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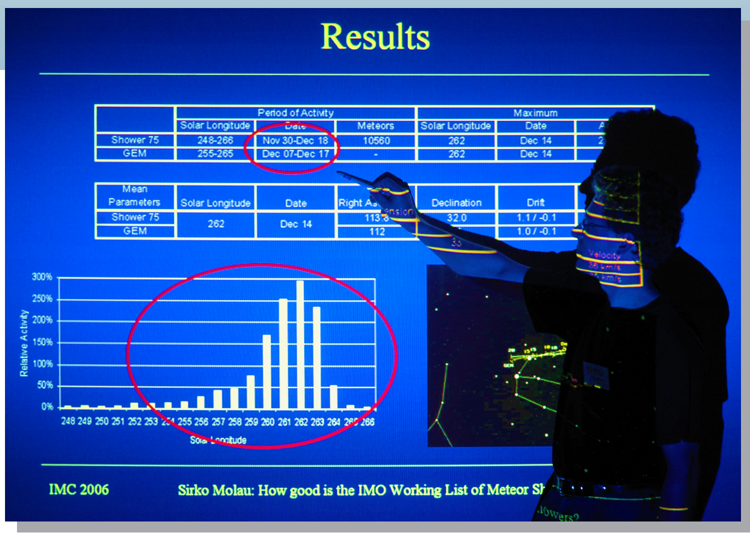

Leonids
Conferences
Meteor databases
Double-station work

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WGN Vol. 34, No. 6, December 2006, pp. 153 – 174

Administrative

Conferences

Databases

Ongoing meteor work

Leonids

History

Front cover photo

Sirko Molau giving his paper at IMC 2006 in Roden. See Vladimir Sliusarenko's article on page 155.

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` .

Legal address International Meteor Organization, Mattheessensstraat 60, 2540 Hove, Belgium.

Editorial

Chris Trayner

In the British Astronomical Association handbook each year, the Ursids are described as 'under-observed'. This could be something to do with their activity being from December 17 to 25 when many people around the world, non-Christians as much as Christians, take time off from the normal pressures of life to be with their families.

Maybe what we need to observe the Ursids is willing slaves. Maybe we now have them. Automated video meteor observation has come a long way in the last ten years. The first working system was probably Sirko Molau's (Molau & Nitschke, 1996). There are now enough for him to have written a review of them (Molau & Gural, 2005). One he reviewed was UFOCapture, which is now getting noticed. Satoshi Uehara, on page 157, describes significant results from this package. Regular, diligent work like this is necessary in science, and in this case was rewarded by the identification of a new shower. It is no surprise to see such work coming from Japan, which has been making a significant impact on the world of organised meteor observing over the last few years.

Karel Čapek (1890–1938), in his play *R.U.R. (Rossum's Universal Robots)*, is credited with having introduced the invented word Robot to the world. (In fact, his brother Josef (1887–1945) apparently used the word in an earlier story *Opilec* written in 1917 (Harkins, 1962).) The robots in the play perform all humankind's drudgery and, in the best of tradition, end up taking over the world. Now, over eighty years after the play's first performance, we have Turing's Universal Observers to watch patiently for minor showers while we unwrap presents and reminisce about the 1998 Leonids. Will the computers take over observing and drive us out? Not, presumably, while humans have the twin aims of furthering science and relishing the night sky.

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Molau S. and Gural P. (2005). "A review of video meteor detection and analysis software". *WGN*, **33:1**, 15–20.

Molau S. and Nitschke M. (1996). "Computer-based meteor search: a new dimension in video meteor observation". *WGN*, **24:4**, 119–123.

IMO bibcode WGN-346-editorial NASA-ADS bibcode 2006JIMO...34..153T

Call for photographs: The history of the IMC-tradition on the IMO website

Paul Roggemans

Since the founding of the International Meteor Organization the International Meteor Conferences guaranteed the vital personal contacts between its members. In recent years a belief that the IMCs started with the IMO gained popularity. However, the IMCs grew out of a much older initiative: the Meteor Seminars of 1979 and 1980. It's obvious that memories of past events get lost. Having the internet with the IMO website we have a perfect medium to set up a collective photo-album for all 25 past IMCs. Several people contributed already with pictures of the latest IMC editions, but we need more photographs. For pre 2000 IMC's, prints of photographs may need to be scanned, a time consuming job. We hope some more people will dive in their photo archive and dig up some 'forgotten' IMC pictures.

As years go by and memories fade, the descriptions and photo galleries will provide lasting souvenirs of the IMCs. The galleries serve as a collective photo album with images of the IMC locations and, of course, especially of the people answering questions like "Who are we? Who makes up IMO? Which persons are behind the names mentioned in publications?". These pages put a human face to well-known authors and observers in the meteor world. They also offer a glimpse of the magic atmosphere that people share at an IMC, and it is hoped will encourage more to sample the delight that is an IMC.

Further pictorial records are most welcome, especially for early IMCs and those showing participants not already represented. Please contact paul.roggemans@telenet.be (postal address, Pijnboomstraat 25, B-2800 Mechelen, Belgium) if you are willing to add photographs. The author has bought a slide scanner for this purpose as some hundreds of IMC pictures are on slide films.

IMO bibcode WGN-346-roggemans-photocall NASA-ADS bibcode 2006JIMO...34..153R

IAU nomenclature for meteor showers

The IAU Commission 22 has set up a Task Group to look into the naming of meteor showers; this was explained by Peter Jenniskens in the last WGN on pages 127–128. The IMO intends to keep in contact with this Task Group to avoid duplication of effort and confusion over temporary shower names.

Note that the IAU procedure for formally accepting a new shower name can take up to a year and a half. Showers can be submitted at any time. Half a year before the annual IAU General Assembly the list of proposals is finalised. It is voted on at the Assembly, and proposed showers which are accepted then become official.

The IAU has now published this in section 4.6.1 (pp. 61–63) of their Information Bulletin 99, available at `http://www.iau.org/fileadmin/content/IBs/ib99.pdf`. Note however that the commission is erroneously given as 20; it should be 22. The text is is essentially that of Peter's paper in the last WGN.

In a recent email, Peter notes that the website for this work has been transfered to Ondrejov Observatory and a page for the Task Group has been added at `http://meteor.asu.cas.cz/IAU/nomenclature.html`.

IMO bibcode WGN-346-iaunames-website NASA-ADS bibcode 2006JIMO...34..154I

Lunar impact video

Cis Verbeeck draws our attention to a web page worth visiting. On 2006 May 2, a meteoroid of around 1/4-metre diameter hit the Moon and caused a flash which was recorded by NASA. A slowed-down recording, with a general write-up and a light curve, are at `http://science.nasa.gov/headlines/y2006/13jun_lunarsporadic.htm`.

IMO bibcode WGN-346-lunar-impact NASA-ADS bibcode 2006JIMO...34..154L

Errata

There were a couple of mistakes in the previous WGN. We apologise for them.

The front cover was a colour print of a figure from Jennie McCormick's paper on fireballs. It was Figure 4, a drawing by Lyn Loveridge of the fireball. It was mistakenly captioned (inside the front cover) as being Figure 7.

The back cover reproduced the front cover of the IMC 2005 Proceedings. Unfortunately the image used was an earlier draft, and omitted the name of Jean-Marc Wislez from the list of authors.

IMO bibcode WGN-346-errata NASA-ADS bibcode 2006JIMO...34..154E

Letter — International Heliophysical Year 2007

Alastair McBeath[1]

As some of you may be aware, 2007 is to be International Heliophysical Year (IHY), the latest in a long tradition of such events, perhaps the best-known of which was the 1957–8 International Geophysical Year. There will be opportunities to promote meteor science during the IHY, so this is a good time to start thinking of ways to achieve this. Unfortunately, it will be a year early for the centenary of the Tunguska event, but apart from the usual observing possibilities, it will give a useful opportunity for reviewing showers such as the Perseids and Leonids (and others), which have shown unusual activity in more recent times, and how meteor astronomy has progressed in understanding the causes of these events, together with the importance of both the amateur contribution to that understanding, and the professional-amateur cooperation which has helped it along the way. For anyone interested in learning more about the early planning for the IHY, there was an article, albeit with a particular British slant, by Richard Harrison et al in the June 2005 issue of 'Astronomy & Geophysics' (46:3, pp. 3.27–3.30), which even briefly mentioned meteor observing.

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IMO bibcode WGN-346-mcbeath-ihy NASA-ADS bibcode 2006JIMO...34..154M

Conferences

IMC 2006 — Roden, The Netherlands

Vladimir Sliusarenko [1]

Meteors are a very interesting phenomenon that occur in the atmosphere of the Earth and, as a consequence, carry a scientific value at their observation. The science concerned with meteoric phenomena is certainly interesting, but it is not enough to observe meteors and to send the observations in to the Commission of the IMO! The most interesting thing in any science is an exchange of experience, the data one gets at a meeting! The International Meteor Organization has organized conferences devoted to studying to the meteoric phenomena for twenty-five years now.

This is the only time I have taken part in a conference! Many say that people who come from abroad are very interesting: representatives of the different countries gather once a year to show what they have achieved in science, also to exchange knowledge and peoples' cultures. So I managed to communicate with amateur astronomers from Venezuela, Japan, England and the other countries. For me it is very big jump in my career. The first discovery is that I like the politics and traditions of the country. But the most important thing I have achieved is practice in colloquial English, as in our country knowledge of it is very much appreciated.

But I was struck by the friendliness, the well organized running of the conference. For me, this conference alone has opened up a lot of new science and I have acquired many new friends. For me it is very important not to sit in one place all the time and to receive new knowledge. To get knowledge with new people it is necessary to communicate, to exchange. In the social sphere it is necessary to provide a good environment for accommodation, relaxation and other activities.

Figure 1 – One of the dishes at the Westerbork radio telescope. Our host Mark Bentum is showing us round.

Figure 2 – Turned into zombies: *left:* Jonathan McAuliffe by his PhD, *right:* Luc Bastiaens by creating the IMO website.

I liked the excursion to a radio-telescope. After the conference I also visited Brussels and Berlin! All Europe is original and interesting, so having visited Holland, Belgium and Germany I have opened for myself a new world! For example in Europe many historical monuments and peoples' culture. So in the same Holland the use of drugs and that there is a street of only red lights ...In Belgium the *manneken pis* boy is authorized, in Berlin the Bundestag ...to be fair, this list could be continued indefinitely, but I shall tell you to visit Europe, to look at it immediately ...

Respectableness, respect for the country, nature very beautiful. I can certainly say that I was very pleased with what I experienced at the conference — with the new friends I found and with the knowledge I received.

Figure 3 – The conference dance on Saturday evening, with an excellent Dutch band The Rebound.

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Databases

SOMYCE database

Orlando Benítez Sánchez[1]

The Sociedad de Observadores de Meteoros y Cometas de España) (SOMYCE) has produced a DVD set with many useful astronomical observations. The data are outlined and made available.

Received 2006 October 22

1 Introduction

Recently, SOMYCE (Sociedad de Observadores de Meteoros y Cometas de España) has edited its first DVD edition with all the Spanish meteor observations: visual scanned observations, video images with MetRec, photographic images, radio counts and telescopic charts. All are collected in a case with four DVDs. This database contains about 17.2 Gb.

We have produced a limited edition of 100 copies to send to SOMYCE members, Astronomical Societies of Spain and IMO members. Unfortunately, the cost of this edition has made it impossible to send a copy to all IMO members, and therefore we have made a selection, and only 21 copies have been sent to IMO members.

This information may be freely copied for personal use and publication, by amateurs and researchers. If you write a paper, please cite the database as: 'Archivos de observaciones de la Sociedad de Observadores de Meteoros y Cometas de España –SOMYCE–, 1st edition, 2006 October.'

2 The database

We will briefly summarise the information on each DVD:

DVD 1

Visual Meteor Database from 1987 to 1995. All these observations are in the form of JPG images. They are the original reports, with data and charts scanned with great effort over the last five years. The key is:

DDddMMAAAA——aNdN.jpg

e.g. 2627091998BENORp1d1

where

DDdd	is day	
MM	is month	
AAAA	is year	
——	is the IMO Code	
a	can be:	
	p	report
	c	chart
	r	summary
	e	train report

NdN: '1d1' or '1d5' indicates how many reports or charts there are in the observation.

This DVD contains the Photographic Meteor database from the 1998 and 1999 Leonids and many images classified by month. Some of them are not normal data, but have been collected for historical reasons. Data are in txt or excel files.

DVD 2

Comet observations and the rest of Photographic meteor database from November, August and December. The Video Meteor database from the cameras TIMES 4 (an intensified camera) and TIMES 5 (a Watec 902-H) with full-frame images. If you need complete data in PosDat format, we recommend downloading the update files from the IMO web site `www.imo.net` or `www.metrec.org`.

DVD 3

Fireballs reports form 1982 to 2003, some photos, and the Telescopic database (charts and reports). All codes are the same as the Visual Scanned reports. The Video Database of TIMES 4: August 2000 and 2001 (complete except for March, August, October and December).

DVD 4

Visual Meteor Database (1985 and 1986 reports), with the rest of the Photographic database and Video observations of the TIMES 4 camera.

3 Conclusion

As you can see, there is a lot of useful information for the meteor observer.

If need copy of all or part of this information you can contact us at `archivosobservaciones@somyce.org`. More information about SOMYCE can be found on our web site `www.somyce.org`.

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IMO bibcode WGN-346-benitezsanchez-database
NASA-ADS bibcode 2006JIMO...34..156B

Ongoing meteor work

Detection of October Ursa Majorids in 2006

Satoshi Uehara [1,2], *SonotaCo* [3], *Yasunori Fujiwara* [2], *Takashi Furukawa* [3], *Hiroyuki Inoue* [3], *Kazuhisa Kageyama* [4], *Kouji Maeda* [2], *Hideaki Muroishi* [2], *Sadao Okamoto* [2], *Toshihiro Masuzawa* [3], *Takashi Sekiguchi* [2], *Masumi Shimizu* [2] *and Hiroshi Yamakawa* [3]

A hitherto unknown meteor shower from Ursa Major was observed by a video observation network in Japan during 2006 October 14 and 16 (UT). 14 meteors were simultaneously observed by videos at multi-stations, and the radiant point R.A. = $144^{\circ}\!.8$, Dec. = $64^{\circ}\!.5$, $V_g = 54.1$ km/s was obtained. The orbital elements of the stream are $a = 5.9$ AU, $q = 0.979$ AU, $e = 0.875$, $\omega = 163^{\circ}\!.7$, $\Omega = 202^{\circ}\!.1$, and $i = 99^{\circ}\!.7$ (J2000.0). The radiation area was compact but the activity of this shower reached to 4–9% of the sporadic meteor background in this period.

Received 2006 December 6

1 Introduction

In Japan, an internet community named the 'SonotaCo Network' has been working since 2005 where users and observers of motion capture software UFOCAPTURE (Molau & Gural, 2005) share their observation results.

More than ten meteor observers joined this community and exchange their data every day to find simultaneous observations. In 2005, more than 30000 meteor observation results were uploaded and more than 3000 multi-station simultaneous observation were found.

The uploaded data are open to the public and anyone can know the outline of the meteor activity through the network within a few days. Currently, because the observation accuracy is dependant on the operator of each station, re-analysis is needed when getting superior scientific results.

Uehara noticed that some meteors emerged from a compact area near R.A. 144° Dec. +64° in northwest part of Ursa Major around October 16 in the observation results of the SonotaCo Network. All original video clips that consisted of simultaneous observations of this shower were gathered to one server and SonotaCo (Author of UFO series software) undertook the re-analysis process of them.

2 Observations

There are 31 meteors which belong to this shower observed by 19 cameras. From them, 14 simultaneous meteors were obtained. Ten of them had fair cross angle ($> 10°$) with duration time (> 0.2s) and were used for calculation. Table 1 shows the observers, equipments and locations of this observation. Figure 1 shows their locations.

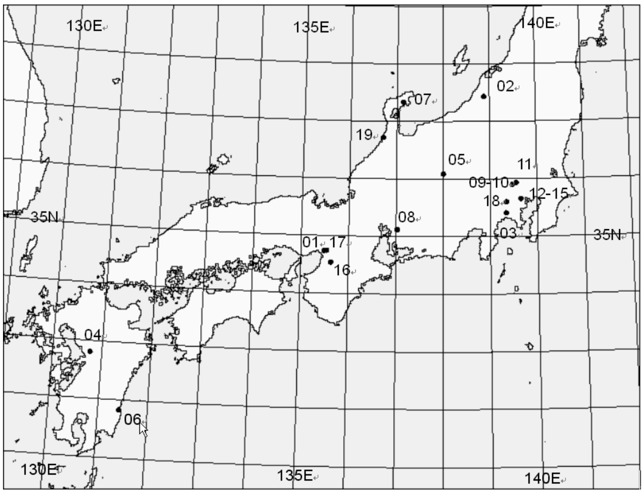

Figure 1 – Map of observers' locations.

3 Analysis process

The analysis software is UFOANALYZER V0.77 and UFOORBIT V0.30. The first is for the post processing of UFOCapture that measures the object's coordinates in each frame of video, calculates the angular velocity, the direction from which it comes, the linearity, and brightness. In the second process finds simultaneous meteors and calculates the orbital elements of meteors.

In this report, a new analysis program called V2 was used as pre-process of UFOAnalyzer to guarantee the accuracy of the measurement. V2 has an automatic parameter optimization function and can compensate for the distortion of a camera lens on video clips using 50 to 500 fixed stars. As a result, the measurement residual errors of fixed star position became less than $0^{\circ}\!.01$ with an $f = 12$ mm lens and $0^{\circ}\!.03$ with an $f = 6$ mm lens for all clips.

Though the visual magnitude of each meteor is not calibrated yet, they are considered as having errors of ± 1 magnitude.

4 Results

4.1 Radiant

The radiants and other results of 10 meteors are given in Table 2. A trail chart which comprises all simultaneous meteors is presented in Figure 2.

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[2] Nippon Meteor Society (NMS). Email: secret@nms.gr.jp
[3] SonotaCo Network. Email: sonotaco@yahoo.co.jp.
(SonotaCo is both the screen name of the author of UFOCAPTURE and the name of the network.)
[4] Kumamoto Civil Astronomical Observatory. Email: astro@magma.ad.jp

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NASA-ADS bibcode 2006JIMO...34..157U

Table 1 – Observing locations and equipment.

Camera number	Observer	Location	Longi tude	Lati tude	Lens all $f/0.8$	Field of view	Azi muth	Ele vation
01	Fujiwara Y.	Osaka	135°.48 E	34°.73 N	6 mm	56° × 43°	55°.59	47°.39
02	Furukawa T.	Niigata	138°.88 E	37°.43 N	6 mm	56° × 43°	119°.46	41°.38
03	Inoue H.	Kanagawa	139°.33 E	35°.41 N	12 mm	31° × 24°	118°.14	59°.95
04	Kageyama K.	Kumamoto	130°.76 E	32°.81 N	6 mm	56° × 43°	84°.66	55°.33
05	Masuzawa T.	Nagano	138°.00 E	36°.09 N	6 mm	56° × 43°	223°.20	24°.28
06	Maeda K.	Miyazaki	131°.42 E	31°.83 N	8 mm	45° × 34°	9°.50	46°.51
07	Muroishi H.	Ishikawa	137°.14 E	37°.34 N	3.8 mm	89° × 69°	174°.22	42°.70
08	Okamoto S.	Aichi	137°.02 E	35°.12 N	6 mm	56° × 43°	256°.11	67°.13
09	Sekiguchi T.	Saitama	139°.47 E	35°.90 N	6 mm	56° × 43°	252°.89	46°.93
10	Sekiguchi T.	Saitama	139°.47 E	35°.90 N	12 mm	31° × 24°	162°.63	55°.39
11	Shimizu S.	Saitama	139°.55 E	35°.93 N	12 mm	31° × 24°	150°.62	51°.67
12	SonotaCo	Tokyo	139°.66 E	35°.65 N	6 mm	56° × 43°	352°.57	32°.94
13	SonotaCo	Tokyo	139°.66 E	35°.65 N	6 mm	56° × 43°	150°.53	55°.88
14	SonotaCo	Tokyo	139°.66 E	35°.65 N	6 mm	56° × 43°	223°.41	24°.27
15	SonotaCo	Tokyo	139°.66 E	35°.65 N	8 mm	45° × 34°	271°.72	17°.31
16	Ueda M.	Osaka	135°.63 E	34°.54 N	6 mm	56° × 43°	55°.24	40°.56
17	Uehara S.	Osaka	135°.54 E	34°.75 N	12 mm	31° × 24°	58°.88	42°.48
18	Yamakawa H.	Tokyo	139°.33 E	35°.41 N	6 mm	56° × 43°	352°.06	42°.48
19	Yamakawa H.	Ishikawa	136°.70 E	36°.72 N	6 mm	56° × 43°	136°.34	30°.62

All cameras are Watec CCD type 'WAT-100N' or 'WAT-902H' which have a 1/2-inch CCD with minimum luminosity 0.001 lx or higher, frame rate of 29.97 frame/s and a resolution of 640x480 or 720x480. Azimuth: North is 0°, East is 90°, and South is 180°. Elevation: Horizon is 0°, Zenith is 90°.

Table 2 – Radiant point and other results.

Meteor No.	Date	Time (UT)	Cameras 1	2	Q	m	R.A.	Dec.	V_g (km/s)	D (km)	Dur (sec)	H_b (km)	H_e (km)
1	14	$14^h37^m36^s$	07	15	83°.8	4.1	144°.18	66°.43	52.7	292.6	0.334	111.0	103.2
1	14	$14^h37^m37^s$	15	17	58°.6	1.3	144°.10	66°.08	53.3	387.5	0.701	113.4	100.4
1	14	$14^h37^m37^s$	07	17	37°.6	1.3	145°.37	66°.31	53.3	321.8	0.701	114.7	101.7
2	15	$10^h21^m39^s$	07	15	61°.9	−0.6	143°.56	64°.44	55.4	292.6	1.101	115.9	103.1
3	15	$15^h23^m12^s$	06	04	77°.9	2.4	143°.99	64°.37	54.1	125.9	0.834	112.5	92.8
4	15	$15^h39^m26^s$	19	09	85°.2	−1.5	143°.90	65°.16	54.6	264.4	0.534	112.3	99.3
5	15	$17^h22^m35^s$	12	02	82°.3	−1.2	143°.61	65°.28	54.3	209.6	0.567	112.6	94.0
5	15	$17^h22^m35^s$	18	02	82°.5	−1.2	143°.89	65°.37	59.8	207.7	0.534	111.9	94.2
6	15	$17^h36^m03^s$	19	09	65°.2	−1.2	152°.32	66°.09	56.0	264.4	0.367	112.0	100.3
6	15	$17^h36^m03^s$	19	14	71°.6	1.4	145°.12	63°.67	55.0	290.2	0.367	112.0	99.7
7	15	$17^h46^m39^s$	19	15	85°.6	2.7	146°.86	64°.75	53.7	290.2	0.367	111.9	100.0
8	15	$18^h25^m07^s$	08	01	78°.5	−2.2	145°.34	64°.87	48.9	142.6	0.233	92.5	85.6
9	15	$19^h29^m44^s$	19	14	71°.4	2.3	143°.10	62°.91	54.8	290.2	0.234	109.1	100.2
9	15	$19^h29^m45^s$	14	01	55°.2	−1.2	145°.39	62°.71	53.6	386.4	0.300	109.0	97.8
9	15	$19^h29^m45^s$	19	01	53°.4	−1.2	144°.38	63°.88	52.4	261.1	0.300	109.5	98.5
9	15	$19^h38^m20^s$	03	11	13°.9	−1.8	144°.75	63°.21	53.8	61.4	0.501	112.9	92.4
10	16	$17^h12^m58^s$	16	05	66°.4	−2.2	147°.30	63°.90	54.7	273.3	0.934	118.5	91.0
10	16	$17^h13^m00^s$	16	08	67°.9	−3.7	146°.92	63°.79	54.9	146.8	1.100	123.2	90.3
10	16	$17^h12^m59^s$	05	01	57°.5	−2.0	147°.55	63°.86	53.5	275.5	1.100	121.0	88.8
10	16	$17^h13^m00^s$	01	08	59°.0	−3.7	147°.05	63°.76	54.6	142.6	1.100	122.8	89.9
10	16	$17^h12^m59^s$	17	05	63°.6	−2.8	147°.53	63°.83	55.6	268.5	0.968	124.9	90.9
10	16	$17^h13^m00^s$	17	08	65°.1	−3.7	147°.18	63°.72	54.7	141.7	1.100	126.3	90.1

Date is the day within 2006 October. Cameras identifies the two cameras. Q is the angle between the apparent great circles of motion as seen from two stations. m is the meteor magnitude. D is the distance between two stations. Dur is luminous time of a meteor. V_g is the geocentric velocity corresponding to $(V_i^2 - 123.2)^{0.5}$. Deceleration by the atmosphere is ignored ($V_o = V_i$) in this calculation. H_b is the beginning height. H_e is the ending height.

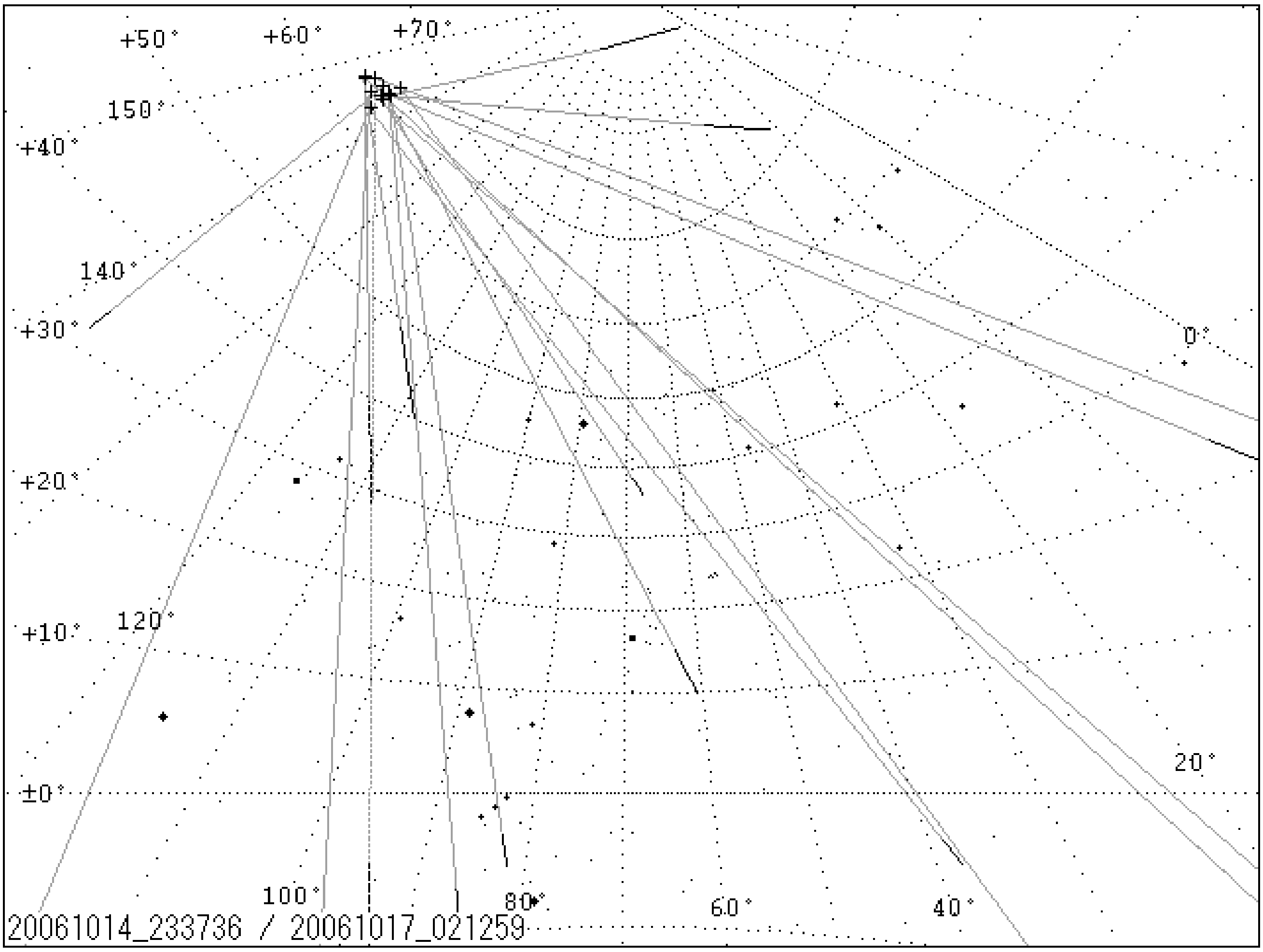

Figure 2 – Trail chart of multi station observations. Some meteors trails extend outside the figure.

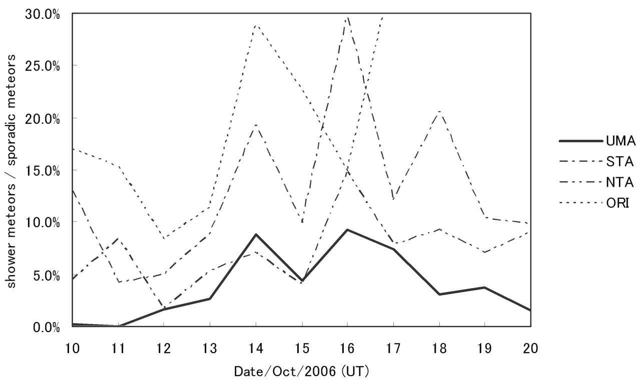

Figure 3 – Appearance ratio (shower meteor rate relative to sporadic rate) of the single site UFOAnalyzer classification result. UMA is Ursa Majorids, STA is Southern Taurids, NTA is Northern Taurids, and ORI is Orionids. The other minor streams are included in sporadic meteors.

4.2 Orbit

The heliocentric orbits of the meteors are listed in Table 4, and those orbits are presented as a chart in Figure 4.

It is the large inclinations that characterize this meteor stream. It is near to being perpendicular to the ecliptic. There is no orbit which is similar in the known asteroids and periodic comets (Jet Propulsion Laboratory, 6). Some parabolic comets show orbits of the same general form as this meteoroid stream. However, we cannot find a direct correspondence between those comets and this meteoroid stream.

4.3 Activities

The observational results of a single station in Uehara's site with 2 cameras are shown in Table 3. The results of the classification of 2187 meteors by single station observation based on the data of the SonotaCo network in mid-October are shown in Figure 3. The former and the latter are in close agreement. These results show that this meteor stream may have activity ranking with the Orionids or Taurids in this period. It reached 4-9% of the sporadic meteor background.

In addition, Molau S. suggested in his personal communication to SonotaCo that this stream has an activity subsequent to the Orionids and Taurids, as a result of single station observation in Europe only between solar longitude 200° and 204°.

Investigations are not yet over, but a few meteors which belong to this stream were confirmed by single station observations of plural site every night in this period.

5 Discussions

The D' value (Drummond, 1979) (for the average orbit) of each simultaneous meteor which showed similarity of orbit was lower than 0.10 (average 0.03) for all meteors. This means that all the meteors belonged to the same meteoroid stream. This meteoroid stream had a short active period, but showed very clear activity.

Hashimoto T. (NMS) stated that there is no record of any radiant point in a range 'year; 1928 – 2005, date; 10 – 20 Oct., R.A. = 131° – 161°, Decl. = +49° – 79°' in the NMS Radiant Database (Hashimoto, *pers com*).

We conclude that this event was caused by the dust trail of an as yet unidentified periodic comet with orbital elements similar to those of the meteors: Epoch = 2006 October 15, $a = 5.9$ AU, $q = 0.979$ AU, $e = 0.875$, $\omega = 163.^\circ 7$, $\Omega = 202.^\circ 1$, and $i = 99.^\circ 7$ (J2000.0).

We have pointed out that many of the meteors of this stream have their brightness peak in the first half of the trail. This fact is related to physical properties of the meteoroid stream and needs further study.

Acknowledgments

The author would like to thank Masayoshi Ueda for having offered his observation data. Thanks also to the members of Jusojuku (A study group of meteor astronomy in Osaka, Japan) for helpful suggestions.

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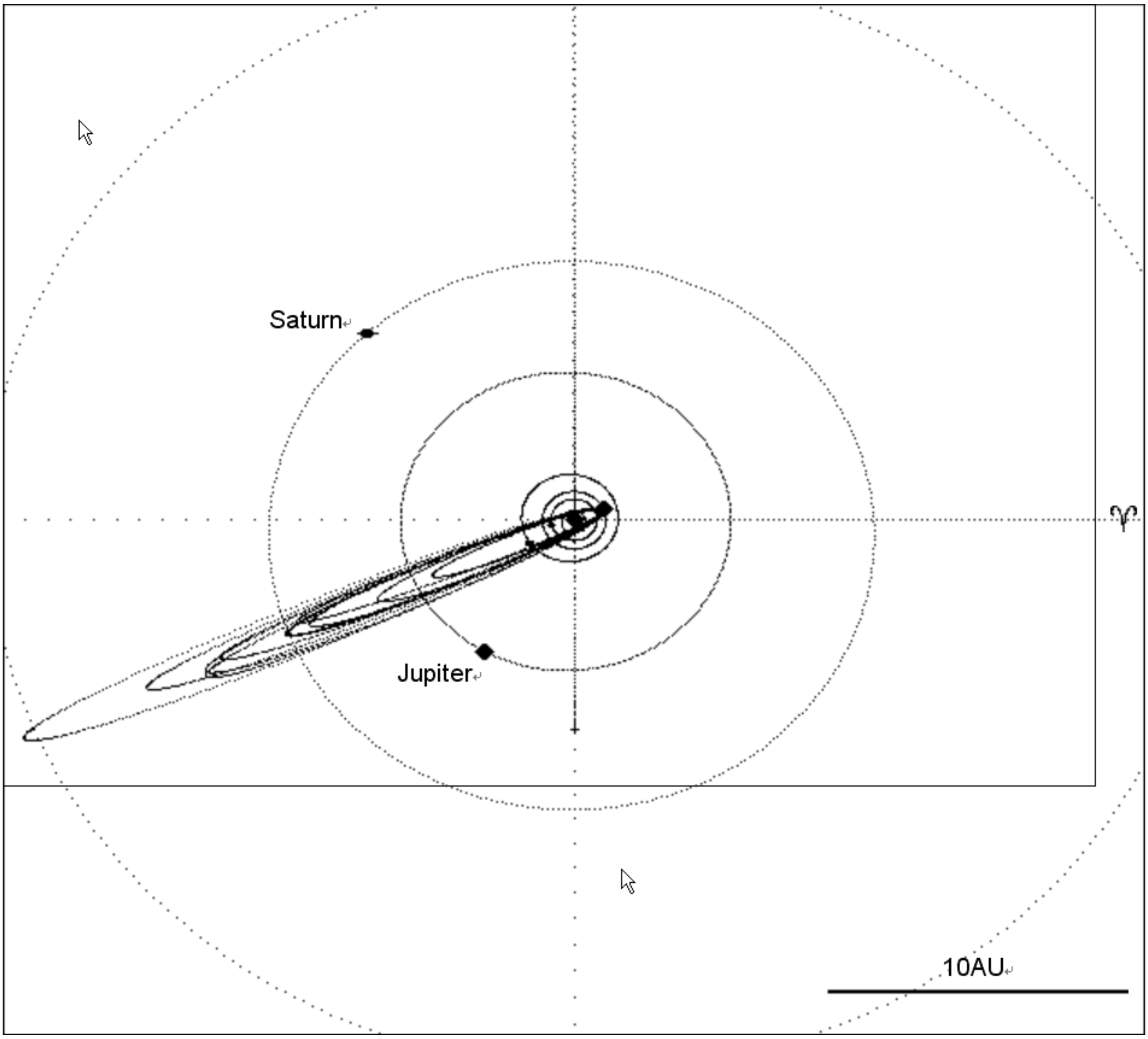

Figure 4 – Orbits of simultaneous meteors - a view from the direction of the North Pole of the ecliptic.

Table 3 – The number of meteors by single station observation.

Date	Camera 1 (6 mm lens)				Camera 2 (12 mm lens)			
2006 Oct	SPO	UMA	ORI	TAU	SPO	UMA	ORI	TAU
14/15	9	4	1	1	25	3	5	7
15/16	10	3	6	3	31	0	1	4
16/17	17	0	3	3	38	2	5	2
Total	36	7 (19%)	10 (28%)	7 (19%)	94	5 (5%)	11 (12%)	13 (14%)

Limited magnitude was $m = 3$–4 mag with an $f = 6$ mm lens and $m = 5$–6 mag with an $f = 12$ mm lens. The sky was not fine owing to a haze or cloud every night.

Table 4 – Heliocentric orbits of the meteors.

No.	Meteor Date	Meteor Time (UT)	N	R.A. (Corrected)	Dec. (Corrected)	V_g (km/s)	a (AU)	q (AU)	e	ω	Ω	i	P (year)	D'
1	2006 Oct 14	$14^h37^m36^s$	3	144.°55	66.°27	53.1	5.71	0.982	0.828	165.°1	201.°0	97.°2	13.6	0.02
2	2006 Oct 15	$10^h21^m39^s$	1	143.°56	64.°44	55.4	11.49	0.981	0.915	165.°1	201.°8	101.°0	39.0	0.04
3	2006 Oct 15	$15^h23^m12^s$	1	143.°99	64.°37	54.1	5.45	0.980	0.820	164.°0	202.°0	100.°0	12.7	0.01
4	2006 Oct 15	$15^h39^m26^s$	1	143.°90	65.°16	54.6	8.66	0.983	0.886	166.°2	202.°1	99.°7	25.5	0.03
5	2006 Oct 15	$17^h22^m35^s$	1	143.°61	65.°28	54.3	7.09	0.984	0.861	166.°6	202.°1	99.°4	18.9	0.02
6	2006 Oct 15	$17^h36^m03^s$	1	145.°12	63.°67	55.0	7.77	0.975	0.874	162.°3	202.°1	100.°9	21.7	0.02
7	2006 Oct 15	$17^h46^m39^s$	1	146.°86	64.°75	53.7	6.02	0.976	0.838	162.°3	202.°1	98.°5	14.8	0.01
8	2006 Oct 15	$19^h29^m45^s$	1	144.°38	63.°88	52.4	3.09	0.975	0.685	161.°1	202.°2	99.°0	5.4	0.10
9	2006 Oct 15	$19^h38^m20^s$	1	144.°75	63.°21	53.8	4.20	0.973	0.768	160.°7	202.°2	100.°6	8.6	0.05
10	2006 Oct 16	$17^h12^m59^s$	6	147.°26	63.°81	54.6	7.72	0.975	0.874	162.°4	203.°1	100.°0	21.5	0.02
			Average	144.°80	64.°48	54.1	5.92	0.979	0.875	163.°7	202.°1	99.°7	14.4	(0.03)

N (column 4) is the number of pairs of simultaneous observations of each meteor. More than two pairs of simultaneous observations were obtained with meteors numbers 1 and 10. At present, UFOAnalyzer does not have a function to calculate the most highly reliable orbital element from a simultaneous meteor with more than two pairs of observations. Therefore an orbital element was calculated with the value that averaged the R.A., Decl, and V_g when more than two pairs were obtained.
The average value of the orbital elements are based on the average values of R.A., Dec. and V_g. However, the average D' is simply the average of the values in that column.

Leonids

Bulletin 21 of the International Leonid Watch: Global analysis of visual observations of the 2006 Leonid meteor shower

Rainer Arlt [1] *and Geert Barentsen* [2]

Visual observations of the 2006 Leonid meteor shower as collected in the Visual Meteor Database (VMDB) are investigated. The Leonids exhibited a short-lived activity peak on November 19, 2006, at $4^{h}46^{m} \pm 6$ m UT. The maximum ZHR was 75 ± 8. The activity peak coincides with a maximum of the population index of $r = 2.46 \pm 0.14$. The outburst is associated with the encounter with the 2-revolution arlt-leonids dust trail of the parent comet 55P/Tempel-Tuttle.

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1 Predictions and observations

A number of activity peaks of the Leonid meteor shower has been observed since 1998. Most of these peaks are associated with particular dust trails ejected at individual perihelion passages of the parent comet, 55P/Tempel-Tuttle. The simulation of the evolution of these dust trails has been used successfully to predict the activity peaks of the Leonids up to several years in advance. A prediction for 2006 was already included in the set of predictions by McNaught & Asher (1999a). They identified the dust trail ejected during the 1932 return of the comet to come close to the Earth in 2006 and found an encounter time of November 19, $04^{h}45^{m}$ UT (solar longitude $\lambda_{\odot} = 236\overset{\circ}{.}613$ referring to equinox J2000.0). A tentative maximum ZHR of 150 was given for the prediction. Little has changed after the refinement of the models since. A dust trail integration by Lyytinen and van Flandern (2000) led to an encounter time of $04^{h}48^{m}$ UT ($\lambda_{\odot} = 236\overset{\circ}{.}615$) and a peak ZHR estimate of 50. The more recent prediction by Maslov (2006) gives a peak time of $4^{h}55^{m}$ UT ($\lambda_{\odot} = 236\overset{\circ}{.}620$) for the 1932 trail. He also computed an encounter time of November 20, $6^{h}28^{m}$ UT for the 19-revolution trail of 1366, but with a pessimistic expected ZHR of 1. The solar longitude of that peak would be $\lambda_{\odot} = 237\overset{\circ}{.}694$.

Weather at many places in central, western, and southern Europe permitted observations; it was probably a better-than-average November 18/19 for astronomical purposes, but fog was a problem for a number of sites. The Meteosat image in Fig. 1 gives a rough impression of the weather situation near midnight. Eastern European observers had to stop early because of the beginning of twilight and could not cover the entire period of interest. In total, 93 observers reported 2801 Leonids seen in 297.54 h of observing time. We are very grateful to

Harshad Abhyankar (ABHHA, $1\overset{h}{.}90$, 4), Ioan Agavriloaiei (AGAIO, $1\overset{h}{.}15$, 6), Karl Antier (ANTKA, $4\overset{h}{.}33$, 65), Julia Babina (BABJL, $1\overset{h}{.}08$, 10), Jaydeep Belapure (BELJA, $2\overset{h}{.}00$, 13), Felix Bettonvil (BETFE, $2\overset{h}{.}92$, 34), Sushrut Bhanushali (BHASU, $1\overset{h}{.}00$, 12), Andreas Buchmann (BUCAN, $3\overset{h}{.}18$, 70), Hans Buchholtz (BUCHA, $0\overset{h}{.}64$, 7), Vasko Cacanoski (CACVA, $4\overset{h}{.}03$, 40), Ed Cannon (CANED, $4\overset{h}{.}18$, 39), Jakub Cerny (CERJA, $1\overset{h}{.}51$, 12), Igor Chalenko (CHAIG, $2\overset{h}{.}41$, 9), Sarthak Chandra (CHASR, $0\overset{h}{.}83$, 7), Lorenzo Comolli (COMLO, $2\overset{h}{.}27$, 41), Tim Cooper (COOTI, $3\overset{h}{.}41$, 8), Nadka Dankova (DANNA, $2\overset{h}{.}15$, 17), Sarthak Dasadia (DASSA, $4\overset{h}{.}50$, 22), Samer Derbi (DERSA, $2\overset{h}{.}99$, 22), Onkar Dixit (DIXON, $1\overset{h}{.}50$, 19), Jaka Dobaj (DOBJA, $1\overset{h}{.}79$, 37), Kenneth Drake (DRAKE, $0\overset{h}{.}92$, 11), Shawn Dvorak (DVOSH, $0\overset{h}{.}50$, 1), Shlomi Eini (EINSH, $3\overset{h}{.}30$, 55), David Entwistle (ENTDA, $1\overset{h}{.}08$, 7), Eric Flescher (FLEER, $3\overset{h}{.}18$, 10), Mitja Govedic (GOVMI, $2\overset{h}{.}00$, 8), Robin Gray (GRARO, $4\overset{h}{.}05$, 18), Peter Greskovic (GREPE, $1\overset{h}{.}51$, 6), Pavol Habuda (HABPA, $4\overset{h}{.}29$, 41), Torsten Hansen (HANTO, $2\overset{h}{.}68$, 64), Roberto Haver (HAVRO, $2\overset{h}{.}58$, 39), Martin Hörenz (HORMJ, $2\overset{h}{.}08$, 19), Petr Horalek (HORPT, $3\overset{h}{.}55$, 55), Sagar Joglekar (JOGSA, $1\overset{h}{.}50$, 8), Carl Johannink (JOHCA, $13\overset{h}{.}08$, 218), Kearn Jones (JONKR, $2\overset{h}{.}00$, 10), Bhargav Joshi (JOSBH, $2\overset{h}{.}77$, 6), Javor Kac (KACJA, $5\overset{h}{.}38$, 74), Amol Kankariya (KANAM, $1\overset{h}{.}00$, 4), Roy Keeris (KEERO, $2\overset{h}{.}13$, 11), Prakash Khatri (KHAPR, $1\overset{h}{.}08$, 4), Gyula Kiss (KISGY, $1\overset{h}{.}75$, 17), André Knöfel (KNOAN, $3\overset{h}{.}87$, 28), Judith de Koster (KOSJU, $1\overset{h}{.}95$, 6), Ralf Koschack (KOSRA, $1\overset{h}{.}60$, 27), Jakub Koukal (KOUJA, $14\overset{h}{.}50$, 85), Richard Kramer (KRARI, $0\overset{h}{.}57$, 3), Ashish Kuvelkar (KUVAS, $1\overset{h}{.}66$, 4), Jens Lacorne (LACJE, $2\overset{h}{.}89$, 29), Anna S. Levina (LEVAN, $6\overset{h}{.}99$, 101), Hartwig Lüthen (LUTHA, $1\overset{h}{.}89$, 23), Tony Markham (MARTO, $6\overset{h}{.}44$, 11), Paul Martsching (MARPA, $13\overset{h}{.}50$, 40), Pierre Martin (MARPI, $1\overset{h}{.}22$, 11), Alastair McBeath (MCBAL, $8\overset{h}{.}67$, 31), Mukul Mhaskey (MHAMU, $3\overset{h}{.}00$, 18), Koen Miskotte (MISKO, $18\overset{h}{.}95$, 300), Sirko Molau (MOLSI, $0\overset{h}{.}88$, 21), Sabine Wächter (MORSA, $2\overset{h}{.}08$, 25), Yousef Mteir (MTEYO, $1\overset{h}{.}83$, 12), Sven Näther (NATSV, $1\overset{h}{.}15$, 6), Martin Nedved (NEDMA, $3\overset{h}{.}85$, 27), Daniel van Os (OSVDA, $2\overset{h}{.}08$, 16), Robert Pomohaci (POMRO, $1\overset{h}{.}00$, 22), Nilesh Puntambekar (PUNNI, $3\overset{h}{.}15$, 13), Tushar Purohit (PURTU, $1\overset{h}{.}50$, 18), Jürgen Rendtel (RENJU, $4\overset{h}{.}68$, 37), Basheer Saleh (SALBA, $1\overset{h}{.}50$, 7), Dan Self (SELDA, $1\overset{h}{.}01$, 43), Jonathan Shanklin (SHAJO, $4\overset{h}{.}89$, 46), Vladimir Slusarenko (SLUVL, $2\overset{h}{.}41$, 5), Ulrich Sperberg (SPEUL, $2\overset{h}{.}85$, 14), David Stine (STIDA, $3\overset{h}{.}00$, 6), Boris Stoilov (STOBO, $7\overset{h}{.}31$, 29), Martin

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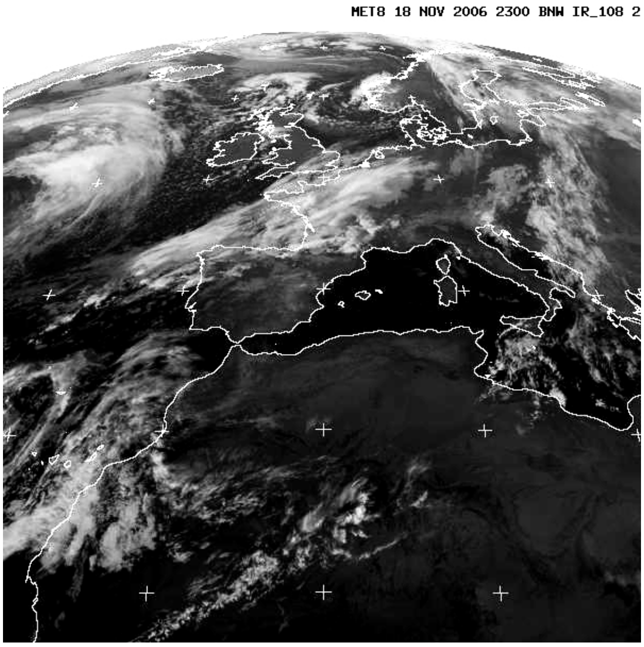

Figure 1 – Meteosat infrared image of 2006 November 18, 23^{h} UT showing the European weather situation a few hours before the expected Leonid peak (copyright 2006 EUMETSAT, `http://www.eumetsat.int`).

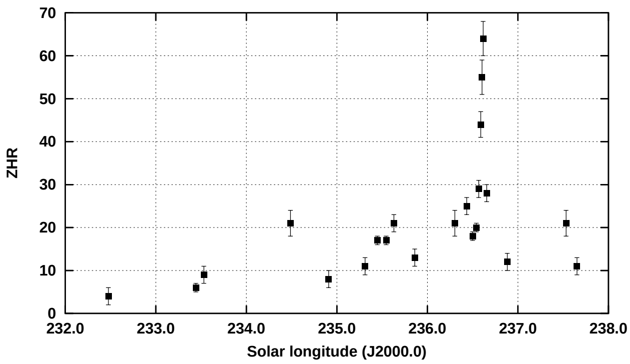

Figure 2 – Preliminary ZHR profile of the 2006 Leonids automatically derived from observations submitted through the online report form until November 30, 2006. All solar longitudes in this and the following graphs refer to equinox J2000.0.

Stojanovski (`STOMT`, $4^{\mathrm{h}}.34$, 49), Wesley Stone (`STOWE`, $1^{\mathrm{h}}.50$, 9), Magda Streicher (`STRMA`, $1^{\mathrm{h}}.62$, 7), Oana Suciu (`SUCOA`, $2^{\mathrm{h}}.99$, 23), Khaled Tell (`TELKH`, $3^{\mathrm{h}}.49$, 16), Cristina Tinta (`TINCR`, $2^{\mathrm{h}}.04$, 8), Rafaél R. Torregrosa Soler (`TORRQ`, $2^{\mathrm{h}}.00$, 21), Josep M. Trigo Rodríguez (`TRIJO`, $2^{\mathrm{h}}.15$, 30), Blanca Troughton Luque (`TROBL`, $1^{\mathrm{h}}.68$, 9), Shigeo Uchiyama (`UCHSH`, $2^{\mathrm{h}}.00$, 10), Michel Vandeputte (`VANMC`, $11^{\mathrm{h}}.94$, 268), Valentin Velkov (`VELVA`, $2^{\mathrm{h}}.72$, 22), Jan Verfl (`VERJX`, $1^{\mathrm{h}}.51$, 12), Frank Wächter (`WACFR`, $1^{\mathrm{h}}.95$, 21), Graham Winstanley (`WINGR`, $2^{\mathrm{h}}.35$, 19), Kim S. Youmans (`YOUKI`, $3^{\mathrm{h}}.00$, 8), Weizhou Zeng (`ZENWE`, $3^{\mathrm{h}}.19$, 17), Wen Zhou (`ZHOWE`, $2^{\mathrm{h}}.00$, 8),

coming from

Australia, Belgium, Bulgaria, Canada, China, Czech Republic, Denmark, France, Germany, Hungary, India, Israel, Italy, Japan, Jordan, Lithuania, Macedonia, the Netherlands, Portugal, Romania, Slovakia, Slovenia, South Africa, Spain, Switzerland, the UK, the Ukraine, and the USA

for their observing efforts and swift reporting of the data.

2 Data treatment

2.1 Live activity profile

A large fraction of observations was submitted very quickly through an online report form implemented by Geert Barentsen as a step on the way to an online global meteor database. For the moment, the online form script sends a message to RA for manual input in the Visual Meteor Database (VMDB), which is at present the largest data set of visual meteor shower activity and magnitude data. Since the form script also checks the data on plausibility, it computes various quantities from the data such as the radiant elevations. These could be employed to derive values of zenithal hourly rates (ZHR) directly on the web server which were averaged every minute for a ZHR profile shown on the IMO web site. The live graph was in fact computed in exactly the same way as the IMO shower circulars are usually created, which are distributed on a few mailing lists, yet without manual interference. The preliminary profile as based on 61 observers who made use of the online report form is shown in Fig. 2 as of November 30, 2006. About half of the total amount of Leonids in the VMDB were reported through the online report form.

2.2 Population index

Since the ZHR implies a correction of the shower meteor number seen under an actual limiting magnitude to a standard limiting magnitude of +6.5, we need to know the population index r of the shower before any computation of the ZHR. It represents the particle size distribution in the meteoroid stream and will naturally depend on time. Our first step towards a final activity profile of the 2006 Leonids is the computation of the Leonid population index profile. A total of 286 magnitude distributions containing 2619 Leonid magnitudes was used to construct the profile. An adaptive-bin-size algorithm goes through the data and forms temporal bins with roughly the same number of meteors in each bin.

The bin-size algorithm is explained below in detail when we describe the ZHR averaging. The population index is the factor by which the true meteor number grows when going to the next-fainter magnitude class. The true meteor number is defined as not being affected by reduced perception capabilities of the observer for fainter meteors. In a diagram of the logarithms of true meteor numbers versus magnitude class, the points should form a straight line (power law). A first guess would determine the regression line through the points, but another way of getting from meteor magnitudes to the population index yields half as large error margins: the population index is based on the average magnitude difference to the limiting magnitude for each individual meteor. For any given population index r, one can sim-

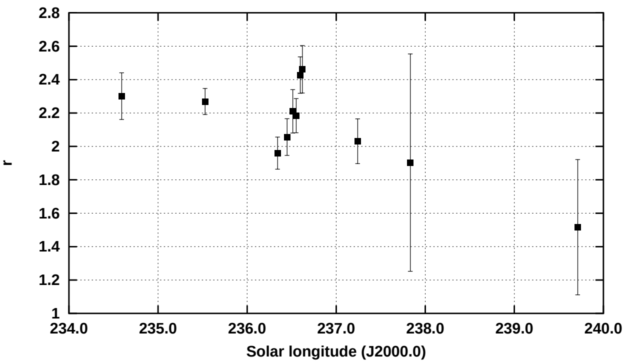

Figure 3 – Population index profile of the 2006 Leonids as derived from visual observations.

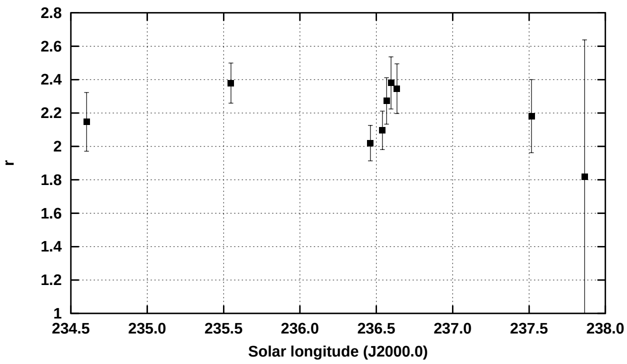

Figure 4 – Population index profile of the 2006 Leonids as derived from magnitude distributions for which the radiant elevation was in the interval from 40° to 60° at the middle. Only the period near the maximum was selected here.

ulate many magnitude distributions which also involve the perception probabilities for any meteor magnitude as published by Koschack & Rendtel (1990). These simulations deliver the mean magnitude difference from the limiting magnitude as well as – from the diversity of simulated distributions – the error margins. A conversion table of mean magnitude differences to r is given in Arlt (2003).

Since the mean magnitude difference is independent of the limiting magnitude, we can group different observers and observations into one average and obtain an average r for a given period. The resulting population index profile is shown in Fig. 3. The population index evolution starts with a value near $r = 2.3$ and ends up with a value of $r = 1.5$, but with a very large uncertainty. We can interpret the profile such that a general decrease throughout the activity period of the Leonids is observed, while a short-lived peak of high r is superimposed to this general trend. The peak is as high as $r = 2.46 \pm 0.14$ and is not typical for cometary shower material which is in its orbit for many revolutions after ejection already. The high population index is compatible with material ejected only a few revolutions ago and thus with a dust trail ejected in 1932.

The time of the peak is $\lambda_\odot = 236\overset{\circ}{.}61 \pm 0\overset{\circ}{.}01$ or November 19, $04^{\mathrm{h}}41^{\mathrm{m}} \pm 15$ m UT. The uncertainty is relatively large, because very many meteors are required to obtain small error margins. A profile with finer time resolution would result in much larger error bars and does not point significantly to a more precise time.

The problem with interpreting the high r as an actual peak is the missing declining branch. The increasing r may not be due to the young material, but simply due to a radiant-elevation effect, since nearly all observers who recorded the corresponding meteor magnitudes were located in western Europe and saw the same behaviour of the radiant rising towards the end of the night.

In an experiment, we computed the population index from observations for which the radiant elevation was in the interval from 40° to 60° at the middle of the observing period. The radiant height dependence should be reduced. Fig. 4 shows the corresponding profile; the r-peak near the expected dust trail encounter is still present. Note that the r-value one day earlier is also high, and we cannot exclude that a radiant-height effect is superimposed to the real features. The original point for about $\lambda_\odot \approx 235\overset{\circ}{.}5$ in the profile of Fig. 3 contained various other radiant elevations and is not that high. The error bars of the points near $\lambda_\odot \approx 235\overset{\circ}{.}5$ in Figs. 3 and 4 still overlap though. The same holds for the peak-r one day later.

2.3 Zenithal hourly rate

We employ a weighted averaging with the total correction coming from the stellar limiting magnitude lm, possible obstructions of the field of view expressed by F, the radiant elevation h_{R}, and the effective observing time T_{eff}. The average ZHR is given by

$$\overline{\mathrm{ZHR}} = \left(\sum_{i=1}^{N} n_i + 1 \right) \Big/ \sum_{i=1}^{N} C_i \,, \qquad (1)$$

where the n_i and the C_i are the number of Leonids and the total correction factors of the N individual observing periods, respectively. The total correction is computed by

$$C = \frac{r^{6.5-\mathrm{lm}} F}{T_{\mathrm{eff}} \sin h_{\mathrm{R}}} \qquad (2)$$

The averaging is again an adaptive process where the essential input is an optimum meteor number to be comprised by each average. The activity period is divided into averaging bins each containing approximately the optimum meteor number. For the full ZHR profile, we set this number to 200 Leonids. While going through the data records in chronological order, the algorithm accumulates periods with meteors until it reaches the optimum meteor number. This defines the bin width. The width may, however, be too short for a few periods which are longer than the bin and thus not suitable. The algorithm has to search iteratively to reach the optimum meteor number in each bin without using periods that are longer than the bin. A period is considered lying in the averaging bin, if its middle is within the bin.

There are of course very few meteors far from the shower maximum, and we have to give an upper bin width as the bin might cover several days otherwise. On the other hand, if very many meteors are available,

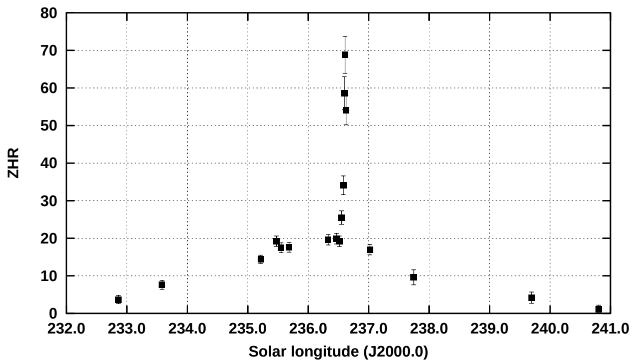

Figure 5 – ZHR profile of the 2006 Leonids as derived from visual observations.

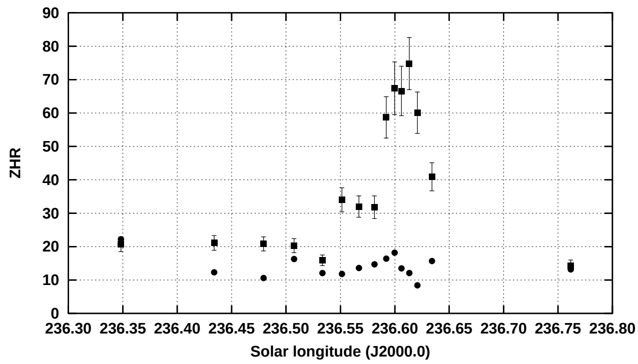

Figure 6 – ZHR profile of the 2006 Leonid maximum as derived from visual observations. The temporal resolution is higher than in Figure 5. The circles are the average sporadic hourly rates for the same time bins as the ZHR. Their error bars are omitted, but are between ± 1 and ± 3 for most of the points and ± 4 for the maximum point near $\lambda_\odot = 236\overset{\circ}{.}6$.

the bin width may become shorter than the typical observing period which is reported during that time, say 5 or 10 minutes. For example, the optimum meteor number may already be reached when the bin width is only 3 minutes, and the algorithm finds that it has to exclude nearly all observing periods from the bin. The optimum meteor number is then not reached and the bin width is extended until it reaches the 5-minute duration to include the periods which are actually available. The algorithm may thus flip between two solutions – a short bin with not enough meteors or a longer period with way too many meteors – without converging. This dead-lock can be prevented by setting a minimum bin width.

Because of the very uneven distribution of observations during the activity period of the 2006 Leonids, we composed the activity profile of two periods: (i) the first runs from $\lambda_\odot = 232°$ to $236°$ (i.e. up to November 18, $\approx 14^{\rm h}$ UT) with a maximum bin width of $8°$ (actually only a safety limit) and a minimum bin width of $1°$; (ii) the second averaging runs from $\lambda_\odot = 236°$ to $243°$ with a maximum bin width of $2°$ and a minimum bin width of $0\overset{\circ}{.}0069$ corresponding to 10 minutes. Each observing period is used only once in a bin.

Additional constraints are a maximum correction factor of

$$\frac{r^{6.5-\rm lm}\,F}{\sin h_{\rm R}} < 8 \tag{3}$$

and a minimum radiant elevation of $h_{\rm R} > 10°$. The observing direction is not considered, neither in terms of a correction nor in terms of a constraint. The radiant elevation correction is actually not based on $h_{\rm R}$ for the middle of the observing period but is the average $\sin h_{\rm R}$ over the observing period (Arlt, 1990). The difference to the simpler version is relatively small, but may matter as the radiant of the Leonids rises very quickly at mid- and low-latitude sites near local midnight. For averaging the ZHR, the solar longitude of the middle of the observing period is used. We are not applying any correction of the timing for the topocentric encounter of the stream as suggested by McNaught & Asher (1999b), because the shortest observing periods are about 5 minutes long, and the correction is smaller for nearly all sites.

The resulting activity profile of the 2006 Leonids is shown in Fig. 5. Two features are evident from the graph: (i) a broad background activity component with a maximum ZHR of about 20 and a full width at half-maximum of about $3\overset{\circ}{.}5$ in solar longitudes corresponding to about 3.5 days, and (ii) a sharp peak at $\lambda_\odot = 236\overset{\circ}{.}61$. At ten minutes resolution, this peak may be resolved though.

A special averaging run with increased temporal resolution was computed for the hours around the Leonid peak on November 19. The optimum meteor number is now 100, and the minimum bin width is $0\overset{\circ}{.}0035$ corresponding to 5 minutes. This is the smallest reasonable bin width, since smaller periods were reported only occasionally (e.g. when time stamps were not taken regularly). The other constraints are the same as for the full profile in Fig. 5. The resulting "magnification" of the Leonid peak is shown in Fig. 6. A peak ZHR of 75 ± 8 occurred at a solar longitude of $\lambda_\odot = 236\overset{\circ}{.}613$ or November 19, $4^{\rm h}46^{\rm m} \pm 6$ m UT. The error in the timing is simply taken as half the distance to the neighbouring averages, rounded to the next minute. The full uncertainty may be somewhat larger though.

The full width at half-maximum of the peak is about $0\overset{\circ}{.}07$ or about 100 minutes. If one subtracts the background component of ZHR ≈ 20, the width is even shorter, about $0\overset{\circ}{.}04$ or 60 minutes.

The graph also shows the average sporadic hourly rate for each of the bins for the averaged Leonid activity points. These sporadic rates are simple averages of the individual HR $= n_{\rm spo}\, r^{6.5-\rm lm}\, F/T_{\rm eff}$ for simplicity. The sporadic rates vary between 10 and 20 and show their strongest variation during the time of the Leonid peak, roughly between November 19, $4^{\rm h}$and $5^{\rm h}$ UT. The general upward trend between $\lambda_\odot = 236\overset{\circ}{.}4$ and $236\overset{\circ}{.}6$ is most likely an effect of the diurnal variation of sporadic rates, but then, before the Leonid peak, the sporadic HR starts to decrease and reaches a minimum of below 10 after the Leonid peak. This is not an effect of observers at more western longitudes starting their observations at earlier local time whence lower sporadic rates. The first observation from an American location starts at $\lambda_\odot = 236\overset{\circ}{.}651$, and there is – unfortunately – only a few minutes overlap between western

Table 1 – Numerical data of the activity profile of the 2006 Leonids. Dates and solar longitudes refer to the average time of all the periods within the averaging bin. Solar longitudes refer to equinox J2000.0, N is the number of observing periods in each average, n_{LEO} is the total number of Leonid meteors involved in the average, ZHR is the zenithal hourly rate, $\overline{\mathrm{lm}}$ is the average limiting magnitude, and r is the average population index as derived from linear interpolation in Fig. 3.

Date (UT)		$\lambda_\odot$	N	n_{LEO}	ZHR	$\overline{\mathrm{lm}}$	r
2006 Nov 15	$11^{\mathrm{h}}29$	232°.8618	7	10	3.7 ± 1.1	6.48	2.30 ± 0.14
2006 Nov 16	$04^{\mathrm{h}}37$	233°.5813	11	41	7.6 ± 1.2	6.17	2.30 ± 0.14
2006 Nov 17	$19^{\mathrm{h}}27$	235°.2130	48	168	14.4 ± 1.1	6.02	2.28 ± 0.11
2006 Nov 18	$01^{\mathrm{h}}41$	235°.4745	32	192	19.2 ± 1.4	6.16	2.27 ± 0.08
2006 Nov 18	$03^{\mathrm{h}}30$	235°.5511	25	181	17.5 ± 1.3	6.37	2.26 ± 0.08
2006 Nov 18	$06^{\mathrm{h}}38$	235°.6826	32	186	17.6 ± 1.3	6.26	2.22 ± 0.08
2006 Nov 18	$22^{\mathrm{h}}28$	236°.3483	21	85	20.7 ± 2.2	5.51	1.98 ± 0.10
2006 Nov 19	$00^{\mathrm{h}}30$	236°.4340	37	93	21.1 ± 2.2	6.18	2.04 ± 0.11
2006 Nov 19	$01^{\mathrm{h}}35$	236°.4793	37	97	20.8 ± 2.1	6.37	2.13 ± 0.12
2006 Nov 19	$02^{\mathrm{h}}15$	236°.5074	37	94	20.3 ± 2.1	6.30	2.20 ± 0.13
2006 Nov 19	$02^{\mathrm{h}}52$	236°.5335	43	96	15.9 ± 1.6	6.43	2.20 ± 0.11
2006 Nov 19	$03^{\mathrm{h}}18$	236°.5514	27	90	34.0 ± 3.6	6.30	2.20 ± 0.10
2006 Nov 19	$03^{\mathrm{h}}40$	236°.5670	29	98	32.0 ± 3.2	6.43	2.27 ± 0.10
2006 Nov 19	$04^{\mathrm{h}}00$	236°.5813	31	88	31.8 ± 3.4	6.27	2.35 ± 0.11
2006 Nov 19	$04^{\mathrm{h}}16$	236°.5921	23	90	58.7 ± 6.2	6.32	2.41 ± 0.11
2006 Nov 19	$04^{\mathrm{h}}27$	236°.5998	25	72	67.4 ± 7.9	6.32	2.43 ± 0.11
2006 Nov 19	$04^{\mathrm{h}}36$	236°.6061	26	81	66.6 ± 7.4	6.26	2.44 ± 0.12
2006 Nov 19	$04^{\mathrm{h}}46$	236°.6133	25	90	74.8 ± 7.8	6.31	2.45 ± 0.13
2006 Nov 19	$04^{\mathrm{h}}57$	236°.6208	33	93	60.1 ± 6.2	6.27	2.46 ± 0.14
2006 Nov 19	$05^{\mathrm{h}}16$	236°.6341	36	93	40.9 ± 4.2	6.23	2.45 ± 0.14
2006 Nov 19	$08^{\mathrm{h}}18$	236°.7617	14	68	14.3 ± 1.7	5.92	2.33 ± 0.14
2006 Nov 19	$14^{\mathrm{h}}27$	237°.0209	36	157	17.0 ± 1.4	6.24	2.19 ± 0.24
2006 Nov 20	$07^{\mathrm{h}}44$	237°.7474	6	21	9.6 ± 2.0	6.14	1.91 ± 0.59
2006 Nov 22	$05^{\mathrm{h}}59$	239°.6942	4	7	4.2 ± 1.5	5.89	1.58 ± 0.51
2006 Nov 23	$08^{\mathrm{h}}23$	240°.8057	2	0	1.1 ± 1.1	5.90	2.20 ± 1.74

European observations and northern American observations. Poorer conditions are also not an issue here for the variability of sporadic rates, as the average limiting magnitudes in Tab. 1 prove. We thus have to presume that the sporadic variability is an effect of higher uncertainty in associating meteors with showers, namely the Leonid radiant during the peak time, when increased rates, fainter meteors, and the prediction in mind may have affected the degree of objectivity of the visual observers. To which degree the Leonid ZHRs are affected is unknown.

The numerical data of the merged profiles of Fig. 5 and Fig. 6 is given in Tab. 1. Besides the ZHR profile, we also give the average limiting magnitude for each of the bins of ZHR averaging as well as the average population index which is linearly interpolated from the profile in Fig. 3 for each individual observing period. Observing conditions were generally very good, with only a few averages of $\mathrm{lm} < +6$. The 2-revolution dust trail encounter is covered with observations with average limiting magnitude near +6.3. The last row is a typical effect of small-number statistics as 0 Leonids produce a ZHR of 1.1 which looks odd at first glance. However, the fact that zero meteors were seen, can be the result of a true rate (measured over an infinitely long time) larger than 0. The observer may have accidentally seen no meteors in the specific observing period. In statistical terms, the ZHR is the expectation value of all possible true rates which may have caused the observer to see 0 Leonids. It results from an integration over a Poissonian-like function. This gives an expectation value ("average") for the true rate of 1 with additional factors due to lm etc. The last line of Tab. 1 is a direct consequence of Eq. 1. The error margin is then 100%, however. The effect of the "+1 there has only negligible effect on the rest of Tab. 1, except for the last two lines.

There are not enough observing periods for the time near the second possible activity enhancement on November 20, $6^{\mathrm{h}}28^{\mathrm{m}}$ UT. About ten periods are available for the four hours around that time. There is also a substantial gap in observing data between the Spanish night time and the first period reported from the USA.

3 Conclusions

We investigated the 2006 return of the Leonid meteor shower as monitored by visual observations. The encounter with the 2-revolution dust trail ejected in 1932 is identified in both the population index as a period with a large fraction of faint meteors and in the ZHR-profile with a peak rate of 75 ± 8 at $\lambda_\odot = 236°.613$ or November 19, $4^{\mathrm{h}}46^{\mathrm{m}} \pm 6$ m UT. The agreement with the dust trail predictions by McNaught & Asher (1999) and Lyytinen & van Flandern (2000) is very good regarding the peak time and fairly reasonable regarding the estimate of the maximum ZHR. The maximum was composed of rather faint meteors given the population index of $r = 2.46 \pm 0.14$ at the peak time. A similar

r-peak like this was found in the 1999 data near the 3-revolution dust trail encounter (Arlt et al. 1999). The population index then climbed up to $r \approx 2.7$ during that encounter, using the same mean magnitude distance from lm technique as is used here.

Part of the increase in faint meteors at the peak time may be caused by a radiant-elevation effect which we cannot entirely eliminate. A restriction of observations to a 20° window of radiant elevations still showed the r-peak though.

We should also not forget though that a peak like this may be due to the increased alertness of the observers during the peak time, as the prediction was known to practically all participants. This would affect both the population index and the ZHR going up due to such an increased perception.

Much of the observational data is concentrated near the expected peak, while other periods are poorly covered by data. It must be noted that the absence of other peaks in the ZHR profile is no proof of their nonexistence. An analysis of a set of forward scatter counts worldwide may give indications for other enhancements.

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History

Meteor Beliefs Project: Meteoric Imagery in SF, Part IV — *Quatermass II* and *Spearhead from Space*

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Two notable 'alien invasion' works from broadcast and published fiction are discussed in detail, both of which featured meteoritic objects as vehicles to transport the invaders to Earth.

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1 Introduction

Continuing the sub-project strand of fictional meteoric appearances in films and TV programmes, we examine two apparently entirely separate productions here, but which have surprisingly similar plots, *Quatermass II* and the 'Doctor Who' serial *Spearhead from Space*. Both stories have been reworked in different formats.

Quatermass II was originally broadcast as a BBC TV serial in six parts during October to November 1955. The following year, it was substantially revised for the cinema, as the Hammer film, *Quatermass* 2. Then the TV scripts were published by the original script-writer Nigel Kneale in 1960, though these are somewhat different to the TV broadcasts in a number of ways (Kneale, 1979). Both the TV serial and the film are available on DVD, but only the film was previously released on video.

Spearhead from Space was first broadcast as a four-part BBC TV serial in January 1970. The script for that was by Robert Holmes, but this was reworked into a novel later by Terrance Dicks, a long-serving script editor for the 'Doctor Who' programme, including for this story, in 1974 (Dicks, 1974). Again, the novelization is at some variance with the broadcast material in parts. The TV serial is available on video and DVD.

We shall examine the meteoric items and their perceived effects from these variations below, but we begin with a general overview of both plots. For simplicity, in places below we will use the abbreviations 'Q2' and 'SS' where some comment applies to all or most versions of each respective source.

2 Plot outline

Both Q2 and SS centred around the invasion of Earth by antipathetic colonial aliens. In each case, the invasion was carried out by stealth from space, using small meteoritic capsules no more than $\sim$ 30–45 cm in maximum dimension. Each 'meteorite' contained a tiny part of the invading intelligence, which was able to recombine into a new physical mass on Earth, when collected and brought together. In all cases, these earthly forms were large to very large, vaguely amorphous, writhing things with tentacles or pseudopods, commonly only partly seen, though often represented by modest to unconvincing special effects when they were on view. These intelligences were able to mentally control humans to an extent to bring all this about (and in Q2, protect themselves using humans as armed guards), after the first 'meteorites' had landed. In both, the intelligence was reconstructed into corporeal form at an industrial plant or factory, under the cover of some secret project.

Naturally enough, given the British authors and productions, both were set in England, though in Q2 there were clear indications that similar secret plants were present in different parts of the world too. As we might expect, the eponymous heroes, Quatermass and the Doctor, managed to defeat the invading aliens in the closing scenes.

3 *Quatermass II* (BBC TV serial, black and white, 1955)

We shall discuss the broadcast serial and the later published scripts together for this version of Q2. Rudolph Cartier directed, while the three central character roles were played by John Robinson (as Professor Bernard Quatermass), Monica Grey (as Quatermass' daughter Paula), and Hugh Griffith (as Dr Leo Pugh). John Robinson turned in a reasonable to good, if at times too-stilted, performance. He sometimes comes across as rather ill-at-ease in the role, not entirely surprising, as he was called-in at very short notice, following the unexpected death of the 'original' Quatermass from the first TV serial *The Quatermass Experiment* (made and broadcast by the BBC in 1953), Reginald Tate. Tate died aged 58 just three weeks before location filming for *Quatermass II* began. Monica Grey was appallingly wooden and unconvincing, featured in the production apparently because she was the wife of BBC Radio's Head of Drama at the time. Luckily, Hugh Griffith's superb performance more than compensated for this failing, along with some fine supporting cast work, including that by Herbert Lomas, Rupert Davies, Wilfred Bramble, Roger Delgado, Michael Golden and John Rae (the only one of the team to reprise his role, as works foreman McLeod, in the later film version). The cast notes above, but not the performance comments, were mostly extracted from (Pixley, 2005).

Part one of the serial, 'The Bolts', took its name from the old concept of meteorites as thunderbolts, as

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has been discussed previously in this journal. It contained most of the meteoric references, though not all.

The episode opened at a mobile army radar training unit, tracking something small, but very fast, nearby. The scene changed to a ploughman, Fred Large (played by Eric Lugg), on a tractor in a field, who looked up, startled by a vaguely aircraft-engine-like sound, which grew quickly louder, and ended in a slight thump. Nothing of this was seen. He went to investigate something that had landed just out of camera-shot, which was smoking or steaming when he arrived at it.

Back at the radar unit, after some calculations, the sergeant announced the object should have landed on the other side of a nearby hill, about 2500 yards ($\sim$ 2.3 km) away. The sergeant and Captain Dillon (the unit commander, competently played by John Stone) drove off to find it, remarking that it was the third such event since the unit had been in that area. The sergeant commented that others were seen early in the previous year, "when the big 'flying objects' scare was on", as Dillon noted (Kneale, 1979, p. 14).

Spotting the ploughman's distressed wife in a field, the pair stopped and investigated, finding Large kneeling as if stunned beside a small scatter of stony fragments. Dillon examined one, and suggested it could be a meteorite. He asked Large if he had seen it fall, and whether it was broken on landing. Large seemed oddly dazed, but confirmed it was broken, and said it had a smell like old stables. Dillon mentioned this must have been what the radar tracked, as it was still slightly warm. The sergeant said that if it was not against orders to enquire about such things, who might they ask. Dillon replied, "Quatermass".

It is easy to recognise common meteorite misconceptions in this, such as the smoking, warm object, freshly landed 'in the next field', while the radar screen images showed nothing identifiable at all. Despite these points, the whole was plausibly handled both in the script and TV versions, and was nicely atmospheric. The TV 'meteorite' fragments were of light-coloured rock, again plausible enough for a broken-up stony meteorite, though it might have helped if Dillon had learnt the pieces had fallen first, before saying they might be meteoritic!

Quatermass was in charge of the fictional British Rocketry Research Group, which designed, built, tested and flew atomic-engined rockets. His grand scheme was to use the rockets to carry materials to the Moon to set up a permanent manned lunar base. Dillon arrived at the Group's earthly base with a box of the 'meteorite' fragments, and asked, "Don't you people make a special study of meteorites?" Quatermass replied, "We have to. They're one of the hazards a rocket can meet" (both quotes: op. cit., p. 24), and referred him to 'the expert', Dr Pugh, something that Pugh modestly and humorously denied.

At this point, there was a slight divergence between the published script and the broadcast one. In the TV version, Quatermass dismissed the 'flying objects' scare the previous year, because there was nothing in their radar records to support it. He concluded with the scornful comment, "To account for all those, there must have been a *pretty* display of fireballs about that time!" There was also a passing mention of typical meteor velocities of 30 miles per second ($\sim$ 45 km/sec). In the script, there was a short discussion of the relatively common nature of ordinary 'shooting star' radar meteor traces, "when the bigger ones hit the atmosphere and explode," as Pugh put it (op.cit., p. 25).

Both sources rejoined with Pugh commenting that maybe one in a billion meteors was able to reach the surface as a meteorite. Then Dillon dropped his bombshell: "And the odds against three of them striking an area twenty miles across — in a single week?" (Twenty miles is roughly thirty kilometres.)

A rapid investigation of the fragments followed. "Enstatite, I think," said either Pugh (script) or Quatermass (TV), though this was said as if it were a class of meteorite unfortunately, not merely a mineral which some are relatively abundant in. Pugh fitted the pieces together into a damaged, finned-raindrop, shape, before announcing that, "it's hollow!" (op. cit., p. 26).

Quatermass and Dillon drove off to question Mr and Mrs Large, and then some other locals in a pub, where they learnt that a village, Winnerden Flats, some 20–25 km away by the sea was demolished the previous year to build a huge, secret, government research plant. Driving on to this place, Quatermass realized it looked just like his plans for the moonbase. The pair then heard something, described by the script's directions as: "*...a curious harsh rushing in the air. They look up and about. Then it ends abruptly in a thud. Quatermass points to where a small cloud of dust is flung up from the bulldozed earth, a hundred yards or so away.*" (op. cit., p. 35). The TV version was less clear-cut than the script, but the effect was comparable. One hundred yards is about 90 m.

Having collected the object, still warm, they found it to be an intact form of the finned-raindrop reconstructed in the laboratory. Quatermass gave it to Dillon, so he could find a rule to measure it with, whereupon the object broke up, releasing a white vapour smelling of ammonia. Dillon dropped it and jumped up, as Quatermass spotted something attached to the side of Dillon's face away from the camera. Thus the episode dramatically ended.

As we can now tell, these artificial meteorites could smoke — the white ammonia vapour — and might still be warm on arrival, though whether the non-specialist viewer would appreciate the distinction between these and natural meteorites seems far less likely. It was not explained in either the scripted or broadcast versions, certainly. One other aspect, that the objects were *heard*, not *seen*, to fall, was refreshingly accurate for typical small meteorite landings.

At the start of part two, 'The Mark', Quatermass described the thing he had seen on Dillon's face as a "dark bubble" (op. cit., p. 37), visible for just a moment. In the broadcast version, Quatermass said, "What I saw — what I *thought* I saw — was transparent. Just for a moment, it shone and then..." Later, he likened it to a soap-bubble. These descriptions are almost identical to the inimical coloured bubble found in the meteorite from H. P. Lovecraft's story 'The Colour Out of Space', which we discussed earlier (McBeath & Gheorghe, 2005). The bubble in *Quatermass II* left a distinctive mark, where the alien creature had invaded its human host, a helpful warning in subsequent scenes, hence also the episode's title.

Further along, again just as in the Lovecraft short story, laboratory investigations of the 'meteorite' fragments were carried out. This was followed by a sequence regrettably only in the script (op. cit., pp. 48–49), where Paula had made an examination of all the meteor radar range-time cards for the previous three years, but found "It shows nothing but the normal, seasonal meteor showers." In the non-meteoric rejected plots, she found clear signs of activity coincident with the 'flying objects' scare, however. The range-time cards were exactly what radar meteor studies were all about in the 1950s, so it is a shame this did not survive into the broadcast scenes. It is worth noting that the character of Bernard Quatermass was loosely based on Bernard Lovell, who ran the Jodrell Bank radio telescope in England at this time, where genuine meteor radar studies were first conducted during the late 1940s and 1950s. An excellent blend of fact with fiction, we feel.

In part three, 'The Food', we discover the 'meteorites' originated from a small, probably artificial, asteroid, eccentrically orbiting the Earth, but always keeping in the planet's shadow.

Part four, 'The Coming', brought the main invasion, by night. As before, Quatermass and those with him only heard the 'meteorites' arriving. The air was alive with short whistling sounds and soft thumps, and Quatermass reinforced the point, saying they were coming in their thousands. The noises and the players' reactions provided some powerful images in the TV version, much more so than if the viewers had been treated to poor-quality 'meteor' special effects, as well as being rather more scientifically correct (as far as the fictional context would support, that is). The arrival scenes continued into part five, 'The Frenzy'.

In the final episode, 'The Destroyers', Quatermass and Pugh set off in a rocket to destroy the asteroid. Some of the requirements of this part pushed the special effects beyond their limitations, but it still holds up reasonably well for all that. It is reputed that Nigel Kneale forbade the issuing of a video version of the serial because of these poor-quality effects. Unfortunately, the final meteoric event was the cliché of the rocket's 'meteorite alarm' going off *en route* to the asteroid, due to a normal 'meteor swarm' which lasted only a few seconds, and did no damage.

Despite its age, and the occasionally slightly poor surviving picture or sound qualities, the TV version remains a dramatically effective presentation. The special effects in the last part struggle to convince at times, but the strong, believably paranoiac storyline drives on throughout, and the whole is well worth seeing — or seeing again, for those fortunate enough to have viewed it when broadcast 'live' originally.

4 *Quatermass* 2 (Hammer film, black and white, 1956)

Given that the cinema version of Q2 was around half the length of the TV serial's running time, it was inevitable some elements would have to be omitted. Indeed, although Nigel Kneale is credited as co-author with the film's director, Val Guest, Guest effectively re-wrote much of Kneale's script, reducing details and characters, sharpening, abbreviating and revising the plot. However, it remains at least as effective and atmospheric as the TV version, largely because enough of Kneale's intelligent premise shone through, helped by a distinctive *cinema verité* style the whole was shot in, a splendidly urgent, dramatic, musical score by James Bernard, and some magnificent cinematography by Gerald Gibbs (including believably turning sunlit-day into moonlit-night images, by use of filters).

The main lead characters were cut to two: Quatermass of course, played by American *noir* veteran Brian Donlevy, who had also starred in Hammer's film version of the first Quatermass story, *The Quatermass Xperiment* (1955), and Inspector Lomax of Scotland Yard, excellently portrayed by John Longden. Donlevy was not favoured by Kneale, because he claimed he came across as too much like a mechanic, rather than the more cerebral scientist of the TV variant. Donlevy's performance in *Quatermass* 2 is perfectly pitched for the film's more driven mood, and although contrasting with the TV Quatermass, he gives a far better performance overall in the role than John Robinson did. Again, a splendid supporting cast helped the believability, including Sid (here billed as 'Sidney') James, Bryan Forbes, William Franklyn, Vera Day, Tom Chatto, John Van Eyssen, Percy Herbert, Michael Ripper, and, as mentioned above, John Rae, amongst others. The cast and some other details here were extracted from Hearn & Rigby (2003).

Opening at pace, even before the title and credits, Quatermass was almost crashed into on a quiet road by a woman driving an injured, delirious man in an open-topped sports car. After stopping, she explained the man had been hurt almost an hour before at a demolished village, Winnerden Flats. There, they had heard an object falling through the air, and when he went to investigate, he had been rendered semi-conscious, and had got a burn mark on his face. She had kept the stone fragments he had found, which Quatermass took with him back to the Rocketry Group.

At the Group's base, two researchers Marsh (Bryan Forbes) and Brand (William Franklyn) were watching scores of incoming 'meteorite' radar traces on two circular screens (which traces were shown as entirely unconvincing tadpole-like tracks, for some reason also making short, staccato, scratching sounds). The discussion made clear these were not natural meteorites, as they were arriving too slowly, and very low (so implying a conflation of 'meteor' with 'meteorite'; how else could a meteorite be considered 'too low' in the atmosphere?). The objects were coming down in groups too. A rapid, again unconvincing, 'calculation' by hand showed the objects must have landed about 90–100 miles ($\sim$ 140–160 km) north of the base. Quatermass arrived briskly in the midst of this, and ordered the stones he had brought be classified, suggesting for the first time they might be meteorites.

Next day, the investigators could not classify the 'meteorites', but had reconstructed the pieces as a symmetrical, hollow, damaged, finned-raindrop shape, if rather more like a missile than those in the TV version. Having established the previous night's 'meteorite fall' area as near Winnerden Flats, Quatermass and Marsh drove off and discovered a moonbase-like plant there. In both film and TV versions, the plant was 'played' by the Shell Haven oil refinery on the Thames Estuary in Essex, incidentally, though its intended location in England passed unstated in all forms of Q2.

Scattered among the village ruins were many fresh to very worn 'meteorite' fragments, but Marsh managed to find a whole one, which shattered, releasing a white puff of ammonia vapour into his face. He was left with a much larger facial mark than in the TV series, but as in that, Quatermass saw that something else, something alive, had come out of the object with the gas, "something that looked like a big, black bubble."

Further efforts at discovery by Quatermass followed, in an abbreviated sequence from the TV plot. Back at the Rocketry Group, a plaster model of the complete 'meteorite' had been made, a roughly 30 cm long object, looking like a finned missile warhead, which Quatermass suggested was aerodynamically designed to allow controlled landings. More 'meteorites' were detected by radar, then eventually the radar was somehow used to trace the source of the 'meteorites': a small asteroid in an unusual Earth orbit, in permanent eclipse.

After further attempts to discover more, at governmental level and at the plant (much as in the TV series), one of the 'meteorites' crashed into the plant construction workers' village hall during a St Patrick's Day dance, where Quatermass, Lomax and the press reporter Jimmy Hall (Sid James) had tried to convince the people of what the plant was really for. The 'meteorite' smashed through the roof and the stage in the hall, just missing McLeod's wife. A sparky young woman, Sheila (Vera Day), picked up the object against advice, and said it was still warm. She listened to it, and it broke, infecting her too. Though a similar event happened in the TV series (there catching the reporter), this variant effectively condensed discoveries in several places from the broadcast work into a single cinema scene.

Meanwhile, outside the hall, the air was full of the whistling arrival of hundreds of the objects. Again, nothing was seen of them, maintaining the tense atmosphere which low-grade meteor special effects might have ruined. The story continued from this to the plant's destruction, as in the TV version, but only an unmanned rocket was used as a missile to destroy the asteroid, shown as a plausible animated light moving across the clear night sky. The asteroid's destruction was seen as a bright flare in the sky when it happened, shortly before the film's end.

Overall, another strong production, and definitely something worth seeking out to view today, albeit the science was much less sound than in the television original, and the meteoritic elements somewhat less developed.

5 *Spearhead from Space* (BBC TV 'Doctor Who' serial, colour, 1970)

Given the long-running nature of the BBC's 'Doctor Who' science-fiction television series (1963–1989, restarting as a different format series in 2005), it is not surprising meteors and meteorites featured more than once. One such example was discussed briefly in this journal some years ago, from the story *The Wheel in Space* (Markham, 1996), and another is presented here, drawing on both the broadcast story *Spearhead from Space* and the novelization of the script (Dicks, 1974).

Spearhead from Space began the tenure of a new actor in the role of the Doctor, Jon Pertwee, who continued in the part until 1974. Though still settling into the character so early on, Pertwee gave a splendid performance throughout. He was ably assisted by the other two leads, Nicholas Courtney as Brigadier Lethbridge-Stewart, a character he first played in 1968, commanding the British part of a secret United Nations special force designed to combat alien invasions of the planet, UNIT, and Caroline John, another newcomer to the series, playing a non-specialist scientist, Liz Shaw. As with Q2, some excellent supporting cast members helped move the whole along smoothly, including Hugh Burden, Neil Wilson, Talfryn Thomas, John Breslin, Hamilton Dyce, John Woodnutt and Derek Smee.

Two other elements added to the story's uniqueness. It was the first 'Doctor Who' serial to be made in colour, and owing to industrial problems, the entire thing was filmed on location, something never done before or since.

The broadcast story started at a military radar tracking station, which was detecting something unusual "high up, but coming down fast" (though not so fast that there was no time for a discussion between the operator and an officer as to what it was!). On the radar screen, a vaguely conical shape made up of discrete dots was shown. In further conversation, the officer suggested that if not just an atmospheric anomaly due to the current heatwave, it must be meteorites. They were puzzled though as to why the objects appeared to be flying in formation. Then, in a dreadful scene-changing shot, we were briefly treated to a group of high-flying jets in a 'V'-formation, leaving contrails, presumably meant to represent the incoming meteorites, but about as unconvincingly as imaginable.

None of this sequence featured in the novel, whose first meteoric episode (Dicks, 1974, pp. 9–10) was the same as the next one in the TV version. A man was seen in some woods, a poacher named Sam Seeley (Neil Wilson), as we later discovered. On hearing a falling-bomb-like whistling sound, he looked up and saw some 'meteorites' falling towards him. The shot of these 'meteorites' showed several translucent, vaguely soccer-ball shaped and sized objects clustered near one another, suspended in the air, while smoke was blown past them, to simulate them falling through the clouds. While not particularly realistic, this was a great deal better than the previous 'jets-as-meteors' shot. Both reinforced the wisdom of the Q2 variants not to show any falling objects, certainly.

Despite being so near one another in the air, only one of the objects struck near where Seeley was half-crouching. It did so with a loud explosion, a cloud of dark smoke, and a central flash of fire. Seeley moved to inspect the spot where the object had buried itself in soft ground. The area was smouldering, but no crater had been formed. He prodded the earth with a stick, and uncovered the top of a sphere, which was rhythmically pulsing with light and making a somewhat 'telephonic' pulsating sound. He moved his hand towards it, but drew it back quickly, as if the sphere were very hot.

Later on in both book (op. cit., pp. 13–14) and TV formats, the Brigadier and Liz Shaw discussed this 'meteorite swarm'. The Brigadier commented that ordinarily ten tons of material drifted through space to land on the Earth each day. On this occasion however, about 50 meteorites had landed in Essex that morning, coming down in a funnel of superheated air about 20 miles ($\sim$ 30 km) in diameter. Liz Shaw expressed incredulity at this, and pointed out that most meteorites do not reach the Earth's surface, usually burning up in the atmosphere. The novel made clearer that this area of hot air, stated as at more than 28° C, was what was elsewhere called the 'heatwave', while outside the cone, there had been a ground frost. Unfortunately, the novel did not go on to correct the common science-fiction error of using 'meteorites' to loosely describe both genuine meteorites, and meteors, the popularity of which concept we have already mentioned above.

The discussion proceeded with the Brigadier remarking that six months previously, another group of five or six meteorites had landed in the same area. Liz Shaw reacted by pointing out the obvious, that the chances of such a thing would be incredible for natural meteorites. The Brigadier agreed, in the novel only, indicating that both swarms must have been deliberately aimed at the Earth.

Back in the woods, Seeley had returned to retrieve the object he had seen fall, what he later called a "thunderball", an appropriate variant of the folkloric 'thunderbolt', given the object's shape. In the TV version, the sphere was apparently cool, though the novel (op. cit., p. 26) indicated it was still warm and steaming.

As the story progressed from here, it was established that the objects were not meteorites at all, but were hollow capsules that were being used to transport alien lifeforms, as energy, to Earth. In another scene with the Brigadier, Liz Shaw said that one recovered fragment was not from a meteorite. She pointed out that meteorites were debris from comets (a further confusion with meteors, seemingly), whereas the fragment had been manufactured, and was actually an unknown type of plastic. She did concede it could have come from space, as it showed faint traces of heat fusion.

While the hunt for further meteorites continued for much of the plot, these were really the last new, relevant points made. One of the meteorite globes reappeared in a subsequent 'Doctor Who' serial from 1971, where the same invading aliens returned, in *The Terror of the Autons*, but that was merely a linking device back to this original, as the aliens did not use meteorites on that second occasion.

Although it had some inaccuracies, mostly to aid the telling of the story, this plot made more attempt to be scientifically correct than *The Wheel in Space* at least. It still has a dramatic power at times when viewed today, though it is not nearly so persistently powerful as the Q2 presentations.

6 Agents of fear, children of their times

Q2 was born from the post-war fears of government secrecy and early Cold War tensions in the 1950s, the kind of paranoia from which also sprouted the spate of American and British science-fiction invasion and disaster movies of the same period. The agents of the alien invaders were ordinary humans, indistinguishable from the rest of the population, except for a mark that few would recognise, and which was not always obvious anyway, playing on fears of spies and fifth-columnists, the 'enemy within'.

Though presented fifteen or so years later, SS still drew on those same fears. This time, the agents of the alien invader were plastic mannequins, made at a plastics factory, but some were so well-detailed as to be able to pass for full humans. These took over key government posts from the real humans at the climax of the story, causing chaos and death throughout the country. However, some of the most memorable scenes were those where apparently ordinary plastic shop window dummies began moving, and broke out through those windows, as the main assault began one dawn.

7 Conclusion

This extended commentary has been necessary to do reasonable justice to two fine works in Q2 and SS, the visual versions well worth seeing still, despite their relative ages. The central importance of meteoritic objects to act as transport for deliberate extraterrestrial invasions reinforced the negative views of meteors and meteorites in much of the SF material reviewed so far in this series. Any excuse to keep watching the skies!

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Orionid fireball

The brightest Orionid fireball recorded by the Spanish Meteor Network (SPMN) during the unexpected 2006 October 20/21 outburst. Photographed at $03^{\mathrm{h}}41^{\mathrm{m}}$ UT. Supplied by Josep Trigo Rodriguez, Institute of Space Sciences, Barcelona, Spain.