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Conferences

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Front cover photo

A proof that meteors can be photographed from large cities. Photo by Arkadiusz Olech from the window of his flat in the centre of Warsaw. Taken on 2006 July 4/5 at $23^{h}52^{m}$ UT. Camera: Canon 300D with Canon EF-S 10-22 mm lens set to $f = 11$ mm and $f/4.0$ at ISO 800. Exposure 30 seconds long. (Photographers reference: img_7858.) The same event was captured by four other stations of Polish Fireball Network; from the video data the flight duration is knowm to be 4 seconds. More details can be found at `http://pfn.pkim.org/?q=pl/node/161` .

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

Cover design Rainer Arlt

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Editorial — What should WGN publish?

Chris Trayner

WGN is the IMO's house Journal, and exists to serve the needs of the members. What sort of articles should it publish? To answer this, we should start by considering who the IMO's members are. They are a mixture of amateur and professional astronomers, but mainly amateur. Their interests include theory and observation, but — I would guess — mainly observation. The IMO is a pro-am (professional/amateur) organisation; part (though not all) of its purpose is to collect good amateur observations and make them available to professionals.

This suggests that WGN should contain a mixture of observational and theoretical articles, possibly with the emphasis on the former. Many articles are a mixture of both, of course. There are also articles of other sorts: administrative, conference reports, historical items (such as McBeath and Gheorghe's *Meteor Beliefs Project*), letters and others.

In recent years, WGN has had more theoretical articles than observational ones. This is not because of editorial policy — we have no policy that prefers one to the other. It is simply that fewer observational articles have been submitted, and we cannot publish what we do not receive.

Academic journals sometimes find themselves in a bit of a Catch-22 situation: authors (by chance) don't submit anything of a particular type, therefore the journal publishes nothing of that type, therefore authors think that the journal doesn't want anything of that type. It may be that this is why WGN is not receiving many observational articles at the moment.

What do WGN readers actually want? If you have preferences, it would be worth telling us. We are always willing to listen to what readers say. Would you like more or less observational material? theory? history? beginners' articles? An email is enough, though it would be good if it is in the form of a Letter to the Editor so I can publish a selection of peoples' wishes.

Emails can be sent to `wgn@imo.net` but remember to put something like Meteor in the subject line to get past our strong anti-spam filters.

If you have any observational articles you are thinking about writing, of course, we would be very glad to have them submitted.

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Aurigids

Aurigid predictions for 2007 September 1

P. Jenniskens [1] *and J. Vaubaillon* [2]

The September 2007 encounter with the 1-revolution dust trail of comet 1911 N1 (Kiess) was modeled to predict the expected peak time, duration, and peak rate of the Aurigid meteor outburst. This event is the only anticipated dust trail crossing of a known long period comet in the next fifty years. With a peak time of 11:36 ± 20 min UT, September 1, 2007, the meteor outburst will be visible from locations in Mexico, the Western states of Canada, and the Western United States, including Hawaii and Alaska.

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1 Introduction

Past encounters with the dust trail of long-period comets were observed only by chance and by few observers. Astrometric measurements were made only during the1995 α-Monocerotid shower (Jenniskens et al., 1997), and to lesser extend during the recent October Camelopardalid outburst (Jenniskens et al., 2005). The α-Monocerotid outburst was predicted based on a similarity in the Sun's reflex position, which mimics the position of a dust trail relative to Earth's orbit (Jenniskens, 1997; Lyytinen & Jenniskens, 2003).

Since the confirmed detection of the 1995 α-Monocerotids (from an unknown comet) and the subsequent Leonid storms, the basic physical principles behind these transient showers is understood: dust ejected from the parent comet is dispersed due to small differences in orbital period from ejection speed and radiation pressure. The dust forms a trail that wanders in and out of Earth's path due to planetary perturbations by the major planets working slightly differently on particles at different positions along the trail (Kondrat'eva & Reznikov, 1985; Kresák, 1993; McNaught & Asher, 1999; Lyytinen, 1999; Jenniskens, 2006). A meteor shower outburst is observed only when the trail is in the Earth's path at the same time of Earth passing the node.

In the case of so-called intermediate long-period comets, with orbital periods of 200 − 10 000 years, the trail is so much perturbed on the way in that the second revolution dust trail is dispersed beyond recognition (Lyytinen & Jenniskens, 2003). Hence, the dust of a long-period comet outburst dates from the last time the comet was near the Sun. All such intermediate long-period comets have a one-revolution dust trail if they completed at least one orbit around the Sun.

2 The 2007 Aurigids

Lyytinen and Jenniskens (2003) investigated when the dust trails of known long-period comets would be in the Earth's path in the next fifty years. They discovered that the most promising case would be that of the α-Aurigids on 2007 September 1, when the position of the trail will be identical to that of three known past outbursts of this shower. In their model, the trail was calculated to be just inside Earth's orbit at all occasions. The past showers make this the only such encounter that can be predicted with enough certainty to warrant a concerted observing campaign, until the 2040/41 AD return of the Lyrid from comet C/1861 G1 (Thatcher).

We investigated the distribution of dust from comet C/1911 N1 (Kiess) using a comet ejection model developed by Crifo & Rodinov (1997) and calculate rigorously the planetary perturbations on the particles from the point of ejection until intersection with Earth's orbit (for a full review of the method see Vaubaillon et al., 2005a, Vaubaillon et al., 2005b).

Some 1 000 000 meteoroids were ejected from the comet orbit in 83 BC, which is the perihelion time of the nominal comet orbit (Minor Planet Center comet orbit database) when integrated backward in time. The calculated Julian day of perihelion passage is 1690869.5, when Julius Caesar was still in the provinces. Forward integration confirms that planetary perturbations occur only on the inward leg. As a result, the precise position of the dust trail is not sensitive to the adopted perihelion time in that previous return.

Figure 1 shows the calculated position of the one-revolution comet dust trail at the time of Earth passing the node in 1935, 1986, and 1994. The graph shows all particles that crossed the ecliptic plane within two months from the time of the observed outburst. The motion of the trail has been removed by fitting simple first or second order polynomials.

Preliminary results were announced at the IAU General Assembly in Prague (Jenniskens & Vaubaillon, 2006) and are summarized in Table 1. Each past shower lasted about 1.5 hours, with a Full Width at Half Maximum = 28 minutes. The width of the trail is not expected to change much from one return to the next, although it will depend on how far we pass from the trail center, based on our experience with past Leonid storms (Jenniskens, 2006). Also, past Leonid dust trails tended to be 0.00025 AU further inward than calculated. If so, the peak time will be up to 21 minutes earlier than calculated.

In 2007, the trail will be at exactly the same position relative to Earth orbit as in prior returns. This confirms

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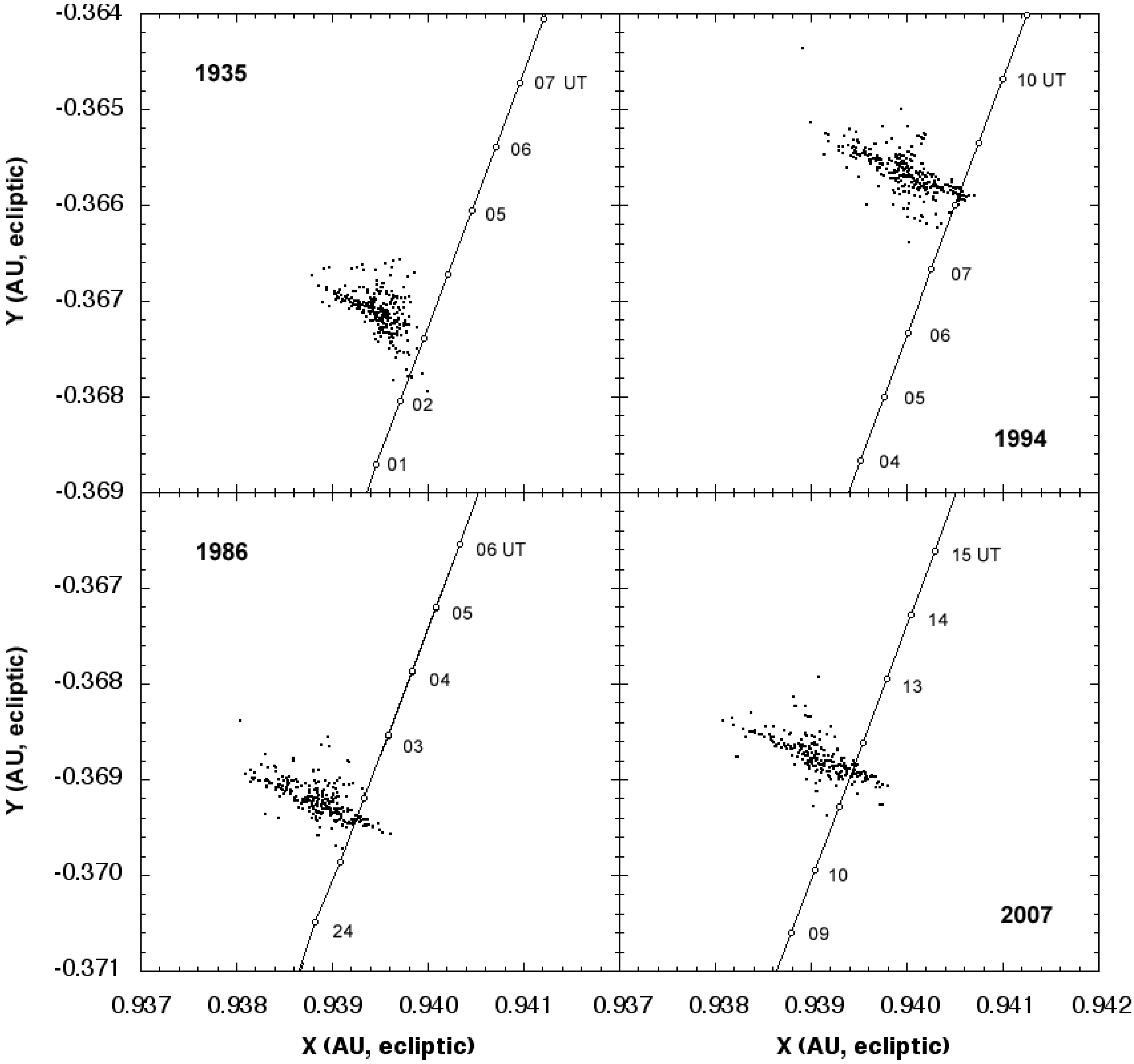

Figure 1 – Position of the node of the model 1-revolution Aurigid stream particles that passed the ecliptic plane within 2 months from the time of past Aurigid outbursts. Only particles are shown that would cause meteors of magnitude −3 to +3. The trail motion over that time period has been removed. The density of points corresponds to the expected intensity of the shower.

Table 1 – Calculated circumstances for the encounter with the 1-revolution (83 BC) trail of C/1911 N1 (Kiess) at the time of Aurigid outbursts. $\Delta r_\Omega(D-E)$: difference in the the heliocentric distances of the nodes between Earth and dust. Δa: difference in orbital element a between comet and meteoroid immediately after ejection. f_M: mean anomaly factor, describing the dilution of dust density in the trail relative to that of the 1-revolution trail (in the absence of planetary perturbations). FWHM: Full-Width at Half Maximum, describing the broadness of a distribution by specifying the width at a level half that of the peak.

Year observed	Year ejected	$\Delta r_\Omega(D-E)$ (AU)	Δa (AU)	f_M	Sol. Long. (J2000)	Day	Time (UT)	FWHM	Phase of Moon
2007	−82	−0.0003863	6.9726	0.005810	$158\overset{\circ}{.}561$	Sep. 01	$11^\mathrm{h}36^\mathrm{m}$	25^m	0.8
1994	−82	−0.0008137	6.0279	0.004612	$158\overset{\circ}{.}738$	Sep. 01	$08^\mathrm{h}01^\mathrm{m}$	33^m	0.1
1986	−82	−0.0003673	5.4497	0.016433	$158\overset{\circ}{.}530$	Sep. 01	$01^\mathrm{h}38^\mathrm{m}$	27^m	0.6
1935	−82	−0.0005241	1.7459	0.031045	$158\overset{\circ}{.}656$	Sep. 01	$03^\mathrm{h}05^\mathrm{m}$	35^m	0.6

Table 2 – Observed parameters of past Aurigid outbursts. FWHM: Full-Width at Half Maximum, describing the broadness of a distribution by specifying the width at a level half that of the peak. $< m >$: average magnitude.

Year	Sol. Long.	Day	Time (UT)	ZHR (/hr)	FWHM (min)	RA (J2000)	DEC	$< m >$
1994	158.°733	Sep. 01	07^h54^m	200 ± 25	~ 30	—	—	+1.13
1986	158.°519	Sep. 01	01^h22^m	200 ± 25	28 ± 7	90.5	+34.6	+0.54
1935	158.°656	Sep. 01	03^h04^m	≥ 100	31 ± 13	86.3	+40.5	+2.62

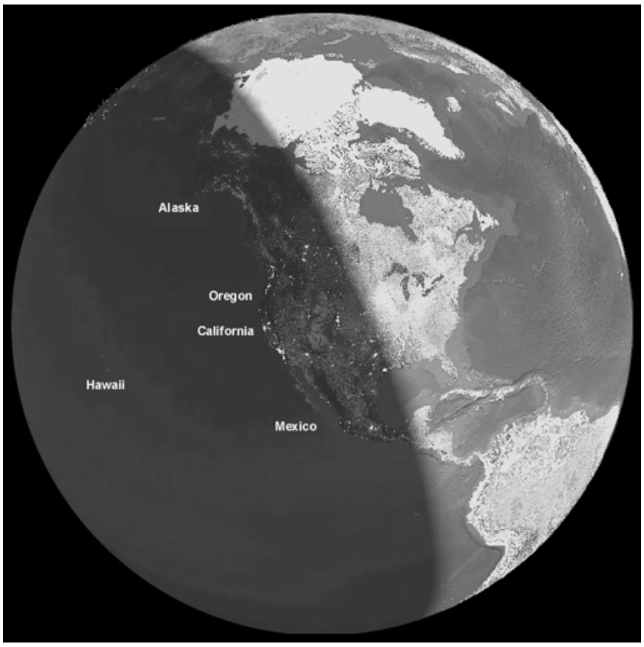

Figure 2 – View of the Earth from the perspective of the approaching meteoroids. Best locations for viewing the outburst are at the dark side of the Earth, somewhat away from the civil twilight border, and closest to the center of the image.

earlier results by Lyytinen and Jenniskens (2003). However, the observed peak time in past encounters was 1, 16, and 7 minutes earlier than calculated (Table 2). Our best estimate for the peak time, therefore, is 11:36 UT on September 1, 2007, with an uncertainty of about ± 20 minutes.

As it happens, the predicted encounter time makes the shower favorable for viewing from the California, where the radiant will be high in the sky just before dawn. A bad Moon, four days past full Moon, will be high in the sky ($\sim 69°$ at San Francisco), which will hamper ground-based observers. Fortunately, the Moon will not dampen the display much, because past Aurigid outbursts were rich in -3 to $+3$ magnitude meteors, with few faint ones.

3 Past Aurigid outbursts

In 1935, Cuno Hoffmeister and Artur Teichgraeber at the Sonneberger Sternwarte in Germany and visual observers from the Štefanik Observatory in Prague reported an outburst of meteors in the predawn hours of the morning of September 1 during regular observations (Teichgraeber, 1935; Guth, 1936). A large number of bright meteors radiated from a point in the constellation of Auriga. The German and Czech observers nicely confirmed each others' reports and, together, documented the event well. Teichgraeber immediately realized that the radiant of the Aurigid stream was not far from that of comet C/1911 N1 (Kiess) at 91.3°, +39.°2, which passed Earth's orbit unusually close in 1911. However, it was long unknown how, 24 years after the return of the comet, there could still be a sudden meteor outburst.

The cause of this outburst came into focus when in 1986 another outburst was observed by Hungarian amateur meteor astronomer Istvan Tepliczky of the *Magyar Meteor- és Tüzgömbészlelö* (MMETH). He saw a flurry of bright meteors radiating from the constellation Auriga, which was in many respects similar to the event in 1935 (Tepliczky, 1987). These were again predominantly bright meteors, +0.54 magnitude on average, all leaving a wake lasting 1–3 seconds. There was no independent observation that year, but the fact that the Aurigids had returned was quickly accepted on account of Teplickzky's experience as a visual meteor observer. Again, the peak of the outburst was close to the comet orbit node. The position of the radiant was derived from plotted trails was close to the theoretical position of Kiess (Table 2).

When the shower returned in 1994, it was observed by only two experienced visual observers under marginal conditions. N.A.M.N. observers Bob Lunsford and George Zay, located near San Diego, California, observed the outburst very shortly after the radiant came above the local horizon (Zay & Lunsford, 1994). These grazing meteors were very slow and made long 60 degree tracks on the sky, lasting 2 seconds. Most were of magnitude 0 and +1. Forward meteor scatter observations by Ilkka Yrjölä of Kuusankoski, Finland, confirmed the outburst and placed the peak some time before Bob and George saw the first Aurigids (Jenniskens, 1997).

Rates continued to rise when twilight interfered during the 1935 outburst. In 1986, Tepliczky derived an average ZHR $= 39.6 \pm 8.1$ from the period between the first and last Aurigid (00^h47^m – 02^h12^m UT), during which 24 Aurigids were seen. He only saw two sporadic meteors in an hour prior to the outburst (limiting magnitude $\sim +5.2$?), and the faintest Aurigid was +4 magnitude, which suggests that observing conditions were not ideal. Jenniskens (1995) calculated a peak ZHR $= 250 \pm 30$/hr, based on 10-minute intervals, but used an exponent of 1.4 to account for the radiant

Table 3 – Observed magnitude distributions (Zay & Lunsford, 1994). Observer VR is Vrátnk (first name unknown) of the MČAS (Chechian Astronomical Society), who saw the shower in 1935 from the Štefanik Sternwarte in Prague (Guth, 1936).

	−4	−3	−2	−1	0	1	2	3	4	5	Observer
Aurigids:											
1994	0	0	1	0	1	8	6	2	0	0	LUNRO
1994	0	0	1	0	1	9	3	3	2	1	ZAYGE
1986	1	0	0	5	7	3	6	1	1	0	TEPIS
1935	—	—	—	—	2	2	14	9	4	1	VR
Sporadics:											
1994	0	1	1	0	3	3	18	24	10	2	LUNRO
1994	0	1	0	2	6	5	16	21	8	6	ZAYGE

altitude correction. For a simple geometric correction $\sim 1/\sin(h_r)$, the ZHR $= 200 \pm 25$/hr.

The rate measurement in 1994 was hampered by the low radiant elevation and a rising radiant during the observations. Lunsford and Zay observed 20 and 17 Aurigids that night. For the hour between 07^h22^m and 08^h22^m UT, with the radiant being at 13° elevation at 07^h49^m UT, they calculated a ZHR = 37/hr and 55/hr, respectively. Again, the rate varied strongly during that interval. In small 10-minute intervals, Jenniskens (1997) had a peak ZHR $= 400 \pm 50$ per hour. For a simple geometric dilution correction, this rate would be a factor of 2 lower.

We can use these past activity estimates to guess how intense the 2007 Aurigid meteor shower will be. Based on these calculations, the rates in 2007 are expected to be of similar intensity as in 1986 and 1994, with a peak ZHR of about 200 (Figure 1).

These showers were very dramatic because of their brief duration and the abundance of bright meteors. These past Aurigid showers contained as many meteors with negative magnitudes as the recent Leonid storms. The 2007 return is not much further from the position of the comet than that of 1994 and we expect again relatively bright meteors of magnitude −3 to +3 magnitude (Table 3) with a low magnitude distribution index $\chi \quad \sim 1.5 \pm 0.3$. The trail does not contain many small particles. In our model, this is because the smaller grains are ejected in wider orbits (Whipple, 1951) and become quickly more dispersed.

The α-Monocerotid magnitude distribution was truncated with an upper mass cut-off, presumably because large grains can not make it this far out in the trail. Our model, however, shows that large particles can make it out to this position in the trail and we are interested in knowing what will be the brightest Aurigid observed in 2007.

4 Importance of this rare shower

From the 1994 return of the Aurigids, it was clear that there was no simple periodicity as expected for a clump of dust in a shorter orbit. Instead, the solar reflex motion was nearly the same in each year, giving birth to the hypothesis that the outbursts were caused by a wandering dust trail (Jenniskens, 1995). This was confirmed the next year, when the 1995 α-Monocerotid outburst was observed and proven to be due to dust grains in a long-period orbit (Jenniskens et al., 1997) and not a dust cloud from a comet fragment orbiting in a 10-year orbit as thought before.

Until now, the α-Monocerotids are the only dust trail crossing with the trail of a long-period comet observed by modern instrumental techniques. Interestingly, these meteoroids were very unusual. They were found to be almost completely lacking in sodium (Borovička et al., 2002; Borovička et al., 2005) and penetrated relatively deep in Earth's atmosphere (Jenniskens et al., 1997), presumably because material was sampled that came from a pristine crust exposed to cosmic rays at the time of cold storage in the Oort cloud.

C/1911 N1 Kiess is an *Intermediate Long-Period comet*, which means that it has survived a few orbits since first entering the inner solar system. This makes it representative of a large number of such comets that appear at Earth very infrequently but betray their presence by a dust trail. We do not know for certain if the debris lost in 83 BC contains any grains from its pristine crust. However, it is very enticing to attempt to detect such meteoroids as they represent the only direct evidence for cosmic-ray induced crusts of comets.

In this context, it is interesting that Bob Lunsford and George Zay described the outburst Aurigids as having a greenish or bluish look to them (Zay & Lunsford, 1994), while being more white outside this interval. That suggests that the meteoroids produced a strong iron and magnesium signature from ablating metal atoms, more so relative to air plasma emissions during the outburst than by meteors from the annual Aurigids. This could point towards a different particle morphology of outburst Aurigids.

Another important reason for observing the 2007 Aurigid outburst is that long-period comets are responsible for some of the largest impact craters on Earth. Dust trail crossings from unknown comets are sometimes observed, which betray the presence of an Earth-threatening long-period comet. A recent example is the 2005 October Camelopardalid outburst (Jenniskens et al., 2005). A study of the imminent dust trail crossing may teach us how to translate observed dust trail crossings into physical data on the parent comet. The duration of such outbursts, for example, depends on how fast the meteoroids are ejected, which can teach us how massive the parent comet is. The results can be compared to observations of comet Kiess itself.

The expected meteor outburst is not a great immediate threat to satellites in orbit. The meteoroids are an impact hazard for satellites because of the high impact speed of the meteoroids (Beech & Brown, 1993). However, the impact probability will be less than that of past Leonid storms due to a lack of small meteoroids in the trail. Fast sporadic meteoroids are more likely to hit, because they are present over longer time intervals. Even so, the chance of impact of fast meteoroids in the mass range of $0.01 - 0.1$ gram will increase a hundred fold at the peak of the brief Aurigid outburst.

More important is the fact that long period comets can break and produce dense dust streams (e.g., Sekanina 2002). If the comet breaks while rounding the Sun and the dust cloud (the zero-revolution trail) moves into Earth's path at the wrong moment, the rate of meteoroid impacts can rise above ZHR = 1 000 000 /hr. The likelihood of this occurring is higher than the chance that the comet itself will hit the Earth. The study of the Kiess dust trail can help future mitigation efforts by calibrating prediction models that determine the exact location of such debris clouds.

Acknowledgements

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Third Radio Meteor School, September 11–13, 2006, Roden, The Netherlands

Antonio Martínez Picar [1]

The background and events of the third Radio Meteor School are described.

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We can, with certain accuracy, establish N_h, the total number of people living on Earth. According to the censuses carried out in different countries of the world it amounts to 6.5 billion inhabitants. The great majority of them have developed in a relatively stable manner. However, many inhabitants exhibit inclinations to madness. Suppose the fraction of inhabitants that present symptoms of irrationality is approximately 1/3. The total number of people potentially crazy in the world would therefore be $N_h * f_p \simeq 2.17 \times 10^9$. In our environment not all the possible lunatics are able to control their folly and direct this force toward meteor astronomy. We can say without a doubt that only a small fraction of those candidates for lunatics develop in an environment suitable enough to guide their life toward this activity. Choosing a conservative factor of $f_{ma} = 1/10000$, the number of people in the world ending up associated with the meteor science is $N_h * f_p * f_{ma} \simeq 2.17 \times 10^5$.

Experiments show that most of those tied with meteor astronomy run for their life when they face the idea of studying meteors with radio. We now tread into an uncertain territory, as dealing with the equipment of this field brings many obstacles, such as financial or practical, although I believe the practical issues can be solved with good theoretical foundation. We choose $f_r \simeq 1/9$, which gives us the total number of people, interested in the meteor astronomy in the world, that actually study meteors by radio, to be $N_h * f_p * f_{ma} * f_r \simeq 2.4 \times 10^4$ — a few dozen thousands. This conclusion is notable in itself. But this is not all.

The selection of next parameters is much more difficult. On one hand, many steps, each equally unlikely, are required for these people to develop a certain intelligence level. On the other hand, there are many different paths that end in a civilized group with the capacity and necessity to share experience. Let us choose for f_i and f_c (factors for intelligence development and capacity or necessity to communicate, respectively) a combined value of 1/100 ($f_i * f_c$); that is to say that only one percent of people that study radio meteors generate an extraordinary intelligent group with notable capacity/necessity for communication. Multiplying all these factors we obtain $N_h * f_p * f_{ma} * f_r * f_i * f_c \simeq 241$, a little more than two hundred people that have developed the capacity to gather and exchange experiences and knowledge about radio meteors. But this doesn't mean that there are over 200 people gathered together at any given moment. Here we have to take into account the factor f_L.

What percentage of people, interested in those radio meteors, has the possibility of attending a meeting without compromising family, marital and work commitments, and how many can afford it? The experiments demonstrate that without the unselfish help of supporting members, without excellent organization and without a lot of determination it is pretty unlikely to assure the attendance in this type of meetings. It is also important to consider the possibility of getting lost trying to reach the location of the meeting. We set the factor $f_L = 1/20$ and therefore $N = N_h * f_p * f_{ma} * f_r * f_i * f_c * f_L \simeq 12$; in any given meeting there would only be a small quantity, a handful of people with the necessity to exchange and acquire knowledge of radio meteors.

During September 11 – 13 2006 the 3rd Radio Meteor School (RMS) was held in Roden, The Netherlands, and the number of attendants corresponds exactly to the value of the previously calculated N, which seems to indicate that the parameters were estimated quite accurately.

The expectations of the School participants are a bit more difficult to express with formulas. However, I venture to say that they were concentrated around the detailed study of the forward-scatter technique, which was possible with the essential help of Svetlana Suleymanova, who came from Germany. Her explanations (and the very valuable help of Galina Ryabova from Russia) broadened the horizon that Prof. Belkovich revealed to us the previous year. Actually, one of the best results of the 2005 Radio Meteor School was the interesting proceedings published by the Belgians Cis Verbeeck and Jean-Marc Wislez who summarised the work of the entire year and described the topics presented in Oostmalle, Belgium. An important part of the 2006 meeting was a review of the concepts and contents of the proceedings, to which Cis and Jean-Marc contributed significantly with their in-depth analysis (again, good work, guys!).

Pavol Zigo, who came from Slovakia, presented his work on observability function and certain observations practices carried out with the forward-scatter system Bologna-Lecce-Modra.

Pieter-Tjerk de Boer, of the University of Twente,

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The Netherlands, shared his experiences with the Software Defined Radio (SDR) and its properties.

Coming from France, Jean-Louis Rault illustrated with simplicity the software 'SpectrumLab' for the reflections' analysis, and Vladimir Sliusarenko, from the Ukraine, brought an interesting sample of meteor observations conducted in his country (in addition to giving us a *virtual tour* of Kiev... Incredible!)

Marc Neijts, Frans Lowiessen and Frans Der Kaizer were excellent hosts, but also contributed passionately to the discussions about future plans, cooperation programs, standards development and publications.

While this whole incredible exchange of ideas was taking place, Antonio Martinez — of Venezuela — only took notes and made coffee (don't worry guys, that's over). Since I didn't do anything useful during the 3rd RMS, I at least got the opportunity to contribute with this text...

It has been therefore demonstrated that the attendants to the 3rd RMS 2006 meet the conditions described in the beginning. Regrettably, due to the last factor (f_L) some important people were unable to attend. Oleg (The Master) Belkovich was in our thoughts during these three magnificent days of fun. It is worth mentioning that the value of N remained unchanged in the last two RMS. The 4th RMS will be held in Barèges, France — will the number N stay the same?

It is my personal belief that N should have a tendency to grow with time, taking into account the success of these meetings and the quality of the topics discussed (and disregarding the negative effect of my coffee, of course). The proof of this is the wonderful text published as 'Proceedings of the Radio Meteor School 2005', which is a clear demonstration of important achievements of the radio meteor studies during these events.

If the number N decreases, it could be concluded that the noxious effect of my coffee is not negligible, in which case I would recommend to hide the coffeepot or to ask Juan Martín Semegone to prepare *mate* for everybody... (we missed you, 'guacho'). It would also mean that some of the parameters were not well estimated. In any case, a decrease of the value of N would represent waste of talent — and that would be a real pity.

Ongoing meteor work

Meteor trains and velocities 2: More methods and some results

Andreas Buchmann [1]

Some ideas of how to improve the evaluation of meteor trains and some results are provided.

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1 Introduction

Some meteors leave trains, which can be observed for seconds or up to minutes in extreme cases. The physics behind trains is not well understood (see discussion). Several factors determine if a train can be seen or not: most importantly, brighter meteors have a higher probability of leaving visible trains. Interestingly, there are very bright meteors without trains. In earlier papers, it has been shown that streams with high velocity relative to the earth have a higher probability of leaving trains in meteors of a certain brightness (Bellot Rubio, 1992) and (Buchmann, 2004) (hereafter B1). This probably has to do with the physics of fast versus slow meteors in the atmosphere: slow meteors receive a significant drag, slow down considerably, have the time to be heated in the inside and finally evaporate as a whole, whereas fast meteors ablate and lose mass at the outside, decelerate little and stay cool in the inside until their diameter has shrunk to zero (Friichtenicht & Becker, 1973). The ablation should help train formation (Baggaley, 1975). Besides, the luminous trails of fast meteors start at a higher altitude, which could conserve trains longer than in the lower atmosphere. Comparing train probabilities between different meteor streams could help to elucidate the physics of the meteor and possibly the composition of meteoroids of different streams (though the author showed in the earlier paper B1 that the velocity explains the biggest part of the variance in train probability, so it could be difficult to extract further factors).

2 Methodological considerations

For the actual work several factors were improved, some of which were mentioned already in the previous paper B1. The first factor is control of limiting magnitude and clouds. Limiting magnitudes of the observations used were between $m = 6.2$ and 6.8, observations with clouds were carefully excluded, because they may influence seeing trains much stronger than seeing weak stars, so high cirrus clouds may not be controlled over the limiting magnitude.

The second factor comes from the observation that the present author rarely noted trains in bright meteors. Theoretically meteors of $m = 0$ should have at least as many trains as meteors of $m = 1$, but in my data, this was often reversed. The problem is that bright meteors are seen very often far from the center of field of view. Since observers are trained not to turn their heads until recognised the starting and end points of the meteor, trains may be lost if turning the head towards the trail some seconds later. To avoid the bias of this effect in the data, meteors which did not reach a circle of 45° around the center of field of view were excluded. Logically this excluded all counted meteors as well, which thinned out the dataset considerably. This is why as many streams as possible had to be aggregated and only two classes of meteors were compared: 'slow' and 'fast' meteors.

Another change concerned the dependency on the magnitude of the meteors: the last paper B1 compared only meteors of $m = 2$ and 3. Results for $m = 2$ and 3 differed slightly, and it was not possible to separate the proportion of trains from the magnitudes of the meteors. For example it may be arbitrary to compare $m = 3$ Leonids with $m = 3$ June Boötids. The idea was to approximate the magnitude-train relation with an appropriate and simple mathematical function and to derive from this function the magnitude at which half of the meteors of a certain velocity have observable trains. It was hoped to find an S-shaped curve which is asymptotic towards 1 at the left, and 0 at the right side. An approach containing exponential functions was sought, but finally the hint of the logistic regression function which nicely fulfills my needs was found. (The first thought was of an integral of a Gaussian distribution, which would be practical, if it existed; the logistic regression has a similar form.) The equation has the form

$$P(m) = \frac{\exp(v - m)}{1 + \exp(v - m)} \qquad (1)$$

where $P(m)$ is the estimated probability that a meteor of magnitude m has a train
and v is the fitting parameter, the translation of the curve parallel to the x-axis.

The rather small pool of data was divided into slow meteors (weighted mean of meteor velocity 29.97 km/s) and fast meteors (66.85 km/s). The curves were obtained with the summed square differences of the five data points consisting of more than ten meteors (which were $m = 0$ to 4 for the slow and $m = 1$ to 5 for the fast meteors). Note that for slow meteors there is far too little high-proportion-of-trains data (which would correspond to very bright meteors), so it is not possible to pinpoint the left side of the curve, but rather one might suppose that it might look similar to the curve for the fast meteors.

It is not possible to base the width of the curve on theoretical considerations so it could also be modeled,

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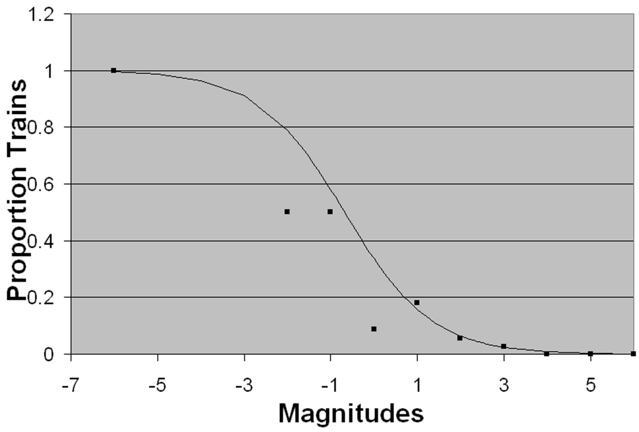

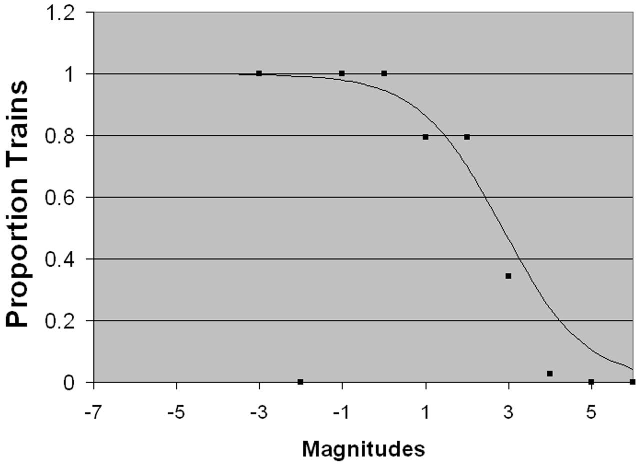

Figure 1 – Fitted curve for (top) the slow meteors and (bottom) the fast meteors. Smooth curves are the theoretical curve (logistic regression), squares the data points. Note that the curves were fitted for $m = 0$ to 4 for the slow meteors and for $m = 1$ to 5 for the fast, because only these points consisted of more than 10 observations.

but this would need more data points. (Jan Verbert provided the hint of the simplest formula which fulfills the need, which is

$$P(m) = \frac{\exp(v - am)}{\exp(1 + v - am)} \tag{2}$$

where a is the parameter for the width of the curve.) Accidentally, the above formula seems to fit the curve for fast meteors, so it was retained for this paper given that more data would be needed to approximate two parameters instead of one.

3 Results

Figure 1 (top) shows the curve for the slow meteors (CAP to LYR; $n = 484$), Figure 1 (bottom) the curve for the fast meteors (HYD to LEO; $n = 163$). For the fast meteors, it was possible to cover the whole range of the values, for the slow meteors, there is far too little data for the brighter magnitudes. Only magnitude points with at least ten meteors were used to estimate the curve. It is easy to see that for the fast meteors, the point where the meteors have 50% trains is at a weaker magnitude than for slow meteors: the estimated values are $m = -0.7$ for slow meteors (weighted mean 29.97 km/s) and $m = 2.8$ for fast meteors (66.85 km/s). These are the values of the fitting parameter v for equation 1.

From these typical magnitudes, at which 50% of the meteors of a given velocity produce visible trains, we can estimate the ratio of energy put into train luminance in fast / slow meteors: we assume that the trains of fast or slow meteors have the same magnitude threshold to be detected by a given observer. With train magnitudes held constant, the ratio of meteor energies is therefore the ratio of the proportions of meteor energy put into train luminance. The difference in magnitudes between the fast and slow theoretical curves, each providing some sort of summary of their data points, is $dv = 3.527$, the ratio of energy can therefore be estimated (under the assumption that the same proportion of energy is transduced into light in slow and fast meteors) as follows: $2.512^{3.527} = 25.75$. The ratio of velocities is 2.23 in this sample, so

$$\log_{2.23}(25.75) = 4.05$$

so that $2.23^{4.05} = 25.75$, which means that the energy put into train luminance in proportion to meteor luminance rises as the 4th power of the velocity.

4 Discussion

This result of the 4th power still has to be considered as preliminary. Especially for the bright slow meteors, there is too little data. With this paper it was rather intended to give a proof of principle and to stress the methodological points that train proportions can be approximated with a logistic regression function, and that trains are often overlooked if meteors occur in the periphery of the field of view of a visual observer. If we report no train for a given meteor, we should keep in mind that we could have overlooked it because of the smaller resolution in peripheral vision.

At first glance, one might think that this paper came to the same conclusion as the previous paper. This is not quite true, because the previous paper looked at train probability as a function of stream velocity for two meteor magnitudes, while this paper rather looks at train probability as a function of meteor magnitude for two stream velocities (Figure 2). That this exponent and the one from B1 both came out to be around 4 seems to be purely coincidental.

We can speculate about the mechanisms that could boost train formation in fast meteors, even stronger than in proportion to their kinetic energy (which would go as v^2). There are hints for different energy transduction in fast *versus* slow meteors:

1. Fast meteors start to glow higher in the atmosphere, around 120 km above the ground. The atmosphere there is thinner than at 100 or 90 km height, where slower meteors start to glow. 'Normal' trains lasting for up to 3 seconds mainly consist of light from the forbidden auroral light of neutral oxygen (reviewed in Ceplecha et al, 1998),

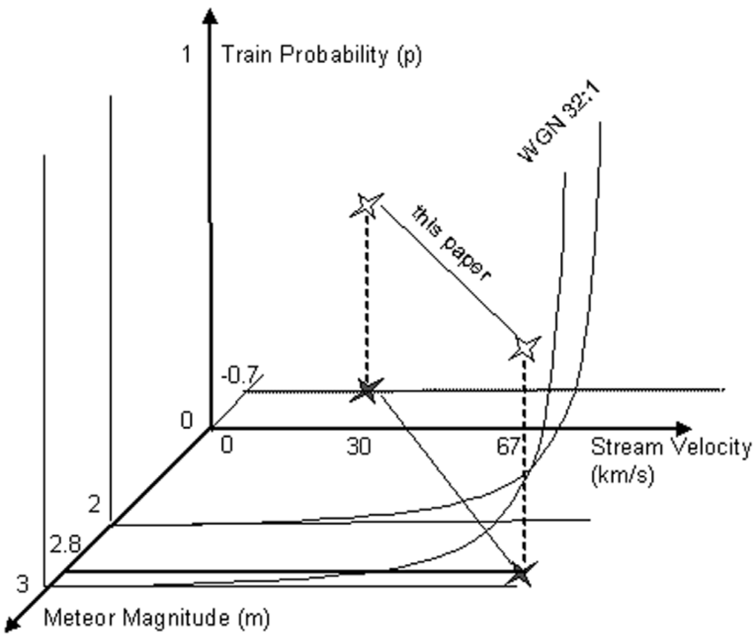

Figure 2 – An attempt to show the difference between paper B1 and the present one: the first measured parallel to the magnitude axis, and the second parallel to the probability axis.

which appears in a high vacuum, but not at sea level, so the low atmospheric density might be important.

2. Fast meteors seem to have a stronger 'second spectrum', which is a high-temperature spectrum (about 10 000 K) as compared to the main spectrum of about 3 500–5 000 K. The second spectrum could stem from the shock wave in front of the meteor head. In faint meteors of medium or high velocity 'meteoric' components of the 4 000 K spectrum (Ca I, Na I, Mg II) can be absent, while atmospheric components (O I, N I and N_2 bands) are quite strong (reviewed in Ceplecha et al, 1998). Only one shock wave has been observed directly with 1000 frames/second equipment in a bright Leonid up to now (Stenbaek-Nielsen & Jennsikens, 2004), whereas three weaker Leonids did not seem to have visible shock waves at all. While the temperature of the second spectrum does not seem to depend on the velocity of the meteor (as for the main spectrum), there is more atmospheric gas involved in the luminance.

3. In parallel with these high temperatures of the shock wave, faster meteors might emit more UV light, which could lead to different photochemical cascades. Radiation even in the far ultraviolet has been observed (Carbary et al., 2002).

This might all seem a bit fuzzy and speculative, but our knowledge of the physics of weaker (i.e. normal) non-Leonid meteors is quite limited at the moment. Obtaining meteor spectra is quite difficult, and it is even more difficult to get spectra from trains. There is no model yet which could explain why meteor heads can be as large as 100 m (Stenbaek-Nielsen & Jennsikens, 2004). So there is more work to be done.

5 Outlook

Unfortunately the author's small data set does not allow one to say much about individual streams (because counting data were excluded, there is not more data from the four intense streams QUA, PER, LEO and GEM than from smaller streams like VIR). However, the myth that the Geminids should be train-less can be excluded — Geminid trains in meteors of $m = 0$, 1 and brighter were observed, which is what one would expect from a slow stream (35 km/s). For the Lyrids, which is a medium-velocity stream (49 km/s), trains in meteors of $m = 2$ are common. For the Leonids (71 km/s) there are trains down to meteors of $m = 4$ in good conditions, whereas trains in $m = 2$ Leonids can often be seen for several seconds. On the other side of the scale, a JBO (18 km/s) should be very bright to show a train: Theoretically around $m = -3$ (and it could be difficult to notice a $m = 6.5$ train after a $m = -3$ meteor!) It would be good to have more data for slow streams as well (for the official train report form, see (Verbert & Deconinck, 2001)).

The author's data just allow one to separate two velocities. With more data, it will be possible to check if the exponent stays the same for all velocities, or if there is some threshold pointing to different kinds of processes for slow and fast meteors. This could be an elegant way to find out if ablation has to do with train formation. To search for differences between individual streams (controlled for stream velocity), one would need FAR more data (for example at least 30 meteors per magnitude over the whole range of the curve). On the other hand, it seems better to have little high-quality than much low-quality data: shower association, control for limiting magnitude, and near-central vision are crucial.

Acknowledgements

To Jürgen Hänggi for the idea with the logistic regression. To Jan Verbert and Rainer Arlt for comments to an earlier draft of this paper.

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Orionids

Three days of enhanced Orionid activity in 2006 – Meteoroids from a resonance region?

Jürgen Rendtel [1]

In 2006 the Orionids showed significantly enhanced ZHR of up to 60 over three days combined with an unusually low population index r around 1.6 rather than the long-term average of 2.3–2.9. Two of the extracted ZHR sub-peaks coincide with minima of r. Therefore the particle population between $207\overset{\circ}{.}8$ and $210\overset{\circ}{.}5$ significantly deviated from the average Orionid meteoroids. Similarities to the June-Boötids 1998 and the Leonids 1998 hint at meteoroids moving in a resonance with Jupiter with the 1:6 commensurability being the most favourable. Data from the period 1933–1938 hint at enhanced Orionid rates, supporting the assumption of meteoroids in a resonant trail.

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1 Introduction

The Orionids are regarded as a rather constant meteor shower with a maximum ZHR of the order of 20–25. The period of the maximum covers several days usually from October 20–24. Obviously, this maximum period consists of several successive submaxima. No enhanced rates were found in the years before or after the comet's last perihelion passage (Porubčan et al., 1991). Other outbursts, such as in 1993 (Rendtel & Betlem, 1993), are due to isolated particle concentrations not in the comet's vicinity. Hence these may occur when the comet is far from its perihelion position (Jenniskens, 2006). Most modelling attempts date around or after the return of the parent comet 1P/Halley (e.g. McIntosh & Jones, 1988). Speculations about particles in resonances date back to (Hajduk, 1970). However, neither visual nor radar data give a hint of the passage through such a dense region. The unique return of the Orionids in 2006 requires new investigation of this question.

2 Observational data

The radiant reaches sufficient height above the horizon around midnight local time. In 2006, astronomical conditions were perfect with the New Moon on October 22. Both the maximum period around $\lambda_\odot = 208°$ and position near the 1993 peak at $\lambda_\odot = 203°$ were well covered with observational data. While the latter showed no enhancement, rates increased significantly above the long-term average for several nights on either sides of the given maximum position. Further, the magnitude data showed a significantly different particle population as compared to the average of previous returns.

The sample included in this paper was collected by 58 visual observers. It contains data of 12 012 Orionids observed in 389 hours effective observing time.

Observers contributing to the analysis (VMDB code, effective observing time, number of Orionids) follow. Elena Babina (`BABEL`, $3\overset{h}{.}20$, 268), Julia Babina (`BABJL`, $3\overset{h}{.}20$, 184), Ricardas Balciunas (`BALRC`, $0\overset{h}{.}75$, 16), Geert Barentsen (`BARGE`, $2\overset{h}{.}74$, 200), Cen Chen (`CHECE`, $2\overset{h}{.}34$, 134), Ivana Cvijovic (`CVIIV`, $2\overset{h}{.}08$, 30), Nadka Dankova (`DANNA`, $1\overset{h}{.}00$, 8), Peter Detterline (`DETPE`, $3\overset{h}{.}17$, 114), Jaka Dobaj (`DOBJA`, $2\overset{h}{.}00$, 10), Gunther Fleerackers (`FLEGU`, $1\overset{h}{.}13$, 36), George W. Gliba (`GLIGE`, $3\overset{h}{.}00$, 238), Shelagh Godwin (`GODWI`, $1\overset{h}{.}83$, 46), Sylvie Gorkova (`GORSY`, $4\overset{h}{.}00$, 44), Mitja Govedic (`GOVMI`, $1\overset{h}{.}12$, 2), Ivan Gradinarov (`GRAIV`, $1\overset{h}{.}56$, 12), Robin Gray (`GRARO`, $16\overset{h}{.}23$, 766), Wayne T. Hally (`HALWA`, $10\overset{h}{.}76$, 274), Ivana Lukacova (`IVANA`, $2\overset{h}{.}90$, 20), Carl Johannink (`JOHCA`, $8\overset{h}{.}13$, 166), Javor Kac (`KACJA`, $14\overset{h}{.}32$, 270), André Knöfel (`KNOAN`, $1\overset{h}{.}02$, 6), Petar Kostić (`KOSPE`, $2\overset{h}{.}26$, 48), Jakub Koukal (`KOUJA`, $55\overset{h}{.}75$, 836), Richard Kramer (`KRARI`, $1\overset{h}{.}18$, 16), Jan Lembregts (`LEMJA`, $2\overset{h}{.}33$, 112), Peter van Leuteren (`LEUPE`, $1\overset{h}{.}00$, 24), Ren Li (`LI RE`, $4\overset{h}{.}25$, 130), Robert Lunsford (`LUNRO`, $16\overset{h}{.}00$, 946), Sonja Manojlovic (`MANSO`, $1\overset{h}{.}51$, 60), Paul Martsching (`MARPA`, $26\overset{h}{.}75$, 470), Pierre Martin (`MARPI`, $4\overset{h}{.}85$, 280), Mikhail Maslov (`MASMI`, $1\overset{h}{.}41$, 4), Bruce McCurdy (`MCCBR`, $2\overset{h}{.}40$, 102), Koen Miskotte (`MISKO`, $7\overset{h}{.}32$, 204), Sabine Wächter (`MORSA`, $1\overset{h}{.}10$, 4), Ian Musgrave (`MUSIA`, $1\overset{h}{.}75$, 62), Martin Nedved (`NEDMA`, $0\overset{h}{.}97$, 8), Daniel van Os (`OSVDA`, $5\overset{h}{.}00$, 60), Tamara Radakovic (`RADTA`, $3\overset{h}{.}99$, 152), Jürgen Rendtel (`RENJU`, $32\overset{h}{.}52$, 1056), Samantha Ridgeway (`RIDSA`, $1\overset{h}{.}07$, 6), Denis Samsonov (`SAMDE`, $3\overset{h}{.}20$, 182), Wei Sang (`SANWE`, $1\overset{h}{.}34$, 32), Branislav Savic (`SAVBR`, $4\overset{h}{.}54$, 106), Nastassia Smeets (`SMENA`, $2\overset{h}{.}82$, 156), Boris Stoilov (`STOBO`, $5\overset{h}{.}35$, 62), Wesley Stone (`STOWE`, $7\overset{h}{.}25$, 780), Rushikesh Tilak (tt TILRU, $2\overset{h}{.}00$, 68), Marija Todorović (`TODMR`, $1\overset{h}{.}97$, 102), Shigeo Uchiyama (`UCHSH`, $2\overset{h}{.}00$, 20), Hendrik Vandenbruaene (`VANHE`, $1\overset{h}{.}66$, 36), Michel Vandeputte (`VANMC`, $18\overset{h}{.}32$, 460), Jovan Vasiljevic (`VASJO`, $1\overset{h}{.}75$, 60), William Watson (`WATWI`, $25\overset{h}{.}48$, 1932), Thomas Weiland (`WEITH`, $4\overset{h}{.}16$, 170), Jing Xu (`XU JI`, $2\overset{h}{.}42$, 120), Kim S. Youmans (`YOUKI`, $6\overset{h}{.}96$, 302).

3 Population index profile

Most descriptions of the Orionids hint at the rather faint meteor magnitudes with few fireballs as compared to other meteor showers. The 2006 return was differ-

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NASA-ADS bibcode 2007JIMO...35...41R

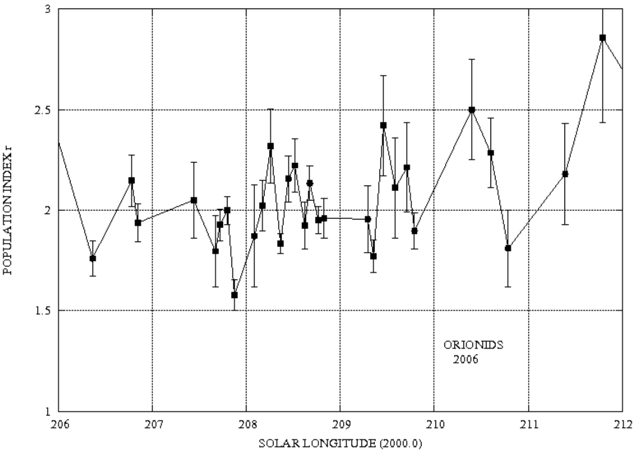

Figure 1 – Profile of the population index r of the 2006 Orionids around the maximum period. Each point represents a sample of at least 100 Orionid magnitude estimates.

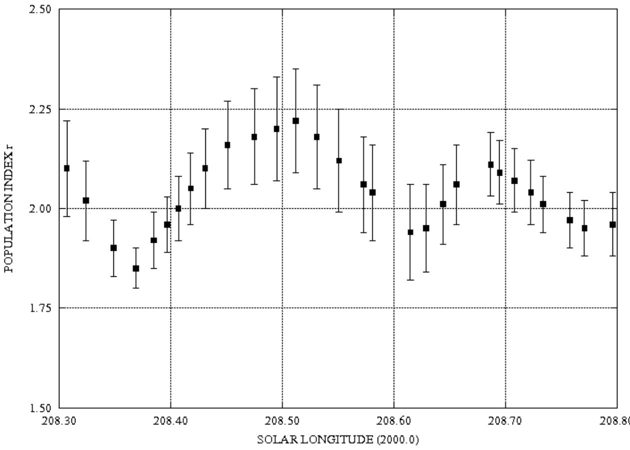

Figure 2 – Detail of the population index r for the transition period between observers in Europe/Canaries and North America on 2006 October 22. The profile is interpolated from values shown in Figure 1.

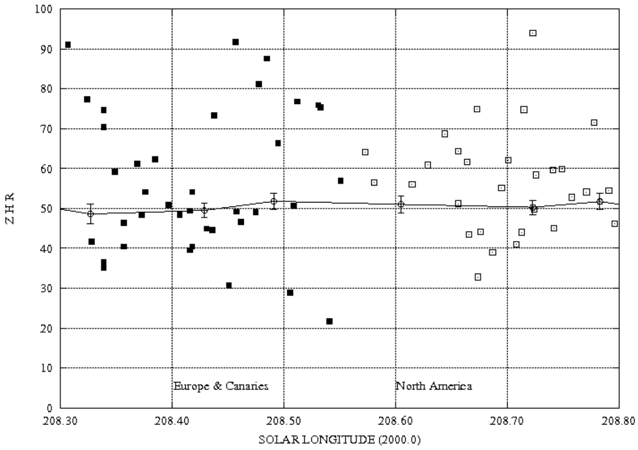

Figure 3 – Detailed ZHR profile for the same period as shown in Figure 2. The European and Canarian data points are shown as black squares, the North American data points as open squares (with no distinction of their weight). The open circles connected with lines represent the averages calculated from all individual ZHRs.

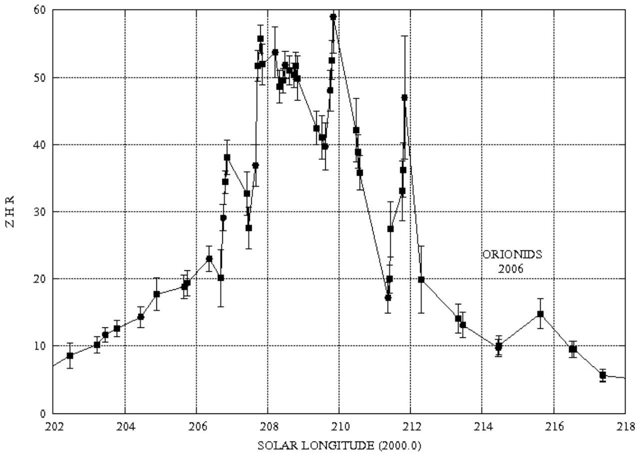

Figure 4 – ZHR-profile for the entire Orionid activity in 2006.

ent in this respect. First, the average value of r over the entire period was significantly lower than the average of 2.9 usually given for this shower (Rendtel et al., 1995) or around 2.5 (Dubietis, 2003). The lowest value found by Dubietis is $r = 2.25 \pm 0.03$ during the 1993 return. The large amount of data collected in 2006 allowed the calculation of a temporally well resolved profile of the population index r (Figure 1). We find a distinct minimum of $r = 1.58 \pm 0.08$ at $\lambda_\odot = 207.875$. Another obvious feature is a rather high $r = 2.86 \pm 0.36$ at $\lambda_\odot = 211.792$ occurring late in the maximum part of the Orionids. Each point represents a sample of at least 100 shower meteors. The sequence of the data points therefore illustrates the number of observations and the rate. The entire period between $\lambda_\odot = 207.6$ and 209.8 is well covered with observations.

There are dips in the r-profile occurring almost exactly in 1° distance on 206°.80, 207°.88, 209°.79 and 210°.79. A first assumption was that this could be due to the 'Atlantic gap'. As an example for this 'transition' we show data of the 12-hour interval between 208°.3 and 208°.8 in great detail. The values of the population index r shown in Figure 2 are interpolated between the nearest calculated values. The last intervals from European and Canarian sites end at 208°.56, while the first North American observer starts at 208°.55. That means there is essentially no overlap, but also no gap. The profile in Figure 2 shows no rapid variations which can be associated with the change of the observing locations.

As a further illustration of this transition, Figure 3 shows all individual ZHRs from each observation interval in the same 12-hour period with a limiting magnitude of at least $m = 5.8$. Details of the ZHR will be discussed in the next section. The ZHR graph clearly shows an almost perfectly smooth profile over the entire interval. Therefore we should regard the minima and maxima of the population index (as well as those in the ZHR profile) as real features in the stream.

4 ZHR profile

For the ZHR calculation we use the r-profile derived from the magnitude data. The Orionid's peak position is given as $\lambda_\odot = 208°$, usually lasting for about 2° to either sides of the maximum. In Figure 4 we show the ZHR profile for the entire activity period of the Orionids in 2006. In all ZHR analyses we excluded intervals with a radiant elevation of $h_R < 20°$ and a limiting magnitude below $m = 5.8$. Further, we use a zenith exponent $\gamma = 1.0$. Details are given in Table 1, with

Table 1 – ZHR and population index for the 2006 Orionids. Obs. gives the number of observers contributing to the average. LM is the average limiting magnitude of all included intervals and the values of r are interpolated from the detailed profile shown in Figure 1.

Date Oct	Obs.	$\lambda_\odot(2000.0)$	ZHR	Error	ORI	LM	r	Error
15.05	3	201.497	6.5	1.9	29	6.33	2.63	0.24
15.55	4	201.717	6.1	1.7	36	6.34	2.63	0.24
16.06	4	202.471	8.6	1.9	54	6.40	2.64	0.25
16.56	15	203.229	10.2	1.2	197	6.39	2.64	0.25
17.07	25	203.463	11.7	1.1	250	6.31	2.65	0.25
17.57	19	203.789	12.6	1.2	210	6.31	2.66	0.26
18.08	10	204.451	14.3	1.6	160	6.38	2.67	0.27
18.58	8	204.898	17.7	2.4	81	6.06	2.68	0.28
19.08	23	205.664	18.8	1.7	106	6.16	2.69	0.30
19.58	19	205.750	19.4	1.9	75	6.26	2.69	0.30
20.04	18	206.369	23.0	1.9	98	5.96	1.79	0.09
20.24	3	206.689	20.1	4.3	33	6.44	2.06	0.12
20.34	15	206.752	29.1	2.0	123	6.55	2.10	0.12
20.44	29	206.819	34.4	1.7	169	6.49	2.04	0.11
20.55	17	206.856	38.1	2.6	79	6.41	1.96	0.10
21.05	7	207.412	32.7	3.2	93	6.40	2.02	0.19
21.15	5	207.462	27.6	3.1	95	6.41	2.02	0.19
21.25	9	207.660	36.9	3.1	65	6.20	1.83	0.17
21.35	21	207.718	51.7	2.3	132	6.33	1.91	0.11
21.45	29	207.804	55.7	2.1	162	6.50	1.84	0.08
21.55	16	207.854	51.9	3.0	85	6.62	1.71	0.08
21.86	14	208.214	53.7	3.8	61	5.89	2.19	0.16
21.95	22	208.327	48.6	2.4	142	6.24	2.02	0.10
22.06	45	208.429	49.5	1.8	175	6.35	2.04	0.09
22.16	47	208.491	51.8	2.0	121	6.28	2.11	0.11
22.26	37	208.605	51.0	2.2	146	6.13	2.07	0.10
22.36	47	208.723	50.3	1.8	230	6.20	2.02	0.08
22.46	41	208.783	51.7	2.0	197	6.32	1.97	0.08
22.56	13	208.833	49.8	3.3	68	6.55	1.96	0.10
23.06	21	209.373	42.4	2.5	157	6.14	1.97	0.14
23.16	9	209.514	41.0	3.2	61	6.32	2.23	0.24
23.26	8	209.608	39.7	3.5	45	6.24	2.18	0.25
23.36	18	209.755	48.0	3.0	56	6.37	2.02	0.14
23.46	23	209.792	52.5	2.9	77	6.46	1.98	0.12
23.56	8	209.832	59.0	5.5	29	6.55	1.94	0.10
24.07	5	210.470	42.1	4.7	26	6.33	2.44	0.23
24.17	16	210.528	38.9	2.5	103	6.28	2.36	0.20
24.26	13	210.570	35.8	2.6	81	6.19	2.30	0.19
24.97	8	211.372	17.2	2.3	66	6.38	2.17	0.25
25.07	14	211.415	20.0	2.1	106	6.27	2.21	0.26
25.17	8	211.443	27.4	4.1	49	6.07	2.27	0.27
25.37	5	211.774	33.1	4.5	28	6.06	2.82	0.41
25.47	8	211.795	36.2	4.1	32	6.10	2.82	0.42
25.94	2	212.301	19.9	5.0	18	6.21	2.47	0.42
26.95	6	213.336	14.1	2.1	114	6.39	2.57	0.43
27.45	7	213.470	13.1	1.9	138	6.42	2.57	0.42
27.94	11	214.457	9.7	1.3	149	6.33	2.61	0.38
28.45	10	214.475	10.1	1.4	125	6.30	2.61	0.38
28.95	7	215.630	14.8	2.2	40	6.06	2.57	0.48
29.94	11	216.509	9.5	1.2	147	6.15	2.75	0.35
30.44	12	216.570	9.5	1.2	161	6.15	2.75	0.35
31.45	12	217.385	5.6	0.9	150	6.33	2.81	0.29

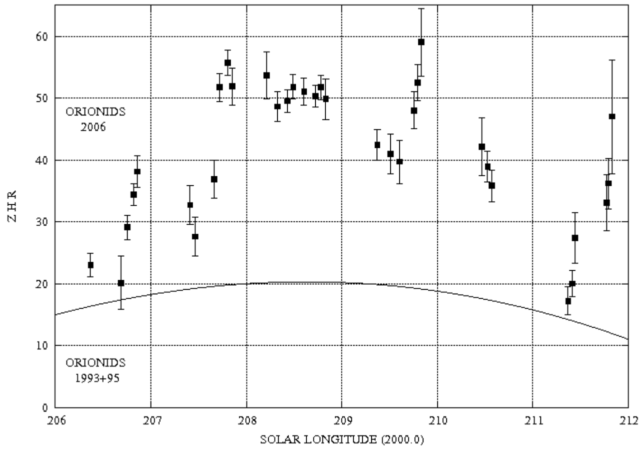

Figure 5 – ZHR-profile of the Orionids for the period shown in Figure 1 around the maximum activity. For comparison the average smoothed profile of the 1993 and 1995 returns is plotted as a solid line.

the values of r being interpolated between the values shown in Figure 1 for the actual ZHR positions.

In 2006, the ZHRs start to deviate from the average profile shortly after $\lambda_\odot = 206°$. This is obvious from Figure 5 where we included a line which represents the smoothed average ZHR of the well observed 1993 and 1995 returns. The enhanced Orionid ZHRs of the 2006 return reach a level of over 50 at several positions. Using a smooth r-profile instead of the detailed profile with the dips at the rate maximum positions, the result would be an overestimated ZHR in these specific intervals.

Two of the sub-peaks in Figure 5 coincide with local minima of r indicating that they are not a product of overestimated values of r and underlining the reported excess of bright Orionids just during the high ZHR period. The last ZHR peak, however, coincides with a higher value of r and therefore represents a different particle population. In other words, we see two ZHR submaxima coinciding with a minimum in r and a third ZHR peak caused by a larger fraction of faint meteors. The positions of the features in both the population index and ZHR profiles are summarized in Table 2.

The general ZHR level returns to the rates observed in 1993 and 1995 only after a final peak at $\lambda_\odot = 211\overset{\circ}{.}8$. Thus the ZHR remains above 40 in the entire period between $207\overset{\circ}{.}8$ and $210\overset{\circ}{.}5$ and exceeds this level again for some hours around $211\overset{\circ}{.}8$. We find no observational evidence that such a ZHR level was observed in the past. The highest value found by Dubietis (2003) is ZHR$= 30.9 \pm 0.9$ in 1998 and 29.1 ± 1.4 in 1996. Kronk (1988, p. 198) states that 'the activity of the Orionids is not consistent' and reached a high of 35 in 1922. Further he summarizes that 'between 1960 and 1974, the average ZHR was approximately 24, with rates of 30 to 40 occurring on four occasions'. Spalding (1987) noted a stable zone of high activity at $\lambda_\odot = 206°$ to $210°$, with a dip at the centre (208°).

5 Discussion

Two of the three sub peaks in the 2006 ZHR profile are connected with locations with an excess of bright Orionids (low r). The concentration of meteoroids and the different particle population is somewhat similar to the observed meteoroids during the June Boötids 1998 and the Leonids 1998 which were connected with particles trapped in the vicinity of resonances (Asher & Emel'yanenko, 2002; Asher et al., 1999). In the case of the Orionids, (Hajduk, 1970) favoured the 1:6 resonance. Emel'yanenko (2001) lists several resonances for particles of 1P/Halley with the 1:6 looking the most promising one as it has the largest size and thus may be the first which could contain enough particles in relative vicinity of the Earth's orbit. It is known that the minimum distance between the Orionids center and the Earth's orbit is quite large: the minimum Earth-stream orbit distance at the Orionid passage is about 0.15 au (at $\lambda_\odot = 210°$) and the Earth only crosses the outer regions of the meteoroid stream. The activity profile of the Orionids observed over decades shows several peaks at each return and led to the model of a ribbon structure (Hajduk, 1970; Rendtel et al., 1995).

Table 2 – Positions of specific features in the profiles of the population index r and the ZHR during the Orionids 2006. Max./Min. indicate local peaks or dips in the respective profiles.

Solar longitude	Population index	ZHR
207.88	1.58 ± 0.08 (Min.)	53 ± 3 (Max.)
209.46	2.42 ± 0.10 (Max.)	41 ± 3 (Min.)
209.79	1.90 ± 0.09 (Min.)	58 ± 7 (Max.)
211.79	2.86 ± 0.40 (Max.)	47 ± 9 (Max.)

The high rates extending over about three days may be connected with meteoroids trapped in a resonance similar to observations of the June Boötids in 1998 (Asher & Emel'yanenko, 2002) and the Leonids 1998 (Asher et al., 1999). Of course, the distance between the parent comet's orbit and the Earth's orbit is quite large and it seems to be difficult to get the meteoroids on an orbit close enough to the Earth. In this respect, the 1:6 resonance looks most promising as it has the largest size (Emel'yanenko, 2001). The 1:6 resonance would yield six 'resonant zones' which could be filled over time because 1P/Halley itself is not resonant with Jupiter and therefore drifts through one resonant zone after another (Asher, 2007 — personal communication). Six times the Jupiter period amounts to 71.172 years. This could make the 1935 return of the Orionids a candidate for a previous passage of the Earth through the same resonant zone. A plot of Orionid rates observed between 1928 and 1939 shown by Lovell (1954, pp. 288–289) hints at enhanced rates between 1933 and 1938. Figure 141 on page 289 yields a factor of about 4 in the Orionid maximum rate in 1938 compared to 1928 around $\lambda_\odot = 208°$ (1950.0), that is $208\overset{\circ}{.}7$ (2000.0). This is based on reports published by Prentice (1936, 1939). Unfortunately, the intervals are often quite long (sometimes exceeding seven hours) and no information about the observing conditions is given. Therefore it is difficult to compare the rates with our ZHR values. We mainly have to refer to relative rates between the different years instead. Another good hint at enhanced

Orionid rates can be found for the 1936 return. Millman (1936) shows Orionid rates observed at Bologna by M. Loreta with a peak rate of 50 on 1936 October 22. The rates on the days before and after the maximum are also relatively high and may thus hint at a similar profile as we found it in 2006. The non-Orionid rates of about 10–15 in most periods indicate that there is no significant over-correction of the Orionid rate. A statement in (Olivier, 1936) indicates, that there was no unusual increase in the number of bright Orionids.

From this rather small compilation of observational data we may assume that either the 1936 or the 1938 return (or both?) showed some similarity to 2006. Model calculations of other meteoroid streams show that particles are well distributed along the orbit (e.g. Vaubaillon & Colas, 2005, Vaubaillon et al., 2006) In the case of the Orionids, we may also assume that a significant part of the resonant zone gets filled over time and therefore the extension of meteoroids along the orbit should cover more than one year. If this is the case, it seems possible that the Earth could hit further parts of the resonant trail zone during the next Orionid returns in 2007 or 2008.

6 Conclusions

The exceptional return of the Orionids 2006 with an unusually low value of the population index $r = 1.6$ over a significant period and including two of the ZHR peaks hints at a particle population which significantly differs from the average Orionid stream. Due to the similarity in appearance with resonant streams in 1998 (June Boötids and Leonids) we searched for past unusual Orionid returns around the period of the suspected 1:6 resonance. We found evidence for high rates in 1936 and 1938 which may support the assumption of resonant Orionid trails. If such zones extend along a substantial fraction of the orbit, further Orionid enhancements may occur in 2007 or 2008.

Recently data back to 1944 was included in the VMDB and it seems worth to try adopting further data into a comparable format. A first analysis of the 1944–2006 data applying the IMO's standard procedures indicates that we can trace some of the structures over almost the entire period. This is still subject of investigation and shall be reported in detail in a later paper.

Acknowledgements

We thank all observers sending their data to the IMO's Visual Meteor DataBase (VMDB). The largest fraction of the data input was done by Rainer Arlt with the assistance of Javor Kac. Another substantial addendum of Orionid data to the VMDB was made during a meteor observing camp in Germany in April 2006 by Pierre Bader, Frank Enzlein, Ulrich Sperberg and Roland Winkler.

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History

Meteor Beliefs Project: Meteoric Imagery in SF, Part V: *This Island Earth*

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

The classic 1950s science fiction film *This Island Earth* is discussed for its meteoric elements, along with a more recent movie which pokes fun at it, by way of celebrating the Meteor Beliefs Project's fourth anniversary.

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1 Introduction

Of all the films listed in the opening article to this subproject (McBeath & Gheorghe, 2005), the use of meteors in *This Island Earth* was unique. While others invoked meteors or meteorites as carriers of invading life-forms, diseases or the like, or extrapolated from the scenario of a possible natural large impactor striking the Earth, the meteoric objects in *This Island Earth* were used as deliberately destructive missiles in an interplanetary war. This uniqueness, plus the fact that a cut-down version of the film formed the core of an entertainingly wisecracking subsequent movie, *Mystery Science Theater 3000: The Movie*, prompted its selection for discussion here, as the Meteor Beliefs Project's fourth anniversary piece. Both films are available on DVD.

2 *This Island Earth* (Universal-International, colour, 1955)

The film was directed by Joseph Newman, though not entirely satisfactorily, as the uncredited Jack Arnold had to direct re-takes of some of the later scenes, which had not been done well enough, apparently. The story was based on Raymond F. Jones' novel of the same name, whose origins went back to material published by him in the magazine 'Thrilling Wonder Stories' in 1952. The plots for both book and film are similar for the first half, but then part company, and as only the film contains any meteoric material, the novel is not considered here. It is worth reading for those interested however (if only to find out how to spell things such as 'interociter'), available as (Jones, 1991), for instance.

The three leading roles in the film were Exeter, played by Jeff Morrow, a largely human-looking alien but for his oddly high forehead, and Drs. Cal Meacham (Rex Reason) and Ruth Adams (Faith Domergue), as two nuclear physicists. The plot revolved around the aliens, led by Exeter, having been sent to Earth to secretly recruit and use the most brilliant human scientists to find new means of converting materials like lead into uranium, to help power the defences of their extrasolar home planet Metaluna, in their war against attackers from Zahgon. Meacham and Adams were eventually taken to Metaluna in the second half of the film.

Jeff Morrow puts in a fine performance, somewhat variable in a few places, but overall very convincing, in what has been reckoned as probably his best film role (Warren, 1982, p. 232). He comes across as more of the hero of the piece than Rex Reason, whose square-jawed efforts are too often wooden or unsympathetic to the character. Faith Domergue seems there largely to make up the numbers, and provide the obligatory 'love interest' for Reason's character. She does this pleasingly enough, but with little real impact. The small supporting cast with more than the odd line or two is generally adequate, though it is largely only Robert Nichols' portrayal of Meacham's assistant Joe Wilson that has particular authenticity.

The first half of the film works as a mystery story, as Meacham is secretly tested by the aliens, and then invited to join their research team — again without being told why. More of the plot is revealed at the research facility, beneath a hilltop mansion in Georgia, USA. Much of this is intriguingly handled, and is rather a cerebral contrast to the more active second half.

Up to this point, the aliens had seemed to be merely intelligent humans with high foreheads, but they were suddenly recalled to Metaluna, and ordered to destroy the facility on Earth. This was done in spectacular fashion, blowing up the entire hilltop (not altogether convincingly shown over a special effects matte painting), killing all the humans except Meacham and Adams, who had tried to escape in a light aircraft. Two other physicists were killed separately by scarlet 'neutrino rays' to emphasize the cauterization of the site, and the total disregard the aliens had for humans. While this aspect is obvious on later reflection, it did not come across clearly enough in the film, largely through the failure of Rex Reason to exhibit any real sense of anger and indignation at what had happened, after Meacham and Adams' aircraft was sucked up into the aliens' spacecraft (an impressive aluminium model 'flying saucer').

Once in space, *en route* to Metaluna, the spacecraft had to carry out the cliché 'swerve' maneouvre to avoid an icy lump of material heading towards it. The object (perhaps intended as a dormant comet) was not discussed at all. Later, as the craft neared Metaluna, two burning, sparking, fiery masses were seen, each leav-

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ing a smoky trail, and, despite being in space, making falling-bomb screaming whistles. Meacham called these 'comets', but Exeter corrected him and said they were 'meteors', controlled by Zahgon spacecraft. Indeed, there was a tiny arrowhead shaped craft attached by a vertical bar to each of the main burning objects, which broke off and pulled away as the 'meteor bomb' was released.

For all the questionable nomenclature and scientific failings (not just those mentioned here), the burning 'meteoric' masses did look fairly, if loosely, meteoric, and the effects shots were done sympathetically, to try to minimise the obvious difficulty of the ascending smoke trails. The 'meteors' were made of a mixture of plaster and magnesium powder (op. cit, p. 233), and from time to time, burning magnesium sparks falling vertically down did give the game away, but for the period, this was a bold attempt to do something quite innovative, and worked better than this basic description might suggest.

Back at the plot, Exeter explained that the Zahgons had ignored Metaluna's peace overtures (and since we never have the opportunity to see any Zahgons to learn their side of the story, we must rely on the word of this mass-murderer alone!), and that Zahgon was a planet that had once been a comet. Any attempt at discussion on this latter point by us here would seem inconsequential we feel, given the knowledge of what comets and planets were believed to be in the early 1950s.

Closer to Metaluna, pinpricks of light were seen in the planet's atmosphere, plausibly short-lived, which were announced as due to the continuous bombardment by Zahgon-controlled 'meteors'. Nearer still, and the bombs were shown to make fiery splashes on the atmosphere and the extensive aurora-like curtains of its artificial defensive ionization layer. Some were starting to get through this, striking down to the planet's surface too.

Once in Metaluna's atmosphere, we are treated to an impressive, if not overly realistic, model landscape, of a dead, scarred planetary surface, with many chasms and holes leading down to a subsurface world, with towers and buildings where the Metalunans lived. Occasional surface explosions occurred without an obvious external cause, along with others in the higher atmosphere, as the Metalunan spacecraft approached. A slow, smoke-trailing, burning meteor impacted near where the craft passed down below ground level, to a docking tower, while other explosions followed, and a few burning meteors smashed through the ground into this underworld, complete with whistling sounds.

The bombardment worsened after the crew and passengers had disembarked. On meeting the Metalunan ruler, The Monitor (played by Douglas Spencer), Meacham and Adams discovered the Metalunans intended to relocate to Earth, with the obvious intention of becoming Earth's rulers. Again, Rex Reason failed to muster any believability in his response to this revelation, but luckily, shortly after the Earth people and Exeter left this building, it, and much of the surviving city, was pulverised by a group of three burning meteors striking down.

Exeter, Meacham and Adams barely escaped back to the spacecraft and away from the planet. The increased numbers of guided meteor-missiles were clearly demonstrated, but some looked less convincing than the earlier ones, presumably as the special effects budget became too stretched. Safely away from the planet and looking back from space, our much reduced crew saw many more pinpoints of light on the planet, while the whole began to glow "like a sun", as Exeter put it, and the planet was destroyed.

Aside from this 'sun' comment, this was all reasonably plausibly managed, given that, thankfully, we have no real idea of what it would be like to watch a planet being bombed to destruction in this manner. The journey back to Earth was meteorically uneventful, the final act being for Exeter to suicidally destroy his craft like a fireball in Earth's atmosphere, having first released Meacham and Adams in their aircraft.

Overall, this is a fine, sometimes thought-provoking, film, one of the leading 'classic' science fiction movies of the 1950s, and despite some of our comments here, one still far better than many of its time. The effects do not always hold up, but those that do still look impressive today, and the whole is worth seeing, or seeing again.

3 *Mystery Science Theater* 3000*: The Movie* (Universal, 1996)

This movie was made after the TV series of the same name, directed by Jim Mallon. The basic premise was that a mad scientist, Dr Clayton Forrester (played by Trace Beaulieu), had shot a man into space in Earth orbit, Mike Nelson (played by Michael J. Nelson), with only three robots for company, Servo, Crow, and Gypsy (animated puppets, voiced by Kevin Murphy, Trace Beaulieu and Jim Mallon respectively), with the intention of driving him mad too, by making him watch awful old science fiction movies. Forrester then intended to use the 'successful' movie to allow him to take over and rule the world. This was deliberately silly. In effect, the premise was merely a ruse to allow the cast to broadcast old movies and sit making smart remarks, wisecracks, sound effects, etc., to poke fun at those same movies. It works extremely well in this respect.

Mystery Science Theater 3000*: The Movie* used a cut-down version of *This Island Earth* as its centrepiece, a better standard of film than those used in the TV series, apparently (Fane-Saunders, 2001, p. 234; as we have not seen the series). Enough of the Zahgon 'meteors' and the bombardment of Metaluna ("I see their Patriots don't work either!") survive for us to recommend it as an alternative to the full original, or as an adjunct to it, for those who would enjoy this kind of item as well. There is certainly much of amusement and entertainment to be had, with every hint of wooden acting mercilessly pounced upon for comic effect (Exeter to Meacham: "We're looking for scientists of exceptional ability"; added comment, "D'you know any?").

One new meteoric effect was included too, in an interlude on board the spacecraft away from watching the movie. Having accidentally crashed into the Hubble Space Telescope, Mike Nelson released it back into space, "like a sparrow into the night sky," whereupon the special effects' wire supporting the Hubble model was cut, and it dropped impossibly vertically down out of shot, into the Earth's atmosphere and burned up, unseen but for a reflected red glow on the craft and the amazed crew's faces. Done quite deliberately thus, by people with a genuine appreciation for their subject, and the poor representation of science in too many science fiction movies, this was another highlight of a good film. Some of the asides need a knowledge of American culture to fully appreciate, but even without that, this is definitely a film to watch.

4 Conclusion

Although the close-up shots of the 'burning meteors' do not work well as scientifically-realistic items individually, the impression as a whole is quite effective. While a more knowledgeable fraction of the audience might take them to be artificial 'meteor-bombs', it seems likely the majority would have the concept of burning meteors striking a planet's surface reinforced by this. For all that, *This Island Earth* is still entertaining, in whichever form it is viewed.

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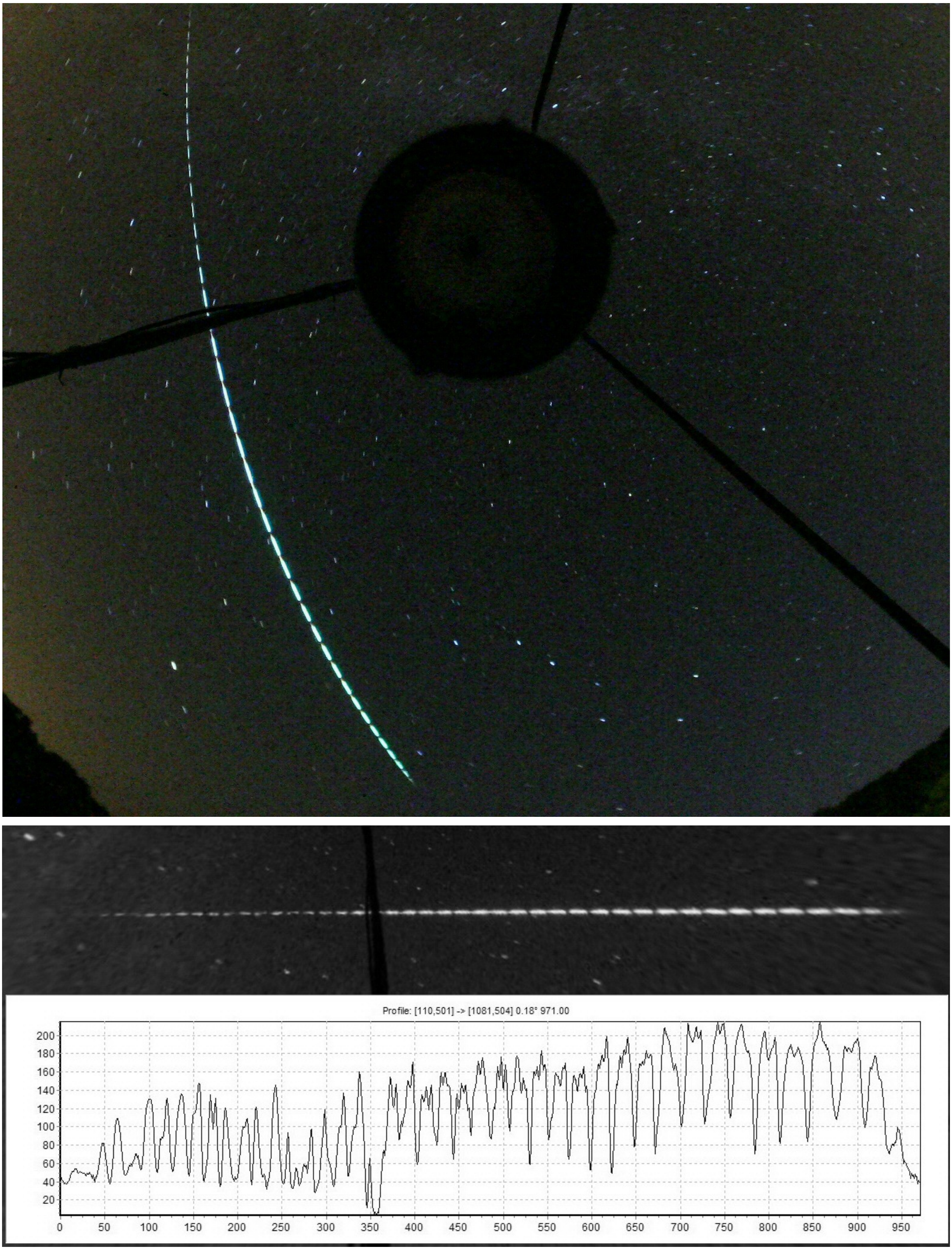
Sporadic fireball



An $m = -9$ sporadic photographed by Klaas Jobse's fireball station at Oostkapelle in The Netherlands on 2006 July 18/19 at $22^{\mathrm{h}}54^{\mathrm{m}}$ UT. Camera: Canon 350D with an $f = 45$ mm, $f/4.5$ lens. Exposure 175 second at ISO 800. Many more such fireballs can be seen at his website `http://www.klaas-jobse.net/cyclops/All-Sky/EN%2097%20Oostkapelle.htm` .