but please do not be put off by that, or the thought that your material might duplicate something we have seen already. We would rather be sent repeated material, than miss the chance to bring something obscure or long-forgotten back to light.

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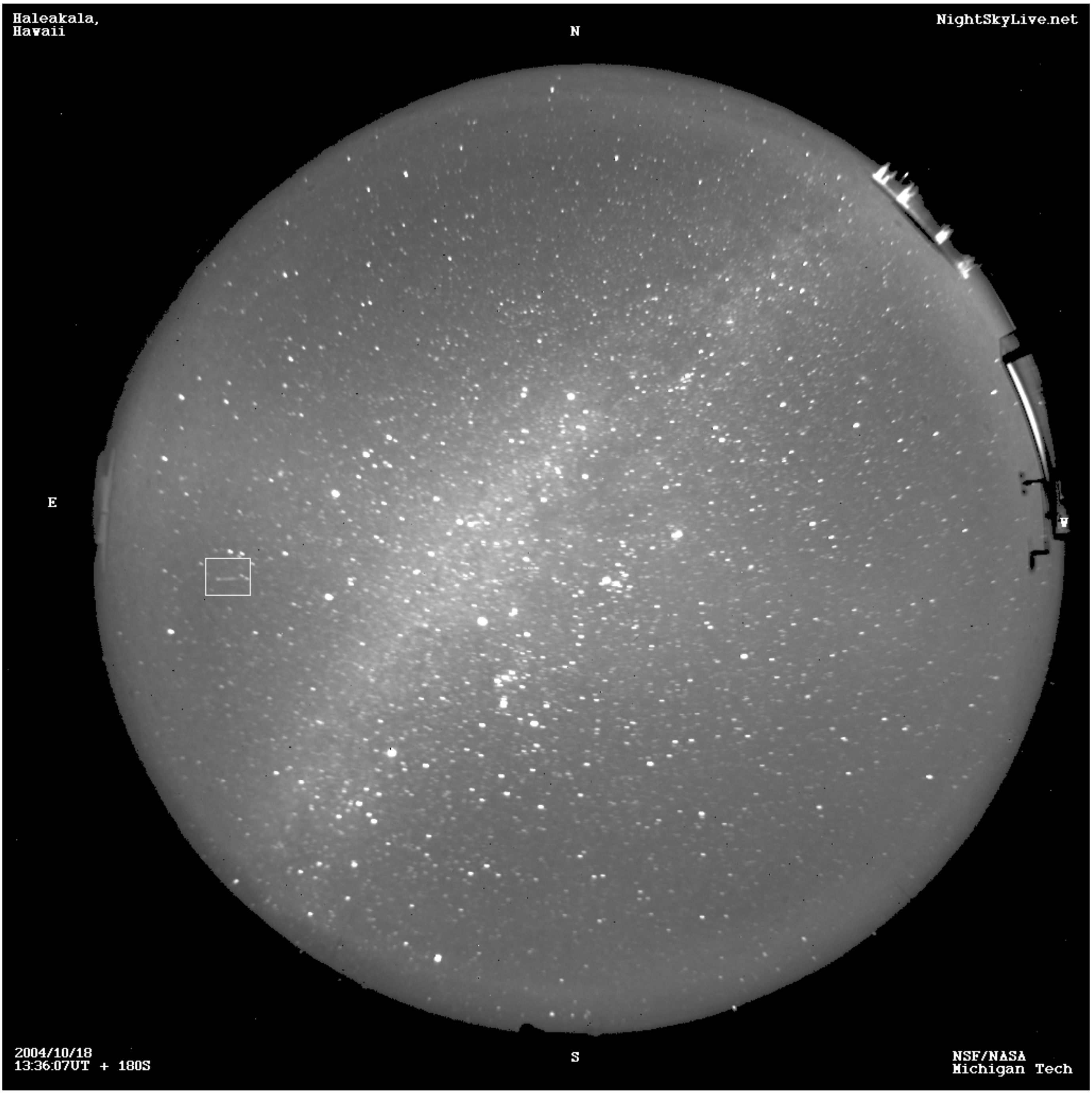

A meteor (in the white rectangle)
recorded by the CONCAM Night Sky Live camera
at Haleakala, Hawaii.
For details, see the article on page 75.