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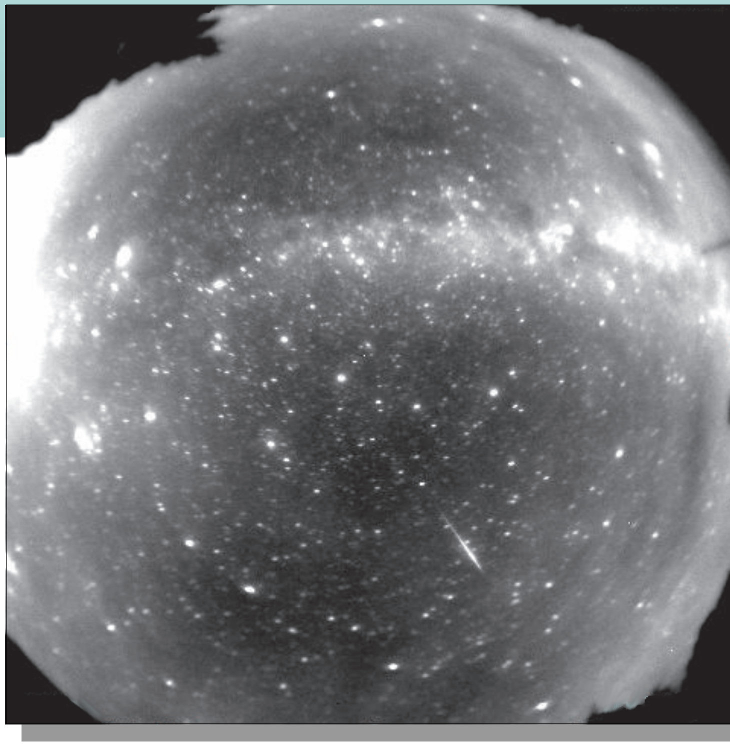

Radio meteors
Leonids from Greece
Minor-shower research
Shakespeare and meteors
Meteor-shower association

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Front cover photo

A fish-eye view of the sky with a fireball heading south-west. Taken by the CONCAM camera on Kitt Peak, Arizona, operated by Michigan Technological University in Houghton, Michigan, USA. North is up and east is to the left. See `http://concam.net` for details of this project.

Future covers

Have you an interesting or spectacular meteor photograph that you think would look good on the cover of WGN? If so, please offer it to us. For the moment we can only accept machine-readable forms. More or less any image format will do, though ideally not JPEG as the JPEG compression algorithms lose information. A brief description will also be required: this should say what the photograph shows, when and where it was taken, plus (if possible) technical details such as the camera and exposure. We can be contacted at `wgn@imo.net`.
Any photograph submitted during 2003 will be entered for the competition — see next page.

Cover design Rainer Arlt

Editorial

Chris Trayner

Does WGN exist to serve professional or amateur astronomers? Our answer, very emphatically, is ‘both’. Meteor studies are an area where amateurs can make a real contribution to science. This is part of the reason for the IMO’s existence: it produces high-quality observations for theoretical astronomers to analyse.

Those who read professional astronomy journals will realise that professional astronomers do use the IMO’s results. This is shown by the amount of IMO-generated material referred to in professional papers: IMO meteor observations, WGN papers, and papers by IMO members published in other journals. We are not just producing data which no-one else ever looks at.

The theoretical analyses are not only performed by professionals. A look at the contents pages of a year’s WGNs will show plenty of good theoretical work by IMO members. As Rainer Arlt said in one such paper (WGN 31:1, p.27), ‘comprehensive analyses are a readily achievable goal for many amateur astronomers . . . a lot of projects are waiting!’

Some WGN readers have been interested in meteor science for years and are very knowledgable. Others have come to it more recently, however, and have less knowledge. Most of us would like to know more. To help people learn more, WGN is starting a series of **Fundamentals of meteor science** articles. Many will deal with the more elementary aspects of meteor science, but others will look quite deeply into the subject. They will be written by experienced IMO members, who will bring together the sort of information you might have to read several textbooks to find.

The series starts in this issue, with Bob Lunsford and Rainer Arlt’s article on meteor shower associations on page 117.

I should like to thank Alastair McBeath for suggesting the idea of this series.

Writing for WGN

WGN depends on its authors, and they provide very professional papers for us to publish. Not all of us are trained in the writing of scientific papers, however, and many would appreciate some guidance. We are therefore printing some information for authors on page 124. There is also information for writers who use LaTeX, to help them use it in WGN’s style.

Photographic competition

The new layout of WGN allows us to print photographs on the back cover as well as the front. To encourage this, we are announcing a photographic competition. A prize will be given for the best meteor photograph submitted to WGN. All photographs submitted by the end of this year will automatically be entered. The formats accepted are those for any WGN photo — see the inside of the front cover. The prize will a book of astronomical photographs.

IMC 2003 — not too late

This year’s International Meteor Conference will be held in September in Germany. It is not quite too late to book. Details can be found in April and June issues of WGN.

Hypothetical new showers

On the small meteor outburst of 1996 June 15–16

Alexandra Terentjeva[1]

The meteor activity on 1996 June 15–16 was caused by the known γ-Draconid meteor shower (Terentjeva, 1968).

Received 2003 June 6

1 Introduction

A small meteor outburst was observed in the Netherlands by Marco Langbroek (1996) during the night of 1996 June 15–16. Meteors dispersed from a radiant $\alpha = 280°$, $\delta = +55°$ (1950.0). During 1.9 hours, 38 meteors were observed: 25 of these were sporadics and 13 meteors were seen to disperse from the above-mentioned radiant. Consequently, a relative activity of this minor shower was 34%. Marco Langbroek reported that the meteors from this radiant had a velocity 'on the edge of medium fast to fast (comparable to Lyrid meteors, i.e., about 50 km/s), a distinct yellowish color and a short persistent train'. The highest activity was determined as around $23^{\mathrm{h}}35^{\mathrm{m}}$ UT with a peak ZHR of the order about 20. Marco's opinion was that 'there has indeed been activity from a previously unknown stream'. Therefore he has decided to call the shower the 'ξ-Draconids' (Figure 1).

2 Analysis

I have compared the data of these observations with the parameters of minor meteor showers of the well-known catalogues. There are grounds to suppose that the activity of radiants $\alpha = 280°$, $\delta = +55°$ determined by Marco Langbroek, $\alpha = 274°$, $\delta = +54°$ determined by Robert Lunsford and $\alpha = 280°$, $\delta = +53°$ determined by George Zay (Langbroek, 1996) is caused by the γ-Draconid meteor shower (No. 216 in Terentjeva, 1968). This shower has two groups of radiants, (a) and (b), and two groups of orbits corresponding to them. Besides, the visual radiant No. 679 (Astapovich, 1956), which was observed before 1886, has a probable connection with the γ-Draconids (a). It is also of interest that I.S. Astapovich gives a radiant (from visual observations) of the June Draconid meteor shower (No. 131 in Astronomical Yearbook, Permanent Part, 1962, p. 625): June 13–28, $\alpha = 271°$, $\delta = +46°$; the diameter of the area of radiant dispersion is 3°. The shower has a velocity of 39 km/s and the number of meteors per hour is 4. The shower contains fireballs and bright meteors. There is no doubt that the radiant of these Draconids belongs to the γ-Draconids (b) (Table 1). Thus, the duration of the γ-Draconid activity extends up to June 28.

One should note the following. Marco Langbroek reports 'a distinct yellowish color' of the ξ-Draconid meteors, their similarity with the Lyrids. But first of all, the dominant color of the Lyrid meteors is white (observations by R. Khotinok, G. Zay et al.). This suggests that the geocentric velocity of the ξ-Draconid meteor shower is less than the 47 km/s of Lyrid velocity. Secondly, subjective estimation of angular velocity on an arbitrary scale at the time of visual observations may have an error of as much as ±14% to ±19% (Astapovich, 1949). In that case the velocity of the ξ-Draconids may by overestimated by 7–9 km/s (relative to the Lyrid velocity). Taking into account the information given below the ξ-Draconid velocity will correspond to the velocity of the γ-Draconids (Table 1).

Rainer Arlt (1996), analysing the IMO observations of a radiant near ξ-Draconis around 1996 June 16, also concluded that an estimate of the ξ-Draconid geocentric velocity was somewhat higher. And certainly a problem of mutual contamination of the observational samples of June Lyrids and ξ-Draconids (γ-Draconids) by each other exists (Gyssens, 1996).

3 Acknowledgment

This research is supported by the Ministry of Industry, Science and Technologies of Russia (Contract No. 40.022.1.1.1108, February 1, 2002).

Table 1 – Orbital parameters of the γ-Draconid minor meteor stream. (Equinox 1950.0)

No.	Dates	Corr. Rad. α	δ	V_∞ km/s	V_h km/s	a AU	e	q AU	ω	Ω	i
216 [1]	May 25 – June 11	(a) 276°	+52°	32.4	38.6	3.58	0.72	0.98	201°	64°	50°
		(b) 275	+50	39.3	44.9	−3.68	1.30	0.98	202	76	56

Note: [1] Terentjeva (1968).

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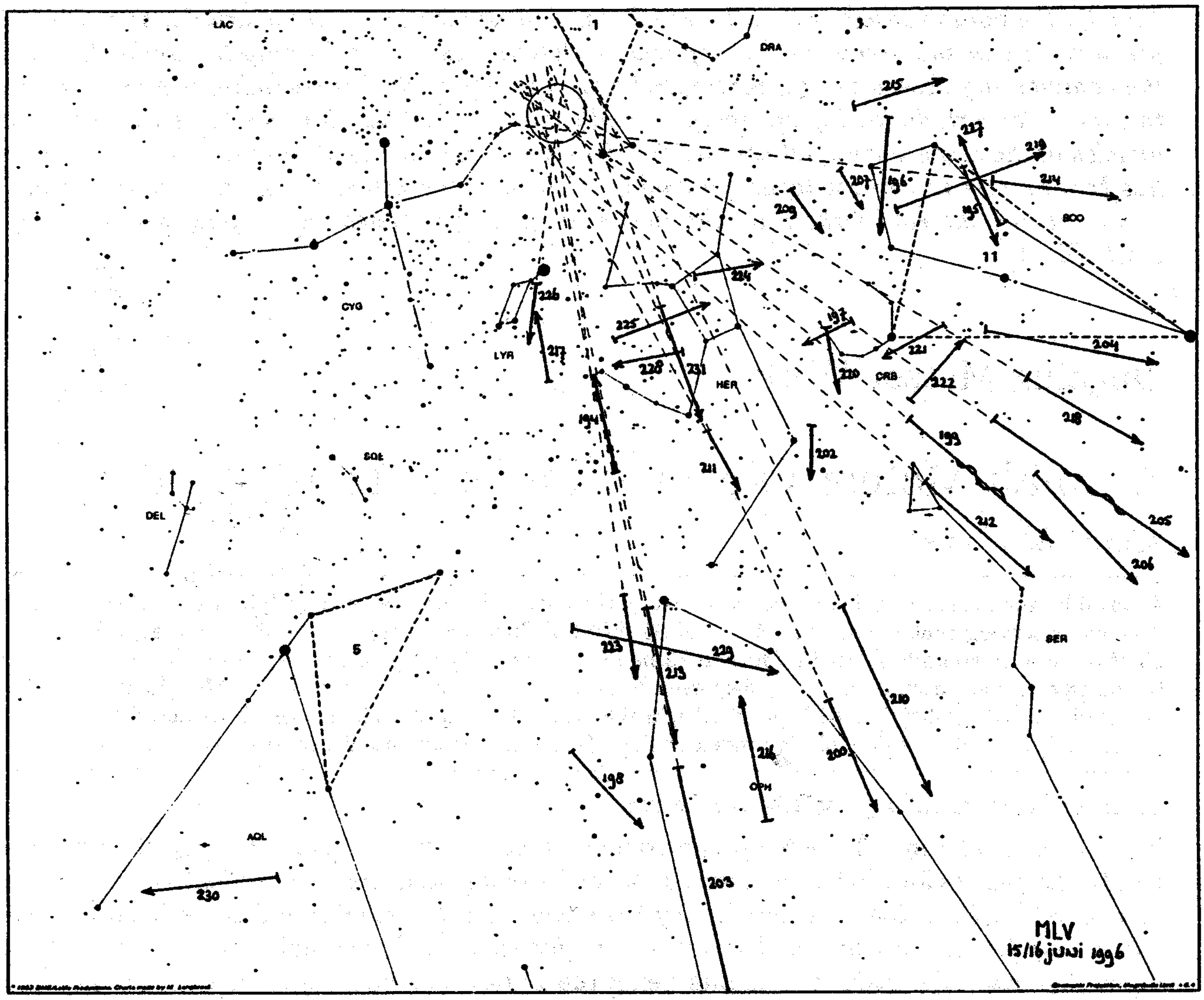

Figure 1 – Marco Langbroek's original presentation of the proposed 'ξ-Draconids'. From (Langbroek, 1996).

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Ongoing meteor work

Greek observations of the 2002 Leonids

Petros Georgopoulos[1]

The results of the Greek observations of the 2002 Leonid storm are presented in this paper. The analysis is based on data from two observers, spanning a period of 2.5 hours, and 875 recorded meteors. We find a ZHR of the order of 3000 and a very low population index of $r = 1.2$ before the storm, climbing to $r = 1.8$ at the peak.

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1 Observations

From the experience of the last three years, it turns out that the most important variable when observing a Leonid meteor storm is the weather... Unfortunately, in the last couple of years, a weather pattern has been emerging in mid-November in Greece: foggy weather. This problem made its appearance this year as well, and very low altitude fog hampered the previous night's observations (November 17/18) from a reasonably dark sea-level location (we could barely see magnitude +2 stars). Obviously this dictated a mountaintop site for viewing the activity peak the next morning!

Therefore, we (the small group was made up by Petros Georgopoulos, Grigoris Maravelias and Nikiforos Georgiadis) were planning an excursion to some mountain on one of the Ionian Sea islands (between Greece and Italy) to also gain a quarter of an hour or so before sunrise. However, the forecast the previous day suggested that a low-pressure system from Italy would move East and affect Greece in the morning hours of November 19. Therefore, on the afternoon we decided to finally move to Southern Greece instead, towards the mountain Taygetos near Sparta, were we could possibly avoid the incoming bad weather.

Figure 1 – The team of observers. From left to right: Grigoris Maravelias, Petros Georgopoulos and Nikiforos Georgiadis.

When we reached Sparta at night the weather was clear, but at midnight, as we pulled away heading for the mountain, we found out that it was overcast... This was quite discouraging at first, but we continued towards the mountain, and with relief we saw that as we were gaining height and leaving the valley behind, we were also leaving behind the heavy cloud cover. Obviously the clouds were due to low-altitude fog that was forming over the valley.

With the weather headache now left behind, and clear skies above, we were looking for a good high altitude location to set up and get ready for the observation, which did not take us too long. Having several hours before the Leonid peak we then decided to try to find a higher mountain peak. This decision turned out not the best we could make since we ended up 100 km away, trying to reach a 1800-m site via an unsurfaced road, which was certainly not for our vehicle! So we turned back and arrived at the first location (1230 m) just in time to start the observations.

There, Murphy's law wasn't avoided and in the dark Grigoris had accidentally pressed a button on his tape recorder that he shouldn't have, and in the rush to start observing he couldn't figure out what was wrong. So he left the recorder aside and took up paper and pencil. This meant that when the activity became stronger he dropped the magnitude estimates, as he couldn't write everything down that fast. The misfortune however was double since my tape recorder door at about the same time didn't close fully, after I changed the tape, and nothing was recorded after $04^{h}05^{m}$ UT...

2 Analysis

Moreover another Greek observer (Manos Kardasis), who observed the storm from a seaside location near Athens, experienced variable cloud coverage and limiting magnitude due to the foggy conditions, and therefore his data were not taken into account in this analysis.

However, despite those misfortunes, there were enough data to perform some analysis and derive a meaningful value for the ZHR. Of course in order to do so a value for the population index must be determined first. This was done by fitting an exponential function ($y = Ar^{m}$) to the magnitude distributions of

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both observers for specific time periods (selected so as to have a large number of meteors, i.e. > 50). The fit was limited to data up to magnitude +3 (two brighter than the limiting magnitude) where perception probabilities start to become important (Koschack & Rendtel, 1990). The effect can be observed in Figure 2.

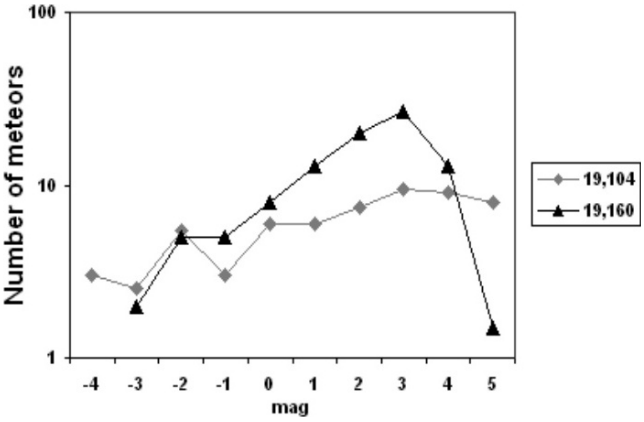

Figure 2 – Logarithmic plot of the meteor brightness distribution for two different time periods (denoted by corresponding UT dates) for observer PG.

The results are presented in Table 1, and plotted in Figure 3. Notice that the population index values found are extremely small before the peak, and there is a sharp rise to more normal values as we approach the peak. Unfortunately there were no magnitude data at and after the peak.

Table 1 – Population index data of the 2002 Leonids.

Date UT	Time UT	r
19.1042	2:00–3:00	1.20 ± 0.1
19.1354	3:00–3:30	1.33 ± 0.2
19.1510	3:30–3:45	1.28 ± 0.1
19.1597	3:45–3:55	1.48 ± 0.1
19.1667	3:55–4:05	1.80 ± 0.4

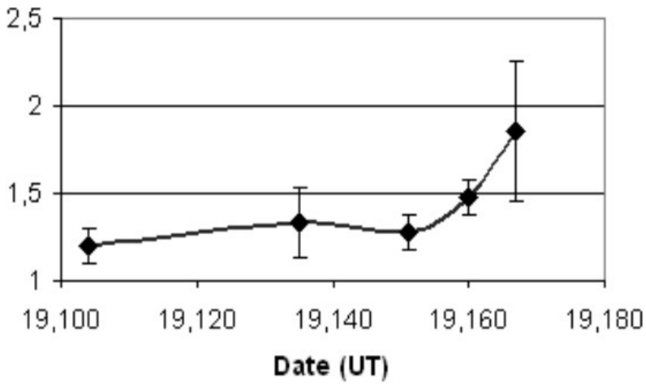

Figure 3 – Population index profile of the 2002 Leonids.

However these r-values are about 60% lower than those stated on the Preliminary Global Analysis by Arlt et al. (2002), but the resulting ZHR is roughly the same, to an order of magnitude. Thus, if higher values of r are to be used then the ZHR will more than double! To explain this inconsistency the LM had to be greater than the observers had assumed and/or the meteor magnitudes were overestimated. If this is the case, the presence of the moon may have played a role in this.

Based on these values of r and the observer counts a value of ZHR was deduced for each observer, as well as an average ZHR rate. These results are presented in Figure 4. Notice the good agreement between the observers, however the peak data are only based on one observer alone. Also note that the large error bars around the peak are not due to statistical errors but mostly due the error in determining the population index r (as given above), which has been calculated with the error transmission formula (c is an arbitrary constant):

$$\delta N = \sqrt{N + \left(\tfrac{\partial N}{\partial r}\delta r\right)^2}$$
$$\overset{N=cr^{\Delta m}}{\longrightarrow} \quad \delta N = \sqrt{N + \left(\Delta m \tfrac{N}{r}\delta r\right)^2}.$$

Moreover, a Gaussian function has been fitted around the peak by means of least squares. The resulting best fit parameters are: $\mathrm{ZHR_{peak}} = 2930$, $T_{\mathrm{peak}} =$ November 19.17365 ($04^{\mathrm{h}}10^{\mathrm{m}}$ UT), $\sigma = 0.005967$ days $\rightarrow$ FWHM $= 2.35\sigma = 20.2$ min. (FWHM is the Full Width at Half Maximum, i.e. the time interval between the times at which the ZHRs were half their maximum values.)

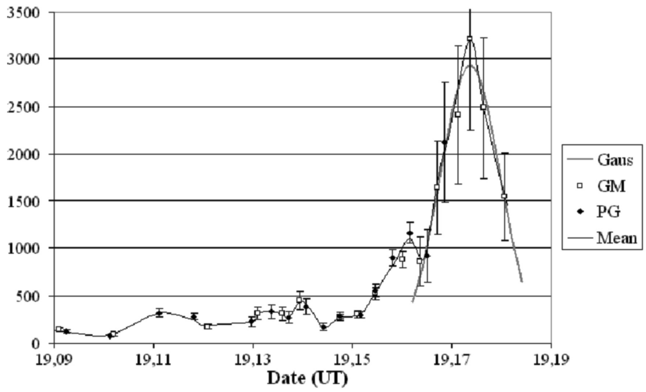

Figure 4 – ZHR profile of the 2002 Leonids.

3 Conclusion

The 2002 Leonid meteor storm did materialize on the morning of November 19 and was observed from Greece as well as to other locations worldwide (Olech, 2003). In spite of some difficulties, these observations can reveal useful information on the storm. Although there is large uncertainty about the exact peak ZHR that was deduced, the time of the peak itself was shown to be somewhat later than predictions. And most important, the activity profile of the peak was much sharper than expected (McNaught & Asher, 2002; Vaubaillon, 2002), since an FWHM of just 20 min was displayed. Moreover, another important characteristic that was observed was the rise of the population index in tandem with the meteor activity, which means that the peak was mostly a result of the intensification of fainter meteors.

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SPA Meteor Section results: preliminary report from 2003 April 20–26

Alastair McBeath[1]

Radio data from 2003 April 20–26 inclusive are presented and discussed. From these results, a relatively weak Lyrid return is suggested, with a maximum probably on the UT night of April 22–23, but no evidence to support any significant π-Puppid activity around April 23 or 24 was found. π-Puppid rates at about the visual detection threshold may have happened from roughly April 23–25, however, from the radio and limited visual data. A by-product of the detailed radio analysis between these dates was the apparent recovery of the minor daytime April Piscids and the δ-Piscids, which suggested a peak around April 22 or 23, perhaps either a slightly later April Piscid maximum or an early δ-Piscid one.

Received 2003 July 1

1 Introduction

The possibility of a (perhaps faint-meteor) π-Puppid return in 2003 April, coupled with its near-coincidence in time to the Lyrid maximum, prompted me to examine the April radio data during this epoch more closely than previously, where generally only the Lyrid maximum has been particularly well studied. The most probable meteorically-interesting periods, and the need to provide some comparison spells away from these, resulted in choosing the interval between 12^{h} UT on April 20 and 12^{h} UT on April 26 inclusive to consider in detail.

Many of the radio results were extracted from Radio Meteor Observation Bulletins (RMOBs) 117 and 118, April and May 2003 respectively, produced and kindly provided by Chris Steyaert (also available at `www.rmob.org`), but reports were received directly from observers Dirk Artoos in Belgium and Robert S White in England too. The RMOB observers covering the selected interval included:

> Enric Fraile Algeciras (Spain), Mike Boschat (Nova Scotia, Canada), Walter Boschin *et al.* (Italy), Jeff Brower (Colorado, USA), Maurice de Meyere (Belgium), Thierry Duhagon (France), Kenji Fujito (Japan), Ghent University (Belgium), Patrice Guérin (France), Kazuyoshi Kanatsu (Japan), Steve Hansen (Massachusetts, USA), Michael Krocil (Czech Republic), Naoki Moriwaki (Japan), Kazuyuki Nagao (Japan), Stan Nelson (New Mexico, USA), Hiroshi Ogawa (Japan), Sadao Okamoto (Japan), Mike Otte (Illinois, USA), TianJing Ouyang (China), Robert Savard (Quebec, Canada), SKiYMET radar (Norway; data via Johannes Weiß), Dave Swan (England), Istvan Tepliczky (Hungary), Yung Cheich Tsao (Taiwan, China), Takashi Usui (Japan), Bruce Young (Queensland, Australia), Ilkka Yrjölä (Finland).

Other data (visual and video) from the period of interest was scant for the Lyrids, with datasets from April 22–23 available from three observers in England, Steve Evans (video), David Entwistle and the author (both visual), but fortunately the IMO shower overview has already been published (Dubietis & Arlt, 2003), and was used as comparison material. For the π-Puppids, a series of summarized visual reports from South Africa was kindly provided by Tim Cooper (personal communications, 26 April and 4 May 2003), supplemented by additional summarized details from a dedicated webpage set up by Jeremie Vaubaillon at `www.imcce.fr/s2p/puppids/2003results.html`. A copy of this latter data was also provided by Tim Cooper. The observers involved and not already listed included:

> **Visual:** Mike Begbie, Tim Cooper, Jean Deleu, Mauritz Geyser, Berto Monard, Jan Plomp, Magda Streicher, Andre van Staden, Tony Viljoen, Herman Wiechers, Neville Young (all in South Africa); Adam Marsh (Australia), Kazuhiro Osada (Japan), Carles Pineda (Spain), Quanzhi (China), Hans Salm (Bolivia; also binocular observations), Albert Sánchez (Spain), Josep Trigo-Rodríguez (Spain), Chia yk (Singapore).
> **Radio:** Javor Kac (Slovenia), George Lauffer (Germany), Jean-Marìe Polard (Belgium), Marcel Schneider (Luxembourg).

2 Radio analysis

The raw radio results were analyzed according to the procedures outlined in (McBeath, 2001) as usual. In the first instance, only results recorded continuously throughout the selected interval were examined, where observing or equipment problems permitted, and where such problem times were clearly identified. Non-hardware difficulties reported by the observers included thunderstorms, Sporadic-E, Auroral-E and tropospheric propagation, unidentified noise and direct signal reception, although these were typically fairly minor, and generally affected at most only a few hours on some days.

This reduced dataset was then compared with all the known active shower radiant elevations. In order to keep this comparative stage to manageable proportions of time, single radiant elevation graphs were prepared for each of four geographic regions, Europe, North America, the Far East and Australia, based on the mean geographic coordinates of the active RMOB observers away from high northern latitudes, ϕ north of 55° N. This $\phi > 55°$ N criterion was selected, as from such a site the π-Puppid radiant's best elevation is $-10°$,

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the theoretical sub-horizon elevation where potential visual observations of a shower are no longer possible, based on geometric considerations (see Chapter 7 by Ralf Koschack in (Rendtel et al., 1995)). This was felt a reasonable choice for radio observations in this instance too. The point is discussed further in Section 4 below. Table 1 gives these mean geographic-site values, but note that only a single Australian dataset was available, so this is technically not a mean!

Table 1 – Mean geographic coordinates for the four identified areas of active RMOB radio observers during the April 20–26 interval.

Area name	ϕ	λ
Europe	$47^\circ\!.8$ N	$6^\circ\!.4$ E
North America	$41^\circ\!.2$ N	$87^\circ\!.0$ W
Far East	$34^\circ\!.6$ N	$135^\circ\!.0$ E
Australia	$27^\circ\!.2$ S	$153^\circ\!.0$ E

Table 2 gives the sky positions for April 23 of all the known active radiants during the April 20–26 period. While not all the daytime showers are currently considered active throughout this period (and the Lyrids have usually dropped below visual detectability by April 25), to simplify the analysis, all showers were assumed to be potentially active to radio observations on April 23. The radiant positions were interpolated from the radiant drift values in Table 6 of (McBeath, 2003) for the night-time showers. For the daytime showers, they were computed assuming suitable mean theoretical daily drift speeds for their sky locations of $\Delta\alpha = +0^\circ\!.8, \Delta\delta = +0^\circ\!.4$ for the April Piscids and $\Delta\alpha = -0^\circ\!.75, \Delta\delta = -0^\circ\!.28$ for the ϵ-Arietids, compared to the positions for their respective maxima on April 20 and May 9. The δ-Piscid radiant was assumed using its April 24 maximum position. The resultant radiant elevations over time were plotted as four graphs, Figures 1–4 here.

Table 2 – Assumed and calculated active radiant positions for April 23.

Shower	α	δ
Lyrids	272°	+34°
π-Puppids	110°	−45°
η-Aquarids	326°	−6°
Sagittarids	232°	−19°
April Piscids	9°	+8°
δ-Piscids	11°	+12°
ϵ-Arietids	32°	+16°

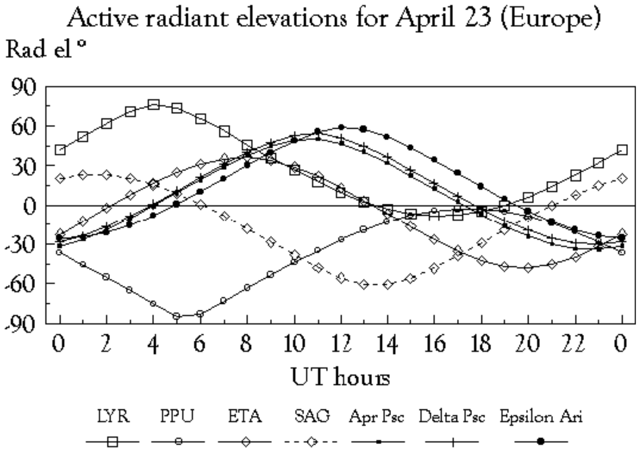

Figure 1 – Active radiant elevations as seen from Europe on April 23, based on data in Tables 1 and 2.

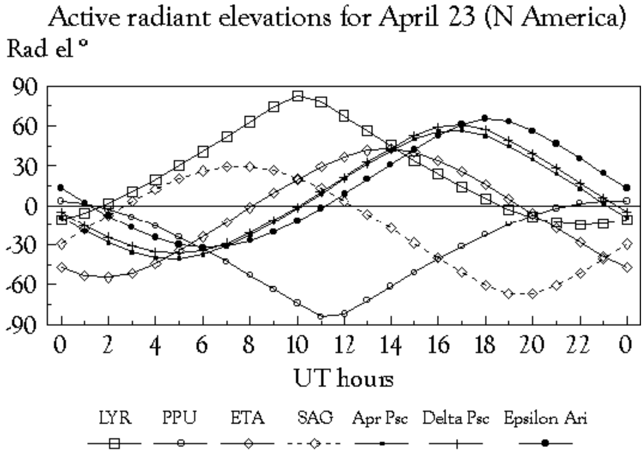

Figure 2 – As Figure 1, but for North America.

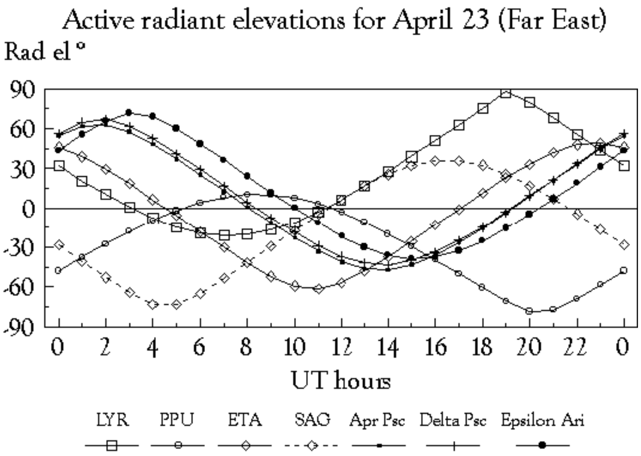

Figure 3 – As Figure 1, but for the Far East.

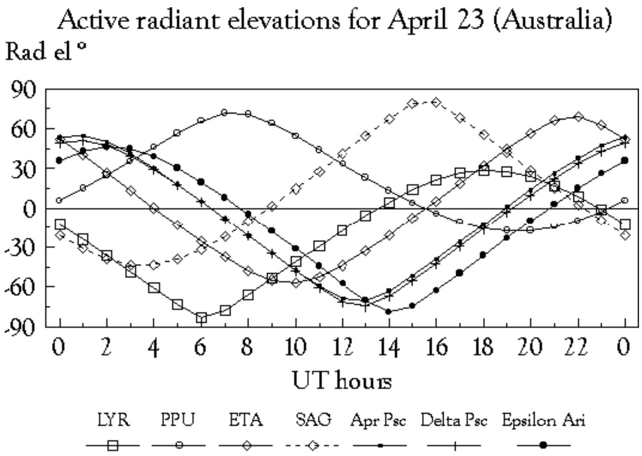

Figure 4 – As Figure 1, but for Australia.

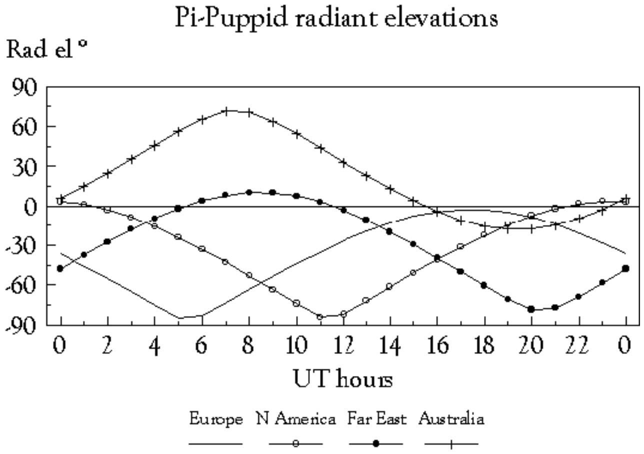

Figure 5 – Radiant elevations for the π-Puppids from the four geographic areas identified, for April 23.

The importance of determining potential coverage for the π-Puppids led to the creation of Figure 5 as well, showing the radiant elevations — or lack thereof — for this shower from the various geographic regions, again for April 23. In using these graphs, it is important to appreciate that the mean geographic positions used may cause a shift of one hour or so to either side of the given line, and that sites north or south of the mean will raise or lower the potential radiant elevations slightly (few degrees), dependent on the individual locations compared to the radiant declinations. However, this does not invalidate the graphs' utility, given the uncertainties in radio meteor observing overall, and that radio count data are typically presented only in hourly bins. The unfortunate circumstance that only one dataset, Bruce Young's from Australia, enjoyed an especially useful π-Puppid radiant elevation, was confirmed by this.

Owing to the close spatial proximity of the April and δ-Piscid radiants, the April Piscid radiant was adopted to represent the effective location of both showers, and hence their radiant elevations, for all subsequent consideration, because of the extant complexities in the daily radiant elevation graphs. The δ-Piscids were assumed from what little is suspected of them to be probably active on just one date, most likely April 24, in any case.

A comparison was then made between the diurnal radiant elevation curves and the raw radio data not stated as affected by interference or other problems. A small number of anomalously strong peaks in individual datasets were noted and re-examined. In almost all cases, these were dismissed from further consideration, as they failed to appear with similar strength in any other reports, thus were most likely due to unidentified local interference. Other problems were found at this stage, including a small number of results which showed no obvious sign of any probable Lyrid activity on April 22 or 23 compared to dates to either side, or where rates actually fell on these two dates. This may be due to something akin to the system saturation which several radio observers have encountered during the stronger Leonid returns of recent years, where fresh meteor echoes are swamped and lost due to continued echoes from earlier trails, or it may reflect problems in the sensitivities of the receiving/transmitting aerials. The affected datasets were given lesser weight in subsequent examinations. Some European observers continued to find a drop-out in activity thanks to transmitters closing down in the hours around local ($\simeq$ UT) midnight, as I have noted before. Sadly, we are never short of possible pitfalls in radio meteor analyses.

Once this potential problem review was completed, the inspection of items of possible interest was begun. Figures 6–11 were chosen for illustration of the general radio results here, as being among the more complete and usefully representative of the surviving samples, and covering each of the four geographic areas.

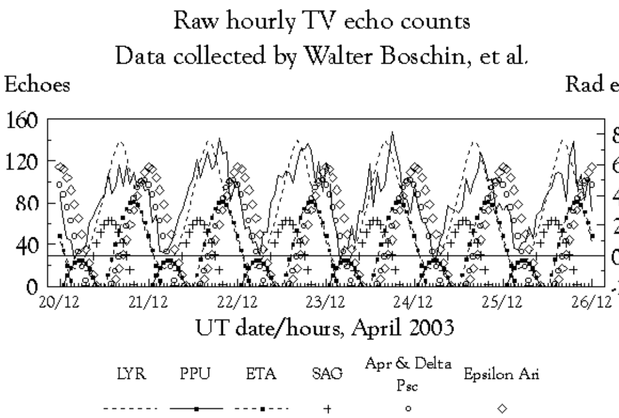

Figure 6 – Raw hourly TV meteor echo counts across the 2003 April 20–26 interval, in data collected by Walter Boschin, Diego Ganzini, Alessandro Candolini and Giuseppe Candolini. In each of Figures 6–11, the thicker, irregular line, keyed to the left-hand y-axis, shows the raw hourly echo count values, while the various other daily symmetrical curves (all keyed to the right-hand y-axis) give the active radiant elevations for the indicated showers, according to the appropriate geographic region (in this case, Europe). All the radio meteor graphs here were derived from systems which were in continuous operation.

3 Lyrids

In previous years, the Lyrids' radio peak has often been well-defined, and has stood out against the generally lower rates for much of the rest of the month, as recorded in earlier SPAMS results articles in this jour-

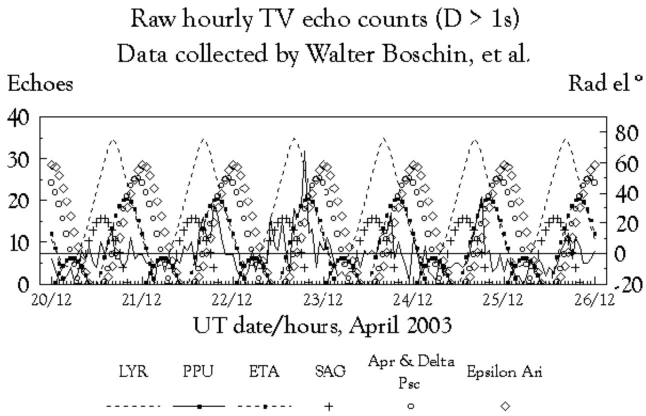

Figure 7 – As Figure 6, but for TV meteor echoes longer than one second in duration, normally taken as representative of brighter meteors.

nal, and in (McBeath, 2001). This has tended to be less so in some of the last few years. Again in 2003, as Figures 6–11 indicate, an ill-defined maximum was present in many datasets on April 22 or 23. The longer-duration echo data collected by Walter Boschin *et al.* (Figure 7) shows a sharp peak between 07^h–08^h UT on April 23, although rates were also preferentially, if less strongly, enhanced at the same time on the previous day, both coincident with some of the Lyrids' best radio-visible times. No other suitable longer-duration results were available during this time interval from Europe, so this peak could not be confirmed, and it does not feature significantly in the all-echo count traces.

From the better radio results as a whole, it seems likely the main shower peak fell on the night of April 22–23 over Europe, and was probably rather weak, but no specific timing can be suggested beyond this from the available information. Thus the visual maximum time found at $\lambda_\odot = 32\overset{\circ}{.}32$, $\simeq 22^h$ UT on April 22, by (Dubietis & Arlt, 2003) could not be confirmed precisely. The normal-level highest ZHR found visually (18.5 ± 1.7) also appears stronger than the radio results indicated, as similar ZHRs have produced a clearer radio peak in the past. This may be more of a problem with the European radio data however, as the visual peak time coincided with the onset of some of the overnight transmitter shut-downs. Some of the Japanese radio data (from where the Lyrid radiant was still readily radio-visible around 22^h UT on April 22–23, well after dawn; see Figure 3) showed a peak at 22^h–23^h UT on April 22, but these also commonly showed equal or higher echo count numbers in hours well before or after this time on April 22–23, with no common consensus as to when these better rates occurred, unfortunately.

4 π-Puppids

The π-Puppids meteor shower has only been observed since 1972. It gained a reputation for producing occasional bursts of stronger activity (ZHRs $\simeq 40$) following the returns of 1977 and 1982, both years when its parent comet, 26P/Grigg-Skjellerup, was at perihelion. Weaker activity was sometimes found in other years as well, at best in 1983 when the ZHR was $\simeq 13$, but most non-perihelion years saw either no sensibly detectable rates, or only very weak ones. Regrettably, the shower radiant's southerly declination coupled with the general lack of active southern hemisphere visual observers since the mid 1980s, means it has received far less coverage in recent years than is desirable. For details on the shower's past see (Kronk, 1988, pp. 57–59) and (Rendtel et al., 1995, pp. 160–162).

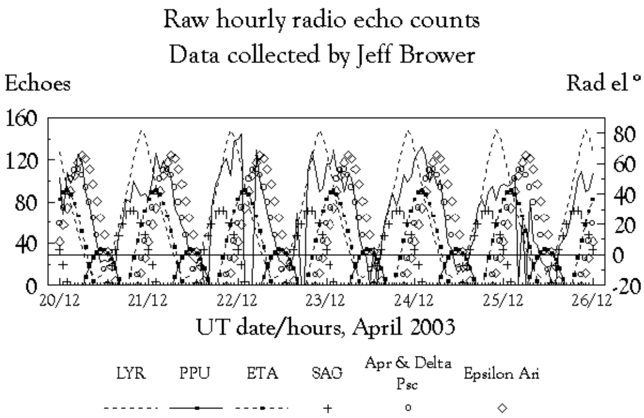

Figure 8 – As Figure 6, but for radio results collected by Jeff Brower (and using radiant curves for North America). Jeff identified several short periods of auroral interference or direct reception, which are shown by drops to zero in the echo count line.

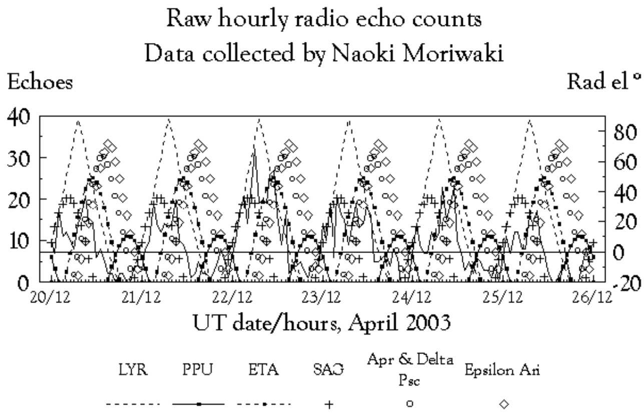

Figure 9 – As Figure 6, but showing data collected by Naoki Moriwaki (Far East radiant curves). Again, brief periods of interference are shown by drops to zero in the echo count line, except those at 05^h and 08^h UT on April 21, which were reported as actual zero-echo hours.

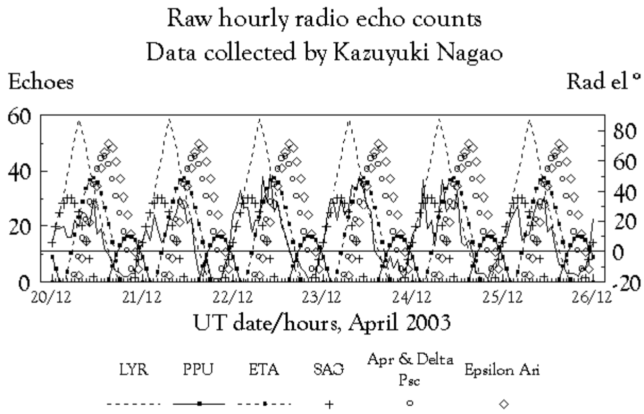

Figure 10 – As Figure 6, but for radio results presented by Kazuyuki Nagao (Far East radiant curves).

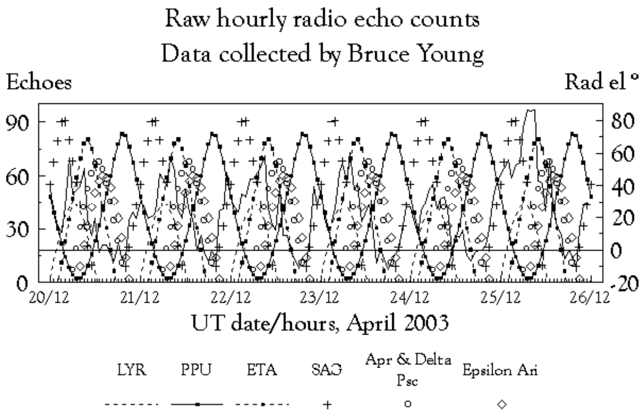

Figure 11 – As Figure 6, but illustrating radio observations collected by Bruce Young (using the Australian radiant curves).

As Comet Grigg-Skjellerup came back to perihelion in October 2002, it was possible some π-Puppid activity might be seen in 2003, if so, most likely around $03^{\rm h}$ UT on April 24 according to previous returns (McBeath, 2003). However, a further prediction was issued at the start of April (Vaubaillon, 2003) suggesting an earlier peak time of $15^{\rm h} \pm 1$h UT on April 23 was likely, based on theoretical simulations. From this work, the shower's duration was expected to be of the order of 7h, but the particles were liable to be very small (and thus would possibly produce many meteors below the visual magnitude threshold).

Radio results from April have been examined in some detail as part of the Forward Scatter Meteor Year since 1994 (McBeath, 2001). A commonly ill-defined series of weak radio maxima have been found in most years between $\lambda_\odot = 34°$–$39°$ (2003 April 24–29), sometimes extending to $\lambda_\odot = 41°$ (2003 May 1), when they may blend into the next weak maximum around $\lambda_\odot = 40° \pm 1°$, probably resulting from the rise in rates towards the η-Aquarid peak in early May. Part of the $\lambda_\odot = 34°$–$39°$ period may also be due to this source. The lack of a strong maximum in any of these years implies no high π-Puppid return has occurred, and passed visually unseen, during the past decade, although the fact that most radio meteor observers were situated at mid-northern locations (most between $\phi = 30°$–$60°$ N, as a rough guide), means this is not as conclusive as it might be. Observations of showers with low radiant elevations, or occasionally sub-horizon radiants, have been apparently achieved by radio in recent times, so observing the shower from these places is likely to be difficult, but not impossible. The 1998 June Boötid outburst (ZHRs $\simeq$ 50–100) was readily detected by radio even when the radiant was very low or slightly beneath the horizon for example (McBeath, 1998), a shower with very similar physical features to the π-Puppids (V_∞ = 18 km/s for both, $r = 2.0$ and 2.2 for the π-Puppids and June Boötids respectively). The June Boötids also had to compete with the near-maximum rates from the β-Taurids at the time too.

Looking at the 2003 April radio graphs in Figures 6–11 suggests immediately that no strong π-Puppid return was detected on April 23 or 24. A closer inspection of the datasets, including those not illustrated here, might suggest weakly-enhanced rates were present during the π-Puppid radiant's radio visible or near-visible times on April 23–24 or 24–25 UT. Such were found in nine of thirteen datasets covering these intervals on both dates in Europe, North America and the Far East (excluding those reports outlined earlier, and those at more northerly latitudes, $\phi = 55°$ N and above). The remaining four datasets showed no obvious indication of rate enhancements near these times, including that where the radiant should have been best seen, in Australia. As only this one southern hemisphere dataset was available, it is unclear how reliable this may be. It is obvious from examination of other radio results elsewhere that not all systems record the same things, nor are all equally useful at detecting even major showers, due to the vagaries of the observing technique. The analyses I have carried out over recent years have relied on being able to compare datasets made at the same time from several similar locations to establish a clearer picture. Overall, it seems possible that some weak π-Puppid radio activity did occur around April 23–25. A majority of the available results would support this as a hypothesis at least. The strength was probably of the order of other weak visual returns of the past if so, but this is mere conjecture based on the radio results alone.

No consensus as to a potential UT peak time was found beyond this. As Figure 5 shows, a peak near $03^{\rm h}$ UT on April 24 should have been detectable from Australia, and possibly North America and the Far East too, if it lasted for several hours, while a $\simeq 15^{\rm h}$ UT maximum on April 23 was poorly timed to be picked up at all, unless it too persisted for several hours. If so, Australia, parts of Europe and perhaps parts of the Far East might have found it.

In the visual summaries, a total of 14 possible π-Puppids and 8 other meteors were reported in 15.88h on April 22, 23 or 24, as seen by 11 observers from South Africa, Bolivia and Australia. Not all these observers provided full watch details, and only two gave the numbers of sporadics seen at the same time. Several others recorded that either no meteors or only some π-Puppids were seen, so it is unclear if some of these observers were not counting sporadics and other shower meteors, or ignored them in their reports, or if they may have misidentified some slow-moving sporadics as possible π-Puppids. A subset of the data for which LMs were given along with watch times (all from South Africa) gave a total of 10 π-Puppids in 8.3h between $16^{\rm h}45^{\rm m}$ to $20^{\rm h}37^{\rm m}$ UT on April 23, with a mean LM of +5.51, although the spread in LMs was $\simeq +4$ to +6.5. This might crudely suggest mean ZHRs were $\simeq 3 \pm 1$ (assuming $r = 2.0$). However, nine of the claimed π-Puppids were seen by a single observer between $17^{\rm h}05^{\rm m}$–$17^{\rm h}15^{\rm m}$ UT in a LM = +6.0 sky, rates which were not confirmed by two other observers with similarly clear skies at the same time, so even this borderline-visual ZHR value is highly questionable, and seems not to be generally applicable.

Checking the European radio data showed no unexpected echo count numbers in the $17^{\rm h}$–$18^{\rm h}$ UT binning interval, although this was close to the best-detectable time for the π-Puppids from this region (as Figure 5 demonstrates). Thus it seems the lone observer may simply have been lucky in catching an unusual group of meteors close together in time (and curiously, no other meteors were reported by this watcher between $16^{\rm h}45^{\rm m}$–$19^{\rm h}00^{\rm m}$ UT, despite continued transparent, clear skies).

Coverage was not ideal nor complete during the most probable maximum times for the π-Puppids this year, especially among the visual observers, who concentrated on watching on April 23 to the virtual exclusion of other dates. This was naturally unfortunate, but the radio reports imply they may not have missed very much anyway. The impression is that, at best, weak π-Puppid rates may have happened between April 23–25 or so. The activity level was probably similar to what has been found in other years when no stronger shower rates have taken place. Such rates would thus have been at or below the visual detection threshold, but the actual strength remains uncertain. It seems safe to say that no high-rate outburst of a length comparable to those seen before occurred. Hopefully, greater attention will be paid to covering the whole of the visual π-Puppid epoch in future, as they are definitely a source in need of more detailed analyses.

5 April and δ-Piscids

An interesting accidental by-product of this analysis was a probable recovery of these two daytime radio showers for the first year in a very long time. Their radiants are too close together in space to be separated by radio observations, and were treated as a single entity in the analysis, as noted earlier. Some activity seems present on most days coincident with this effectively composite radiant's best elevation, while the Lyrid and η-Aquarid radiants were declining in the western sky, or after they had set, as a careful check of Figures 6–11 shows. The April Piscids are supposed to last until April 29, so it is reasonable to suggest at least part of this activity was due to them, probably augmented by the δ-Piscids around April 24, and the nearby ϵ-Arietids from this date onwards.

The proposed April Piscid maximum on April 20 could not be confirmed by this present work, as only the second half of this date was included. However, activity seemed a little more significant from this probable Piscid source on April 22 and 23, which could suggest either that the April Piscid peak fell two or three days later than was previously supposed, or that the δ-Piscid activity and maximum, theoretically scheduled for April 24, might actually have happened up to one or two days early. Some combination of both of these possibilities may have been at work too.

It is one of life's ironies that this probable recovery of two minor sources should be one of the more positive results to come from an analysis which was intended to examine two stronger, if moderate, meteor showers!

6 Conclusions

The discussion above is one of the most intense concerning radio data during the April 20–26 interval in recent times. From this, it seems the Lyrids produced a probable maximum on April 22–23, its apparent weakness perhaps accentuated by reception problems over Europe, but seemingly neither as strong or sharply-defined as the IMO visual results indicated. No significant π-Puppid activity was found, which is in-line with the few visual reports. Although coverage was not global either visually or by radio, as past stronger π-Puppid maxima have produced easily detectable rates for at least several hours around the actual maximum time, as well as lesser activity on days to either side, it seems unlikely a similarly substantial return in 2003 was missed. This point is not conclusive however, and a short-lived peak could readily have passed unnoticed. Some marginally-detectable radio and visual activity from the shower between roughly April 23–25 may have been found, perhaps at a level comparable to, or somewhat under, the visual detection threshold, probably like some of the very weak π-Puppid returns reported in the past. The most successful, if unexpected, aspect of the analysis was the probable recovery of activity due to the minor daytime April and δ-Piscids. A weak maximum due to either or both sources is suggested around April 22 and 23, which interestingly fits to neither of their presumed maxima! Overall, despite the difficulties in its interpretation, radio meteor observing continues to provide a useful tool in our array of techniques to examine the meteor flux the Earth encounters.

7 Acknowledgments

My grateful thanks go to all the contributing observers and correspondents represented by this analysis. Good luck for all your future work!

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Fundamentals of meteor science

A beginner's guide to shower association

Robert Lunsford [1] *and Rainer Arlt* [2]

A guide for new meteor observers is presented. This covers choosing the part of the sky to observe, techniques of recording meteors and of deciding whether each meteor is associated with a radiant. Techniques of observing both with and without maps are presented.

1 Motivation

We are often asked how one can determine the source of each meteor we see. For us, it's simple and is nearly second nature. Not everyone has spent hundreds of hours watching the night sky, though, viewing thousands of meteors. This article is written for the new observer, so that they may use a step-by-step procedure to accurately determine shower association. The full story of shower association with all the mathematical background can be found in the Observers' Handbook of the IMO given in the Reference Section.

2 First approach: without maps

If one is to determine shower association out in the field, then it is necessary to know the location of each radiant that lies above the horizon at that particular time. Lists of active radiants are included annually with WGN (the IMO Journal) and are also available on-line at `http://www.imo.net/calendar/cal03.html`. This source will allow you to determine which radiants are active on any night of the current year, plus determine the position of the radiant in terms of right ascension (celestial longitude) and declination (celestial latitude) for the date of your observing session. Once you have these figures you can use a planisphere or a planetarium program to determine if the radiant will be above the horizon during your viewing period.

Once out under the sky there are some tips and tools to help you observe and determine which meteors are shower members and which are sporadic. To have the most productive session possible, it is best to face toward the darkest horizon available. If one has several good horizons available then look toward the best horizon in the eastern to southern direction where most of the meteor shower radiants are typically located. The center of the field of view should not be lower than, say, 50°.

Some observers write the details for each meteor they see onto a report form. Others prefer to record the data on a cassette recorder. The advantage of a cassette recorder is that one is able to keep their eyes on the sky at all times. Time is lost while one is writing out in the field. The advantage of filling out forms in the field is that they are completed when the session is over. One must listen to the cassette tape to obtain the data seen during the night, thus the data is not instantly ready. Be also aware of that a tape recorder is less fail-safe than paper notes when operated in darkness.

Before settling into your chair it is also helpful to remember to face in the general direction of the radiant under scrutiny. If more than one radiant is being watched then face between the two. The further you face from a radiant, the more difficult it becomes to accurately determine its association. One may like to plan ahead so the radiant will drift through the center of the field of view near the middle of the session. This allows one to stay nice and warm without getting up to adjust the chair.

When a meteor is seen you should immediately take note of its path. To help you with this, bring along a dark string or shoelace. When a meteor is seen, hold the string over the path of the meteor as soon as possible. If the string is long enough the backwards path will either hit or miss the radiant. If the meteor is seen far from the radiant and misses it by less than twenty degrees then there's a good chance it belongs to that shower. If the meteor is seen close to the radiant and misses it by twenty degrees then it is most likely a sporadic meteor.

There are a few rules one should recall when observing.

- Swift meteors are not seen close to their radiants.
- Slow meteors may occur at any distance from the radiant.
- Long meteors, in excess of ten degrees, are not seen close to their radiants.
- Short meteors may be seen at any distance from the radiant.

If you are viewing close to a radiant and see a fast meteor seemingly come from the radiant, then chances are the true radiant lies further away and your meteor is a sporadic. The same scenario occurs if one sees a long meteor appearing close to a radiant. That meteor too has a radiant further away and is most likely a sporadic or belongs to another shower. Once you have memorized these rules then shower association out in the

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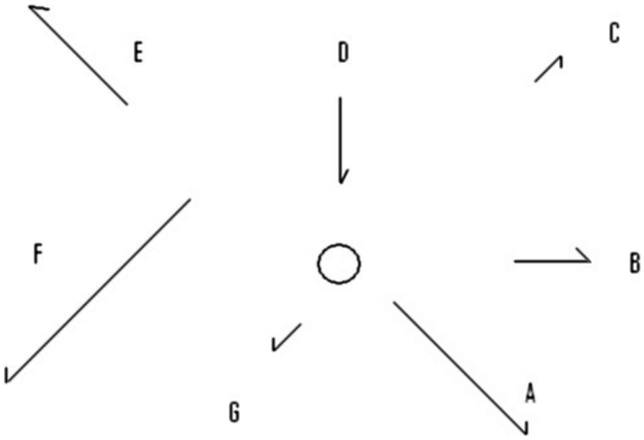

Figure 1 – Sketch of possible meteors around a radiant (shown as a circle).

field will become easier and more accurate. The diagrams help illustrate the relationship between meteors and their radiant. In Figure 1, meteor 'A' seems to come directly from the radiant but is much too long to be associated with a radiant so close. Meteor 'B' also lines up with the radiant and is of acceptable length. If the apparent velocity is medium or slow, then all the parameters for shower association are correct. If the velocity is swift, then it cannot be associated with this radiant. Meteor 'C' is short and also lines up with the radiant. Once again if the velocity is medium or fairly slow then it can be associated with this radiant. It must be stated here that many observers see all short meteors as fast. A short duration is mixed up with a high speed. This is where estimates of angular velocity are important (see below) as short meteors can actually be traveling quite slowly.

Continuing with Figure 1, meteor 'D' is traveling in the wrong direction therefore cannot be associated with this radiant. Meteor 'E' is at the limits for length for belonging to this radiant. Although it should be a bit faster than 'B', if its velocity is very fast then 'E' would be sporadic. Meteor 'F' is too long and misses the radiant by too much. Meteor 'G' is short and occurs close to the radiant. If it is slow moving then it may be associated with this radiant.

3 What to record without maps

The procedure described in the previous Section comes along with other notes about the meteors. These are briefly summarized here:

- The time should be given, preferably in Universal Time (UT) to avoid any later confusion. If you are unsure about the conversion to UT, add your local time zone clearly to the records.

- The meteors' magnitudes are essential for further analysis. Do not omit magnitudes for meteors you have seen less accurately. At this point, an inaccurate estimate is better than a bias by omitted meteors.

- A velocity estimate on a scale from very slow (1) to very fast (5) is optional.

- Notes about color or the duration of a persistent meteor train can be added, too.

4 Second approach: with maps

There is another method where the observer plots the meteors one sees onto a gnomic star chart. Gnomic charts (such as Atlas Brno[1]) allow the observer to plot meteors as straight lines. This is not possible on ordinary star charts, as the actual paths would be curved. One advantage to plotting is that there is no need to know beforehand the location of each radiant. If your plots are accurate, then the radiant will expose itself as intersections on your chart. The key here is accuracy. Since meteors are a fleeting experience, there is very little time to record what you see. It will take many hundreds of plots before a decent accuracy is achieved. The number of meteors seen during a session depends greatly on the quality of your eyes and of the sky. If you see no more than 10–15 meteors per hour, it is recommended to plot all of them. Under very good skies, it is impossible to plot all the activity one sees during a session. It is best to only plot those seen near the center of your field of view. Plots of meteors seen off near the edge of your field will be hopelessly inaccurate.

At this point, one should note that it is not the individual meteors which are essential for the analysis, but their statistical ensemble which gives measures of meteor shower activity. This means we should not omit any meteors from our records because we have not seen them very accurately. If you do not feel confident in plotting a meteor near the edge of your field of view, at least record the data on these meteors and a possible shower membership according to the guidelines in Section 2.

The most experienced plotters can record their data in as little as fifteen seconds. Most of us take between 30 seconds and one minute to get the plot and data on to the chart.

Once you see a meteor that is easy to plot, use your string to determine its path. The string is bound to intersect two bright stars making it much easier to transfer its path on to the chart. It is important but difficult to get the starting and ending points just right. Once again practice will help one to gain accuracy. Once your chart has 10–15 meteors, it is better to switch to a new one. Cluttered charts make shower association more difficult. It is important to also record the velocity of each meteor recorded. Most beginners simply start with slow-medium-fast or a 1–5 scale.

Experienced observers are urged to estimate the angular velocity of each plotted meteor. The angular velocity is the length each meteor travels in one second. You simply estimate the length of each meteor if it had lasted exactly one second. While this sounds daunting, it becomes second nature with experience. New

[1]Available from the IMO: see the inside back cover.

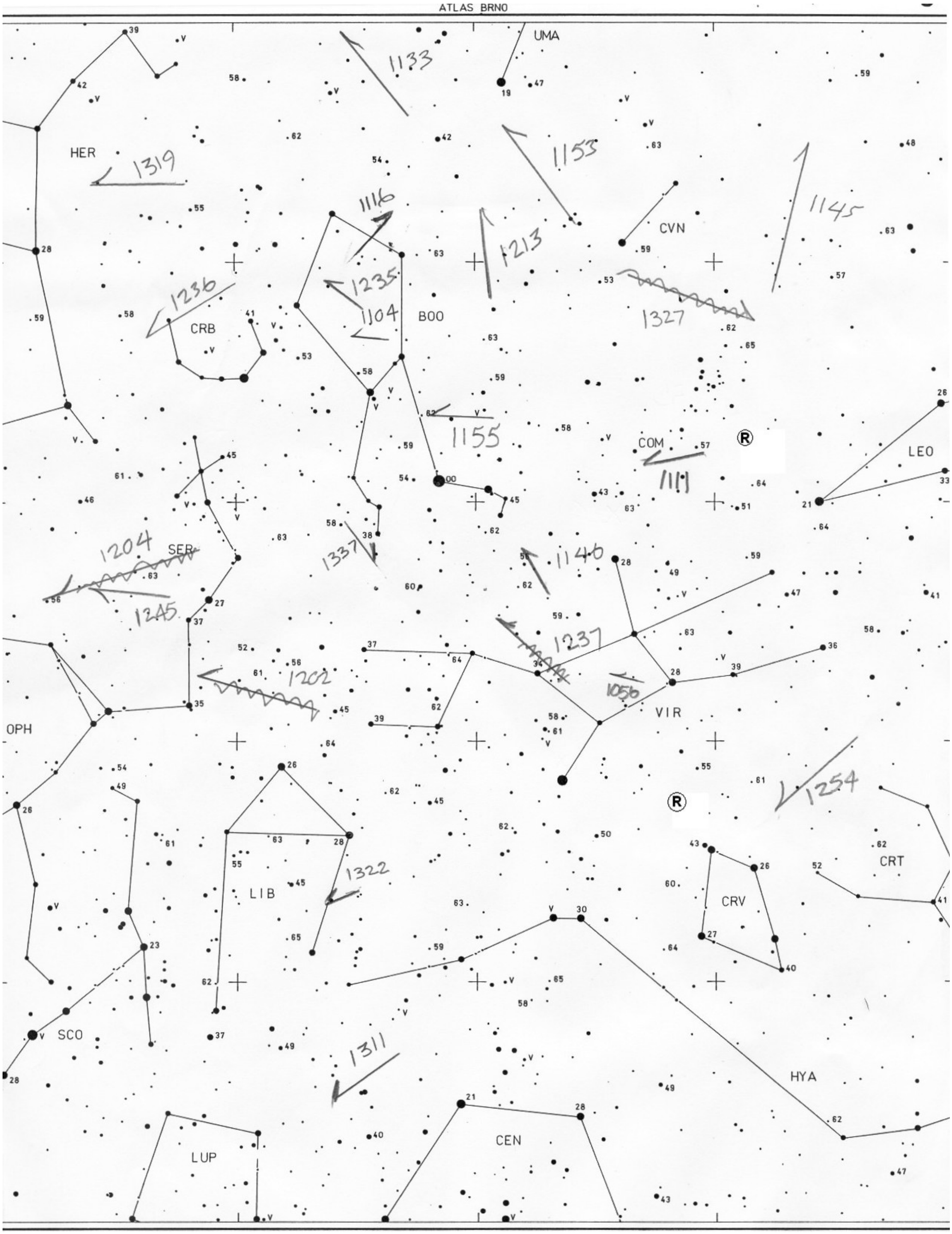

Figure 2 – Meteors from a genuine observation.

observers tend to overestimate the angular velocity. A great majority of the activity seen will have angular velocities between 5 and 20 degrees per second. If you are constantly recording meteors with velocities in excess of 20 degrees per second then you are overestimating your velocities. The absolute maximum angular velocity is 38 degrees per second. With the plot and an estimated velocity, one can determine shower association once the session is over.

Figure 2 shows actual plots obtained out under the sky on 2000 January 12. A quick look at the chart reveals a possible radiant between Virgo and Corvus. Possible meteors associated with this radiant are 1145, 1146, 1202, 1213, 1237, 1311 and 1322.

Meteor #1145 appears far from the radiant and should be swift if it is a true shower member. The velocity for this meteor was 25 degrees per second, so the association is confirmed.

Meteor #1146 appears close to the radiant so the velocity should be slow. The velocity estimate is 10 degrees per second, which is a bit fast, but within the permitted error margin.

Meteor #1202 occurred at a moderate distance from the radiant and should be of medium velocity. The estimate is 20 degrees per second, which is too fast, so the chances are that this meteor is not associated with this radiant.

Meteor #1213 lies far from the radiant and should be swift. The estimate is 18 degrees per second, which agrees well with the predicted velocity.

Meteor #1237 lies close to the radiant and should be slow if associated with the suspected radiant. The estimate was 18 degrees per second, which is much too fast to be associated with this radiant.

Meteor #1311 lies at a moderate distance from the radiant, but also low in the sky. Therefore one would expect the velocity to be medium to slow. The estimate is 13 degrees per second, which is at the fast end but still within the error limits for positive shower association.

Meteor #1322 also lies at a moderate distance from the radiant. The velocity estimate is only 5 degrees per second. This estimate is a bit too slow but within the permitted error limits for positive shower association.

Of the seven meteors, five have the possibility of being associated with this possible radiant. Considering the total observing time of three hours, this is more than what would be expected from random activity. At this time of year the center of the southern branch of the apex [2] area lies some ten degrees from the suspected radiant. It is most probable that these meteors are associated with that particular source.

Another possible radiant lies further north in Coma Berenices. Possible meteors associated with this radiant are: 1104, 1133, 1153, 1155 and 1204. The meteors #1111 and #1145 are too long given their small distance from the radiant and do not belong to this source.

Meteor #1104 lies at a moderate distance from the radiant and should be of medium velocity. The estimate is 7 degrees per second, which is well within the permitted error margin for positive shower association.

Meteor #1133 also lies at a moderate distance. The velocity estimate is too fast to be associated with this radiant.

Meteor #1153 lies close to the suspected radiant and should be slow. The estimate is 10 degrees per second, which lies within the permitted error margin for positive shower association.

Meteor #1155 is also close the radiant and should be slow. The estimate is again 10 degrees per second, which lies within the permitted error margin for positive shower association.

Meteor #1204 lies at a moderate distance and should be of medium velocity. The estimate is 13 degrees per second, which agrees well with the expected velocity.

At this time of year the center of the northern branch of the apex area, also known as the Coma Berenicids, lies some ten degrees from the suspected radiant. It is also probable that these meteors are associated with that particular source.

5 What to record with maps

Apart from the plots and the velocities, we also need to note the time of appearance as explained in Section 3. Once again the magnitude of each meteor is necessary. If you are using several maps for your plots, you should add the map number to each meteor. Finally, an estimate of the accuracy of the plot can be helpful for the shower association. Usually a scale from good (1) to bad (3) is used.

6 Final remarks

Observers are urged to start out with the easier recording method of determining shower association out in the field and then graduate to plotting only after logging several tens of meteors. This is a natural progression, as one needs to obtain the necessary skills of accurately estimating meteor length and duration before proceeding to plotting. The advice is to start slowly to avoid frustration. Meteors often avoid detection for long periods of time and then suddenly appear in swarms. This can often overwhelm even the most experienced observer, so all we can ask is that each observer do their best to accurately report the activity they see. No one is perfect, meteors will be missed and data will be in error. As stated before, as one gains in experience they will begin to see their data fall in line with other longtime observers and ultimately their contributions will become more valuable to the entire meteor observing community.

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[2] A later article in this series will describe sources such as this apex — *Ed.*

History

Meteor Beliefs Project: some meteoric imagery in the works of William Shakespeare

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Passages from three of William Shakespeare's plays are presented, illustrating some of the beliefs in meteors in 16th–17th century England. They also reflect earlier beliefs and information which it is known Shakespeare drew on in constructing his works.

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1 Introduction

William Shakespeare (1564–1616) remains England's greatest poet and dramatist, and his works continue to be re-presented and reinterpreted today, notably his 38 plays. Eighteen of these were published during his lifetime, 36 printed in the First Folio of 1623 after his death. Many of them feature astronomical imagery of one form or another, and it would be impossible in a short article like this to examine more than few meteoric passages. If we have missed some of your favorite meteoric Shakespearean quotes, please let us know! The sort of things we are particularly interested in were explained in the first Meteor Beliefs Project article (McBeath & Gheorghe, 2003a).

It seems unnecessary to repeat historical details of Shakespeare's life here, but we should comment on the nature of the surviving play texts. Despite the fact that his works have been in print since they were first published, there are variations in the content of some of the plays. This is because when the First Folio was constructed, some surviving copies of the plays were used that had been altered and amended by actors and theatrical managers to suit different circumstances. Many manuscript copies of Shakespeare's originals had not survived even by 1623, and the printers of that Folio and subsequent revisions added in their own occasional errors and typographical mistakes. Despite these drawbacks, the 1623 texts remain for many the authorized versions of Shakespeare's plays, although occasional unintelligible sections have been revised or amended in most modern renditions, as have some spellings, some obscurely obsolete words or phrases, and much of the punctuation. Line numbering has also been added to facilitate finding parts of the texts more easily. Here, we have used Craig (1911) for our quotes, by personal preference.

2 *The Tragedy of King Richard the Second*

Our first piece comes from Act II, Scene IV, a short scene set in a camp in Wales, and features a discussion between the Earl of Salisbury and an unnamed Captain of a band of Welshmen in King Richard's army. Lines 7–24 (Craig, 1911, p. 425) run:

Captain:
'Tis thought the king is dead: we will not stay.
The bay-trees in our country are all wither'd
And meteors fright the fixed stars of heaven,
The pale-fac'd moon looks bloody on the earth
And lean-look'd prophets whisper fearful change,
Rich men look sad and ruffians dance and leap,
The one in fear to lose what they enjoy,
The other to enjoy by rage and war:
These signs forerun the death or fall of kings.
Farewell: our countrymen are gone and fled,
As well assur'd Richard their king is dead.
He leaves.

The Earl Salisbury then speaks to himself (and thus the audience):

Ah, Richard! with the eyes of heavy mind
I see thy glory like a shooting star
Fall to the base earth from the firmament.
Thy sun sets weeping in the lowly west,
Witnessing storms to come, woe, and unrest.
Thy friends are fled to wait upon thy foes,
And crossly to thy good all fortune goes.
He too exits the stage.

This is all very negative, making quite a contrast with the powerful and positive meteoric images employed by Apollonius of Rhodes, which we discussed last time (McBeath & Gheorghe, 2003b). Things do not improve as we consider our next quote.

3 *Hamlet Prince of Denmark*

The opening scene of this powerful tragedy is set on a platform before the Castle of Elsinore. One of the guard officers, Bernardo, has just relieved one of the guards of his duty, and is keeping watch. He is soon joined by Hamlet's friend Horatio, and Marcellus, another officer of the guard, who have come out to see a mysterious ghost, which appears at the same hour each night. We discover somewhat later that the ghost is of Hamlet's recently deceased father. Our quote comes from Act I, Scene I, lines 113–120 (Craig, 1911, pp. 942–943), where the three on the guard platform are discussing having just seen the ghost, which has disappeared, but is shortly to return.

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Horatio is speaking:

> In the most high and palmy state of Rome,
> A little ere the mightiest Julius fell,
> The graves stood tenantless and the sheeted dead
> Did squeak and gibber in the Roman streets;
> As stars with trains of fire and dews of blood,
> Disasters in the sun; and the moist star
> Upon whose influence Neptune's empire stands
> Was sick almost to doomsday with eclipse

The 'moist star' is the Moon, controller of the tides, and also long associated with water generally, partly because it was believed it brought out the dew at night. Meteors here are again linked to death and disaster, particularly in connection with the portents before the death of Julius Caesar.

4 *Julius Caesar*

Sure enough, looking at Shakespeare's play on Caesar, the portents are there in ghastly detail. Act I, Scene III opens on a night-time street in Rome with thunder and lightning playing violently overhead. Casca, one of the conspirators against Caesar, meets Senator Cicero (lines 2–13; Craig, 1911, p. 891):

Cicero:

> Good even, Casca; brought you Caesar home?
> Why are you breathless? and why stare you so?

Casca:

> Are you not mov'd, when all the sway of earth
> Shakes like a thing unfirm? O Cicero!
> I have seen tempests, when the scolding winds
> Have riv'd the knotty oaks; and I have seen
> The ambitious ocean swell and rage and foam,
> To be exalted with the threat'ning clouds:
> But never till to-night, never till now,
> Did I go through a tempest dropping fire.
> Either there is a civil strife in heaven,
> Or else the world, too saucy with the gods,
> Incenses them to send destruction.

There is a deliberate ambiguity here. Is the fire dropping from the sky thought to be caused by meteors or lightning — or both? The 'Hamlet' quote above makes it clear they should be meteors, but the issue is clouded now. As we have seen in *WGN* before, meteors, lightning and thunderstorms have a long association (McBeath, 1997), so the uncertainty may well simply reflect popular beliefs.

Continuing with the portents in the play, questioned further, Casca admits to seeing a slave whose left hand was ablaze, yet which remained undamaged; a lion walking in the streets which passed him by with only a glare; a group of a hundred terrified women who swore to seeing men of fire walking the streets; while the day before at noon an owl had sat in the market place hooting and shrieking. Cicero departs for home. Then Casca meets a fellow conspirator, Cassius, who declares he has walked the streets bare-breasted to the storm (lines 49–52; Craig, 1911, p. 892):

> [I] Have bar'd my bosom to the thunder-stone;
> And when the cross blue lightning seemed to open
> The breast of heaven, I did present myself
> Even in the aim and very flash of it.

Thunderstones were a common way of describing meteorites in Shakespeare's day and later, as well as a host of other lightning- and meteor-associated objects, some supposedly protective against lightning strikes; see for instance (Westwood, 2002) and (McBeath, 2003).

But still we are not finished with the potentially meteoric portents in this play. Act II, Scene II, is set in Caesar's house in Rome later the same night. Thunder and lightning continue, while Caesar and his wife Calphurnia are sleepless. They converse, Calphurnia telling of the tales she has heard from the city watchmen that night (lines 17–24; Craig, 1911, p. 897):

> A lioness hath whelped in the streets;
> And graves have yawn'd and yielded up their dead;
> Fierce fiery warriors fought upon the clouds,
> In ranks and squadrons and right form of war,
> Which drizzled blood upon the Capitol;
> The noise of battle hurtled in the air,
> Horses did neigh, and dying men did groan,
> And ghosts did shriek and squeal about the streets.

Some medieval descriptions of battles, armies or warriors in the air seem to be of auroral displays, but here it is improbable we are dealing with any necessarily real events any more. Calphurnia is reporting what she had heard, not what she saw herself — is the lioness the same as the lion Casca saw, but now supposedly engaged in a different action, for instance? The noises of battle, even horses neighing, are now encompassed by events in the sky, rather than the panic apparent in parts of the streets earlier.

Caesar will not be dissuaded from going to the Senate however, and intends to ignore these portents. Calphurnia makes her famous, if melodramatic, comment as a powerful warning, often quoted out of context (lines 30–31; Craig, 1911, p. 897):

> When beggars die there are no comets seen;
> The heavens themselves blaze forth the death of princes.

These portents were certainly known of in ancient times, shortly after the historical assassination of Caesar, and although Plutarch is dismissive of some of these in his 'Life' of Caesar, he is unsure enough to list a good many others without adverse comment (cf. Clough, 1910, pp. 575–581). Many reappear in the text of Shakespeare's play in the same order as Plutarch gives them. Plutarch discounts the meteoric component however (Clough, 1910, p. 575):

> As to the lights in the heavens, the noises heard in the night, and the wild birds that perched in the forum, these are not perhaps worth taking notice of in so great a case as this.

5 Conclusion

Shakespeare's play ends before the comet associated with Caesar can appear, a week after Caesar's death (as mentioned by Plutarch, Pliny — *Natural History* II.XXIII.93–94 — and others), and which became an object of reverence in Rome according to Pliny. This is generally described as being Caesar's soul ascending to the heavens to take his place among the gods, and was partly taken as a benefic sign for his son Augustus' reign. The portents surrounding Ceasar's demise also feature in Ovid's *Metamorphoses* (which we shall consider next time), known to be one of the biggest influences on Shakespeare's view of Greek and Roman mythologies, perhaps helping him continue, or indeed restart, such ancient beliefs in the early modern popular mind.

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Authors

Writing for WGN

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Advice to authors writing for WGN is presented. Comments on writing scientific papers are provided, especially on References, where mistakes are easily made. Information of the correct use of SI units is provided. The preferred LaTeX format is briefly introduced, with information for authors who use this. It is emphasized that LaTeX is not essential. Alternative information is given for those who use other formats such as Word.

1 Introduction

Any Journal depends on its authors, and we encourage you to write up your ideas and results for WGN.

One of the strengths of the IMO is that it includes people from many professions, not just those with a scientific training. Those inexperienced in writing scientific papers may appreciate help, so guidance is given below. This article has been written in the layout of a scientific paper, for illustration.

WGN is produced in a computer format called LaTeX, and those who know this will need a little information to write their papers close to the final format. Those who do not know LaTeX need not worry, as WGN accepts papers in other forms.

2 Writing scientific papers

There are certain conventions in writing scientific papers, i.e. articles, to make them easy to read. One is the way a Paper is divided into sections.

2.1 The sections of a Paper

There are usually six main sections.

1. **Title and Author.** There is nothing special about these, but please remember to provide an address where interested readers can contact you. It is helpful to provide an email address too.

2. **Abstract.** This should describe, very briefly, what the paper is about. It is there for readers who are not sure whether the paper is what they want. It should make it possible for them to decide without reading through the paper.

   Some people advise the following: The first one or two sentences should expand the title and say why the work was performed. The Abstract should say what was done and what it contributes to science. The length should be between two or three sentences and a quarter of a page for a long paper.

   It should be possible to understand an Abstract by itself, so it is bad practice to include citations (see References below).

3. **Introduction.** This should 'get the reader up to speed' on your subject. Remember that the reader may not be a specialist in your part of meteor studies, so some background may help. If your paper describes an algorithm to distinguish meteors from aircraft, for instance, your Introduction should probably say that this is a computer program which examines images from a TV camera. Many readers will be visual observers and will not understand unless you say this.

4. **Detailed sections.** These are the heart of your paper. Their number, names and contents depend on your material. Here you will have least difficulty in deciding how to organize your writing.

5. **Conclusion.** This should remind the reader of what they have learned from the paper. It should draw all the material together and point out the most important results. It may point out shortcomings and future lines of research; other than this, it should not introduce new information.

   Without a Conclusion a paper stops suddenly, as if a radio's batteries had failed during a programme.

6. **References.** These are material (papers, books, etc.) which you have read and which you have referred to in your paper. A later section of this article looks at them in detail.

You may sometimes need to vary this pattern. You may wish to add an Acknowledgments section after the Conclusion. Details which are not essential to the reader's understanding should be put in an Appendix at the end and just summarized in the detailed sections. Occasionally there will be no References, for example in a social report of an International Meteor Conference.

You may want to divide some sections into subsections. These can be arranged as you wish.

2.2 Other aspects of style

There are many recommendations for good writing, including:

Keep it simple. Complicated sentences are hard to understand. A straightforward way of saying things is normally best. This is especially true for an international Journal like WGN, where few readers grew up

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speaking English. If a sentence is too complicated, it is better to split it into two separate sentences.

Keep it formal. Good scientific writing is calm rather than excited, formal rather than slang. Prefer 'it is' to 'it′s', 'do not' to 'don′t', and 'the results were unexpected' to 'what we'd eyeballed was, wow, kinda wild'.

Similarly, avoid exaggerations and extreme descriptions. 'The fireball was enormous, absolutely gigantic' sounds like something from a children's magazine; it does not make you sound like a careful researcher. Exclamation marks (!) are normally a mistake.

It is sometimes thought that a Possessive (i.e. Genitive) with an inverted comma, such as 'meteor′s', is bad style. This is not true. 'The Perseid shower′s maximum' is just as good as 'the maximum of the shower of the Perseids', and shorter.

Do not use ten words when five will do. The fewer words you use, the less time readers need to understand your ideas. Even experienced writers can improve. For instance, a first attempt at this article included

Without a Conclusion, a piece of writing seems to stop suddenly — it is a bit as if a radio's batteries have failed suddenly in the middle of a programme.

This was changed to

Without a Conclusion a paper stops suddenly, as if a radio's batteries had failed during a programme.

Is the meaning different? Has anything been lost? Most people would answer 'No'.

Avoiding the First Person. Traditionally, the First Person Singular (I) and the First Person Plural (we) are avoided in scientific papers. The idea is that you are reporting on your research, not on yourself.

This convention is slowly changing, and WGN leaves the decision to the Authors. However, we suggest that avoiding the first person (saying 'the results were remarkable' and not 'we thought that the results were remarkable') concentrates the reader's attention on your science.

Keep to one tense, normally the Past. It is often hard to decide whether to write in the Past or Present tense. Mixing them makes it hard for the reader — they feel they are jumping between two stories, one written now and one in the past. Scientific papers are normally written in the past tense, since the work was done in the past: 'the Perseids were observed', 'analysis showed that'. However, some statements make more sense in the present tense: 'there is evidence', 'the shower is evolving'.

Understand your readership. Do you start by writing a basic textbook on meteors, or do you assume your readers are experts in your speciality? For WGN, you should assume that

- Your readers have a general knowledge of meteor science. You need not explain meteor showers, ZHR or r-value, for instance.
- They **may** know your specialized field within meteoritics, for instance telescopic meteors, history, video observations or the mathematics of meteoroid orbits. The Abstract and Introduction should say enough for them to see whether this is a speciality they understand. Sometimes it is possible for the Introduction to give a brief comment and reference(s) for people who are new to your speciality. It is impractical to do more: for the rest of your paper, you may assume your readers know your sub-field of meteor studies.

Define mathematical symbols. Some symbols are standard in all physical sciences (e.g. π and G) or in meteor science (e.g. ZHR and r). All others should be defined where they first occur, e.g. 'the number of electrons n_{e} in a CCD pixel is $n_{\mathrm{e}} = n_{\phi} Q_{\mathrm{E}}$, where n_{ϕ} is the number of photons hitting it and Q_{E} is ...'.

Get a friend to read it. By the time you have finished you research, you are so close to it that you forget how much more you know than others. Similarly, when writing your paper you are so close to it that you do not see what is too short, too long, too simple or too complicated.

A good solution is to get someone else to read your paper. There are three requirements: (1) they know meteor science; (2) they have not been involved in your research, so they see it with fresh eyes; (3) they understand that criticisms are helpful to you, not an insult.

3 Writing in English

Few of WGN's contributors are native English speakers. Others may worry about their ability to write good English. There is no space here to teach a language, but a few hints can be given. A good dictionary is an important tool. Spellcheckers are useful, though they miss many mistakes. If you use Linux, the ISPELL spellchecker is available; typing `man ispell` will show whether it is installed.

The Oxford University Press publish a wide range of dictionaries and other language books, including Fowler's Modern English Usage (Burchfield, 1998), a standard work. They provide some free on-line advice at `www.askoxford.com`.

Do not let worries about your English prevent you writing for WGN — your submission will be edited by someone who knows English well. This provides you with a safety-net to ensure that your ideas are presented in language that does you credit.

4 Tables, figures and equations

Remember to provide a caption for every figure and table. They should enable the reader to understand the illustration without reading the rest of the text. Captions like 'See text for explanation.' are unhelpful.

All tables, figures and equations should be numbered. They should each have their own numbering scheme, so there will be a Table 1, a Figure 1 and an Equation 1. All tables and figures should be referred to in the text, for instance 'the apparatus (Figure 4) produced the measurements shown in Table 7'.

Equations are numbered in brackets at the right-hand margin:

$$e = mc^2 \tag{1}$$

Tables can be typed into your document where you want them to appear. Figures should not be included in the text, however. If your submission is a computer document (which is preferred), please supply separate files. Postscript images (extension `.ps` or `.eps`) are preferred, but we can handle other forms, for instance BMP, GIF and TIFF and FITS. If you supply paper, send each figure on a separate sheet; remember to label it in a corner or in pencil on the back, stating author, brief paper title and figure number.

It is convenient if you type the caption at the point where you want the figure to appear. If you are providing the figure as a computer file, add a note of the filename next to the caption. Remember, though, that editors often move figures and tables to make them fit on the page.

5 WGN conventions

What has been said is true for most scientific Journals. Like many Journals, WGN has its own House Style. A brief guide to these follows. For those who know LaTeX, comments on writing in this format are added. If you are uncertain about any of this, do not worry — we will format your paper correctly.

5.1 Units

With a few exceptions, WGN uses SI units, not mks or cgs. Thus energy is in joules not ergs, and power is in watts not ergs per second or joules per second.

The exceptions are those commonly used for good reason by astronomy and meteor science such as years, AU or earth masses.

The SI standard includes conventions as to whether letters should be upright (also called Roman) or italic.

- Numbers are always upright, e.g. 3.142.
- Units of measurement are upright e.g. km/s, W, m/s^2.
- Names of variables are in italics, e.g. T, t, v, θ. There are exceptions to this: see below.
- Names of physical constants are in italics, e.g. c, G.
- Names of mathematical constants such as π and e are upright.

There are two exceptions where a variable name is in upright type, not italic. One is where the name (ignoring subscripts) has more than one letter, e.g. ZHR, LM. The other is where the name does not take numerical values but identifies an object; this mainly occurs in subscripts. For instance h_{R} is the angular height of the radiant, and the **R** states that it is a radiant whose height is being described. Note that the h is italic since this names a numeric variable. Sometimes the subscript identifies one of a set, for instance n_{LEO}, n_{GEM} or n_{PER} for the numbers of meteors from the named showers. Compare this with v_t, the speed at time t, where the subscript is a numeric variable and thus italic. The Editor will deal with difficult cases; at least one official specification document is ambiguous.

Units should follow the quantity after a space, e.g. t = 3 s, v = 5 m/s. There are exceptions to this, the main ones being degrees of angle (e.g. 90°) and temperature (e.g. 10°C or 283K). Note that absolute temperature has no degrees sign before the K.

Units in the denominator can be written with a solidus (/) or a negative exponent, e.g. m/s or m s^{-1}. The latter is preferred for complicated forms.

Multipliers such as milli and micro are placed next to the units, e.g. 15 mm, 10 μs.

Comments follow on two particular cases.

5.2 Date and time

WGN prints this in scientific format, which moves monotonically from most significant 'digit' (year) to least significant 'digit' (seconds). For example: 2003 December 25, 01$^{\mathrm{h}}$23$^{\mathrm{m}}$45$^{\mathrm{s}}$ UT, or some subset of this. Day of the week should be omitted unless there is a good reason for it.

Note (1) the month in words, to remove ambiguity; (2) the comma between days and hours, for clarity; (3) the use of superscripted **h**, **m** and **s** as units and separators; (4) the leading zero, always using two digits; and (5) the specification of the time zone, UT or local. If local time is used, make sure it is clear which time zone this is.

This format may be ignored for non-scientific purposes: 'we arrived just after mid-day on Sunday' is perfectly acceptable, for instance.

5.3 Astronomical magnitudes

The astronomical magnitude is not an SI unit. It is also a logarithmic measure of brightness, so it has no units. Thus a statement like 'the meteor reached 3 magnitudes' is wrong; 'the meteor reached magnitude 3' is correct. One can also write 'the meteor reached $m = 3$'.

There are two symbols for magnitude: m for apparent magnitude, which is the one normally used; and M for absolute magnitude, which is what the meteor's apparent magnitude would be if it were 100 km directly above the observer. Both these can be subscripted to specify the wavelengths used, for instance m_{V} or M_{V} for visible light magnitudes. Most meteor work is at visible wavelengths, however, so this is rarely necessary.

Remember that magnitude 'counts backwards'. Phrases like 'the faintest meteors (less than magnitude 5)' are unclear — did the writer mean magnitudes such as 6 or such as 4? It can be better to say 'brighter than' or 'fainter than'.

5.4 Writing these formats into your paper

Italics, subscripts and superscripts are easy with word-processors such as Word; so are Greek letters. More obscure symbols, such as $\lambda_\odot$ for solar longitude, are probably best put in words, e.g. '[solar longitude]', leaving it to the Editor to typeset them properly. A covering note with the submitted paper can explain, if needed.

If you use a WYSIWYG word processor other than Word or Word Perfect, please export the file as ASCII (otherwise known as text or MSDOS text). This process can lose information, so if possible supply a form such as Adobe Acrobat (i.e. PDF) or Postscript. (The author recently edited a paper where all Greek letters had been exported as asterisks. '* Lyrae' could have been α Lyrae, β Lyrae, γ Lyrae, ...)

There are LaTeX commands created by WGN; for instance, `\g` gives a degrees symbol. The following list will mainly be of interest to those who write in LaTeX.

Table 1 – Special LaTeX commands defined for WGN.

Use	LaTeX	Result
Angle	`\g \mi \se`	$12°34'56''$
Decimal degrees	`\dg`	$12\overset{\circ}{.}34$
Decimal arcminutes	`\dmi`	$12\overset{\prime}{.}34$
Time	`\h \m \s`	$12^{h}34^{m}56^{s}$
Decimal hours *	`\dhr`	$12\overset{h}{.}34$
Decimal minutes	`\dm`	$12\overset{m}{.}34$
V-infinity	`\vi`	$V_{\infty} = 72$ km/s
Solar longitude	`\sol`	$\lambda_{\odot} = 123°$

* The command `\dh` already exists in LaTeX, so `\dhr` is used instead.

All the commands in Table 1 should be used in maths mode, for instance `$12\g34\mi56\se$` to produce the top-right entry.

These LaTeX commands are defined specially for WGN, and so are not part of any normal LaTeX distribution. They are contained in a file `wgn2.sty`. If you want this, send an email to the Editor at `wgn@imo.net` and ask for a copy. At some point in the future it will probably be put on the IMO website.

To use this file, you must place it in the same subdirectory as your paper and add a line `\usepackage{wgn2}` between your `\documentclass` and `\begin{document}` statements.

6 References

This is the section where you refer to work you have read and which is relevant to the paper you are writing. It can help readers to

- Read background which they do not know.
- Check that they agree with your interpretation of other peoples' work.
- Read further, when your paper shows them interesting lines of research.

Just as important, references make it clear that you know when someone else discovered or invented something. There is a convention in scientific papers: if you do not mention the originator of an idea, readers assume you are claiming it as your own discovery.

6.1 Citations and References

There are many ways of writing references. The layout used in science and engineering involves a marker called a **citation** in the text and the full details, called the **reference**, at the end. For instance, I might say that standard reference works (Burchfield, 1998) can help in writing good English. The '(Burchfield, 1998)' is the citation. If you look at the end of this article you will find a section called References. If you look at the author and date matching the citation, you will find full details of the book described. These details are called the Reference; they should be all you need to find the book or article.

Readers get to the references from the citations, so there should be no references without a citation.

6.2 Format of citations and references

There are several formats used in scientific writing. Citations such as (Bloggs, 1999), [Blo99], [42] and many others will be encountered.

To avoid mistakes, please do not use the numerical reference system with citations like [42].

The system used in WGN has **Citations** comprising the name(s) of the author(s) and the year of publication, e.g. (Copernicus, 1543). Two authors are given as (Starsky & Hutch, 1979); three or more as (Kool et al., 2002), naming just the first author. ('Et al.' is Latin for 'and others'.) If you use more than one work by the same author(s) from the same year, use (Bloggs, 2000a), (Bloggs, 2000b) and so on. Multiple citations can be combined as (Dent, 1999; Prefect, 2002a, 2010). If what you read gave no author, use 'Anon.'; if no date, use 'No date'.

For WGN, **References** should be in alphabetical order of author(s), and within that in order of publication year.

The authors' initials should follow the surname. Where there are three or more authors, all are listed; 'et al.' is only used in the citation. Use 'and' between the last two names; '&' is only for the citation. The References at the end of this article show the format.

Different types of writing require different details for the References, as shown in Table 2. Please provide these in the order shown. Do not add any formatting such as bold face or quotation marks; we will add that in the WGN house style.

7 Writing for WGN in LaTeX

Here is not the place to debate the relative advantages of WYSIWYG systems such as Microsoft Word and markup languages such as LaTeX. It is clear, however, that LaTeX has become the accepted standard for much scientific and engineering publication. WGN previously used TeX, but has now changed to LaTeX.

Many WGN readers will already know LaTeX. For those who do not, (Lamport, 1986) and (Goossens et al, 1994) are the standard books on the subject; (Kopka & Daly, 1999) seemss very clearly written and is probably a good start for beginners. Only a few guidelines will be given here.

- Only LaTeX 2_{ϵ} is used, not the older LaTeX2.09.
- The paper size is A4 and the document style is article.

Table 2 – Information required for References in WGN.

	Author(s)	Year	Paper title	Journal details	Book details	Conference details	Pages	URL
Journal paper	√	√	√	√[1]			√	
Book	√	√			√[2]		[3]	
Book chapter	√	√	√		√[2]		√	
Conference paper	√	√	√			√[4]	√	
Entire conference proceedings	√	√				√[4]		
World-wide web page [5]	√	√	√					√

Notes

1. Journal details should include (in order): Journal name, Volume, and Issue (if known). If neither Volume nor Issue is available, month and possibly day of publication should be added.
2. Book details should include (in order): Book title, Publisher, Publisher's town and country. If the town is well known (e.g. Oxford, New York), the country may be omitted.
3. If referring to just part of a book, page numbers are helpful.
4. The Conference Details should include (in order): Conference name, Place of the conference, Conference dates and Proceedings publisher (if known). Conference dates may differ from the date of publication.
5. Web pages are impermanent, and thus are not good references.

- The start-of-document command should be `\documentclass[10pt,a4paper,twoside,dvips]{article}`. Writers in North America may prefer to omit `a4paper` for their own proof prints.
- It will be impractical for you to produce WGN's two-column layout. Use the `article` style as if you were writing for a single-column journal.

More detailed information may be given later when WGN's LaTeX mechanisms have developed more and stabilized. Those who use BibTeX may send a `.bib` file; contact the Editor if uncertain how to do this.

If you find it hard to produce what you want in LaTeX, don't worry — see the next section.

8 LaTeX is not necessary

It is easier for us if you offer your paper in LaTeX, but not essential. We would far rather receive your paper in any form than miss it. If possible, send a machine-readable form — we prefer not to have to type it in.

We will format your paper to fit WGN, and probably adjust the positions of figures and tables. It is not worth your while spending time on the exact layout.

9 Main things to remember

If this seem horribly complicated, remember the advice on the cover of the Hitchhikers' Guide to the Galaxy — Don't Panic! When you submit your paper you are sending it to intelligent humans, not a simple-minded machine. If we can work out what you want, we can format it. LaTeX reduces our work but is not essential.

We may want to contact you about your paper. Please give us an email address where we can contact you in the period between submission and publication.

If you are uncertain whether your work is right for WGN, submit it anyway. We will tell you honestly if it needs improvement, and give you guidance about improving it. Astronomy only advances because people conduct research and then write it up.

10 Conclusion

WGN welcomes submitted papers. The accepted format of a scientific paper has been outlined. With minor exceptions, all submissions should be in this format, which is designed to help readers. This article has been formatted like a scientific paper, for illustration.

Details have also been given of the correct SI format for writing quantities and units.

Papers are prepared for publication in LaTeX, and authors are encouraged to write in this form. Papers in other formats (e.g. Word) are accepted and will be re-formatted.

Above all, readers are encouraged to share the results of their research by writing for WGN. Help to authors will be given where necessary.

References

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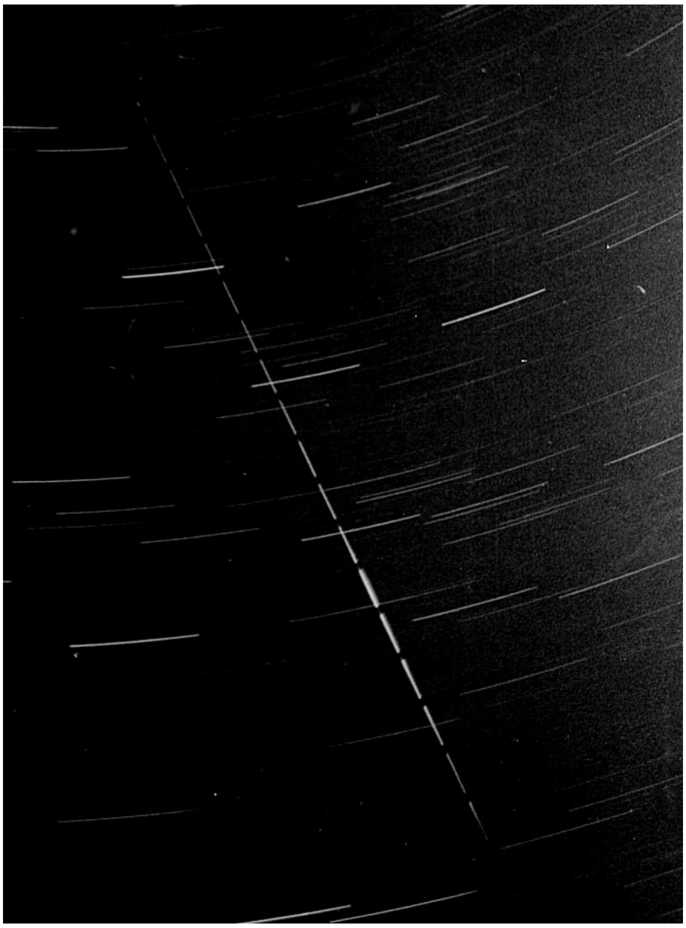
An $m_V = -2$ sporadic photographed from Harderwijk, The Netherlands, on 1992 Oct 20, $23^h46^m15^s$ UT. An 11 minute 58 second exposure on Tri-X with a Canon FD 50 mm, $f/2.8$ lens. Shutter: $2 \times 45°$, 25 breaks/s. [1992 Spo-2].



An $m_V = -3$ Perseid with an 8-second train photographed from Harderwijk on 1992 August 4, $21^h12^m43^s$ UT. A 15 minute exposure on Kodak Tri-X with a Helios 58 mm, $f/2.0$ lens. Shutter: $2 \times 45°$, 25 breaks/s. [1992 Per-3]

A magnitude -5 Leonid with a 40-second train photographed from Xinglong, China, on 2001 November 18, $17^h47^m43^s$ UT. A 12 minute exposure from an equatorial mount on Kodak Elite 200 color slide film with a Canon FD 50 mm, $f/1.4$ lens stopped down to $f/1.8$. No rotating shutter. M44, Praesepe, is visible at the bottom right. [2001 Leo-5]

Three images from Koen Miskotte of Ermelo in The Netherlands. The numbers in square brackets are his photograph reference numbers. For more details, see his website `http://home.planet.nl/~misko002/`.