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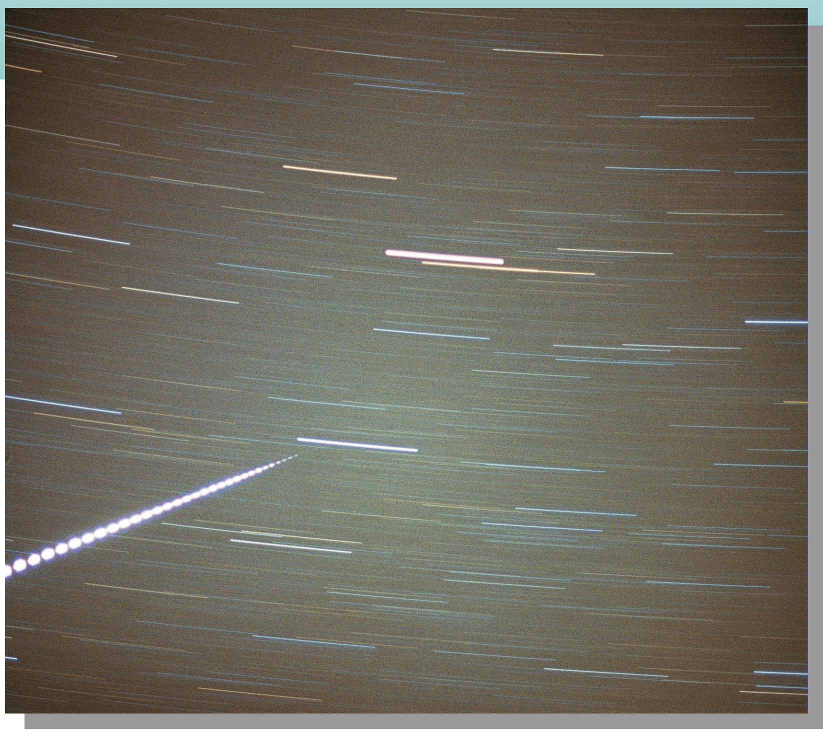

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Geminids
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Tagish Lake
IMC 2004

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Front cover photo

The EN200204 Łaskarzew fireball taken by a Canon T50 camera with a Canon $f/1.4$, $f = 50$ mm lens in Ostrowik near Warsaw. The brightest object in the picture is the planet Saturn. This fireball is analysed in the paper on page 48.

Back cover photo

The EN291103B fireball from the all-sky camera at the EN station 15 Telč. Lens: Zeiss Distagon $f/3.5$, $f = 30$ mm fish-eye. Interruptions of the luminous path of the fireball are caused by a 3-arm rotating shutter placed near the focal plane (15 breaks/s). This fireball is analysed in the paper on page 44.

Cover design

Rainer Arlt

Editorial — comics, comets and meteors

Chris Trayner

The Meteor Beliefs Project has been running for about a year now. Every issue, Alastair MacBeath and Andrei Gheorghe have provided a different slant on meteor work — showing how people in the past viewed meteors, and illustrating the views which have been taken into literature and legend.

This brings a breadth to WGN. Personally, editing every paper we publish, I found Elizabeth Warner's historical piece last Christmas (WGN 31:6, 195–198) one of the most interesting I have handled, largely because it was completely outside my normal area of interest.

Such articles are interesting in their own right — and what is wrong in knowledge for its own sweet sake? But they can also cast interesting sidelights on other issues. One such came to mind when I edited Andrei and Alastair's rather more lighthearted item for this (nominally) April edition. It would have been nice if we could have delivered everyones' copies on April 1, but the realities of production make that rather hard.

Alastair quotes a satirical Irish poem from 1902 about 'a meteor hurled / From Vaynus, or Mars, or from Jupiter's Moon'. The context of these lines makes it clear that the speaker, an Irish farmer, was morally in the right; it is understandable that a down-trodden peasant was ignorant of theories of the origin of meteors.

Or was he?

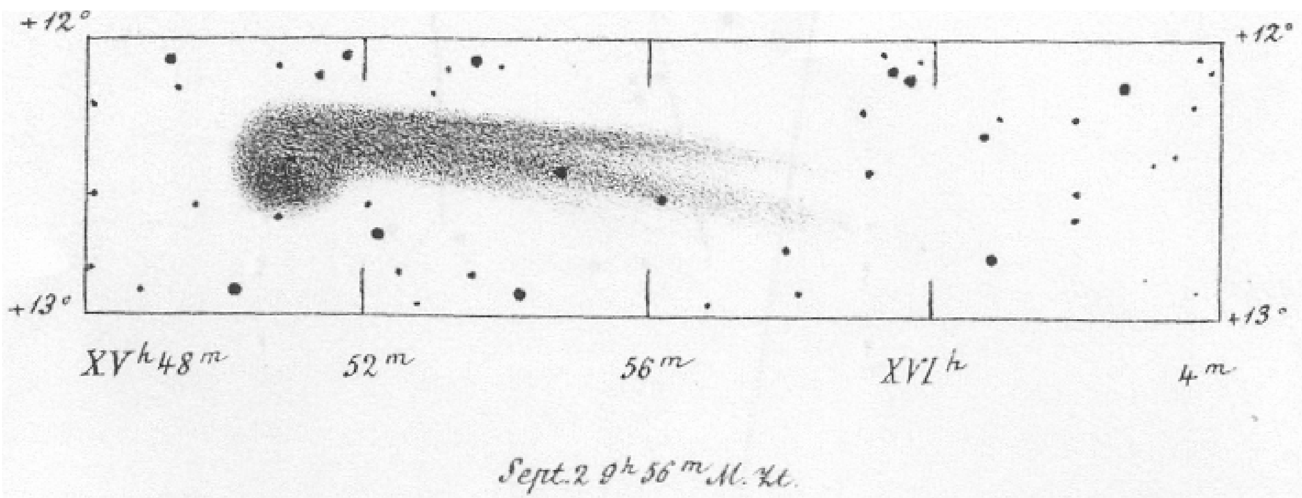
By the late nineteenth century we knew that meteors were associated with comets, and probably came from them (Schiaparelli, 1867), but the origin of comets themselves was unclear. Our present understanding of comets dates essentially from the middle of the twentieth century (Whipple, 1950, 1951). At the time of the poem there was no lack of theories, but it was uncertain which was right.

A fascinating early-twentieth-century book on comets (Proctor & Crommelin, 1937) lists three hypotheses for the origin of comets, quoted from a 1910 paper.

One theory, that comets were emitted by the Sun, sounds comical given our present understanding of the Sun's composition. By the late nineteenth century, observations of solar spectra had shown that it was mostly hydrogen, but with significant-looking amounts of other elements, including iron and nickel (Lockyer, 1874). From this standpoint, it was plausible that material might have been ejected from the Sun, become part of a comet and later fallen as nickel-iron meteorites.

A second theory was that comets originated in material left over from what we would now call the pre-solar nebula. This essentially encapsulates the current understanding of comet formation, although the orbital dynamics suggested is naïve to the point of being downright wrong. Nonetheless, coming nearly a century before our current computer-assisted orbital modelling, this suggestion deserves our admiration.

The third suggestion was that planets like Jupiter produced and emitted comets: 'quite possibly both Jupiter and Saturn still eject matter from time to time' (Proctor & Crommelin, 1937, p. 7). We now know that Jupiter is a gas giant and could not belch forth comets with compositions to produce stony or iron meteorites. Around the start of the twentieth century, however, this was not certain (Hockey, 1999). Some thought that it 'resembles ... the Sun; ... possesses no solid nucleus at all' (Ledger, 1882). Others thought it was 'a liquid seething bubbling mass of fiery heat — just as we believe our earth was once upon a time' (Gilberne, 1905). Yet others thought it to be solid, although 'we are not able to see its surface through the encompassing clouds' (Ball, 1920). Emissions



Comet 109P/Swift-Tuttle drawn on 1862 September 2, from (Winnecke, 1864). The meteors deriving from this comet are analysed in detail in the paper by Kondrat'eva and Ishmukhametova in this issue.

of solid material were therefore plausible. 'We have evidence of disturbances of intense violence in the Jovian atmosphere ...the great red spot denotes a mighty cataclysm ...white spots that occur on Jupiter seem to indicate a series of eruptions far below' (Proctor & Crommelin, 1937, p. 182).

The idea that meteorites might have been hurled from Venus or Mars or Jupiter may show a good grounding in the then current understanding of meteors. Deriving meteors from 'Jupiter's Moon' may have been ignorance, or guessing at further mechanisms, or simply artistic licence to make the line scan well. Nonetheless, the impression given is that the Irish peasant was well educated in the astronomical theories of the day.

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Solar Longitudes for 2004

Compiled by Rainer Arlt

A conversion table of dates to solar longitudes using (Steyaert, 1991) is given as every year. The longitudes are given on the next page; they are only valid for 2004. The conversion formulae for any time of the day are repeated here for your convenience.

If you want to calculate the solar longitude $\lambda_\odot$ of a specific time of the day, you may use a linear interpolation between two dates. Suppose you have a certain *Date* and the *Time* in hours (UT), you get the solar longitude by

$$\lambda_\odot = \lambda_{\odot,\mathrm{Date}} + (\lambda_{\odot,\mathrm{NextDay}} - \lambda_{\odot,\mathrm{Date}}) \times \frac{\mathrm{Time}}{24\ ^\mathrm{h}}.$$

Alternatively, if you want to convert a certain solar longitude $\lambda_\odot$ into a time of the day, look up the *Date* with the next-smaller solar longitude in the table and calculate

$$\mathrm{Time} = \frac{(\lambda_\odot - \lambda_{\odot,\mathrm{Date}})}{(\lambda_{\odot,\mathrm{NextDay}} - \lambda_{\odot,\mathrm{Date}})} \times 24\ ^\mathrm{h}.$$

The solar longitudes of 1988–2005 are given in 2-hour increments and with three decimals at `http://www.imo.net/solarlong`.

Reference

Steyaert, C. (1991), "Calculating the Solar Longitude 2000.0", *WGN* **19:2**, 31–34.

Solar longitudes 2004. Dates refer to 00^h UT.

Jan 1	279.84	Mar 1	340.69	May 1	40.91	Jul 1	99.45	Sep 1	158.84	Nov 1	218.84
Jan 2	280.86	Mar 2	341.70	May 2	41.88	Jul 2	100.40	Sep 2	159.81	Nov 2	219.84
Jan 3	281.88	Mar 3	342.70	May 3	42.85	Jul 3	101.35	Sep 3	160.77	Nov 3	220.84
Jan 4	282.90	Mar 4	343.70	May 4	43.82	Jul 4	102.31	Sep 4	161.74	Nov 4	221.85
Jan 5	283.92	Mar 5	344.70	May 5	44.79	Jul 5	103.26	Sep 5	162.71	Nov 5	222.85
Jan 6	284.94	Mar 6	345.71	May 6	45.76	Jul 6	104.21	Sep 6	163.68	Nov 6	223.85
Jan 7	285.96	Mar 7	346.71	May 7	46.72	Jul 7	105.17	Sep 7	164.65	Nov 7	224.86
Jan 8	286.98	Mar 8	347.71	May 8	47.69	Jul 8	106.12	Sep 8	165.62	Nov 8	225.86
Jan 9	288.00	Mar 9	348.71	May 9	48.66	Jul 9	107.07	Sep 9	166.59	Nov 9	226.86
Jan 10	289.01	Mar 10	349.70	May 10	49.62	Jul 10	108.02	Sep 10	167.56	Nov 10	227.87
Jan 11	290.03	Mar 11	350.70	May 11	50.59	Jul 11	108.98	Sep 11	168.54	Nov 11	228.87
Jan 12	291.05	Mar 12	351.70	May 12	51.56	Jul 12	109.93	Sep 12	169.51	Nov 12	229.88
Jan 13	292.07	Mar 13	352.70	May 13	52.52	Jul 13	110.89	Sep 13	170.48	Nov 13	230.89
Jan 14	293.09	Mar 14	353.70	May 14	53.49	Jul 14	111.84	Sep 14	171.46	Nov 14	231.89
Jan 15	294.11	Mar 15	354.69	May 15	54.45	Jul 15	112.79	Sep 15	172.43	Nov 15	232.90
Jan 16	295.13	Mar 16	355.69	May 16	55.42	Jul 16	113.75	Sep 16	173.41	Nov 16	233.91
Jan 17	296.14	Mar 17	356.69	May 17	56.38	Jul 17	114.70	Sep 17	174.38	Nov 17	234.92
Jan 18	297.16	Mar 18	357.68	May 18	57.34	Jul 18	115.66	Sep 18	175.36	Nov 18	235.93
Jan 19	298.18	Mar 19	358.68	May 19	58.31	Jul 19	116.61	Sep 19	176.34	Nov 19	236.93
Jan 20	299.20	Mar 20	359.67	May 20	59.27	Jul 20	117.57	Sep 20	177.31	Nov 20	237.94
Jan 21	300.22	Mar 21	0.66	May 21	60.23	Jul 21	118.52	Sep 21	178.29	Nov 21	238.95
Jan 22	301.24	Mar 22	1.66	May 22	61.19	Jul 22	119.48	Sep 22	179.27	Nov 22	239.96
Jan 23	302.25	Mar 23	2.65	May 23	62.16	Jul 23	120.43	Sep 23	180.25	Nov 23	240.97
Jan 24	303.27	Mar 24	3.64	May 24	63.12	Jul 24	121.39	Sep 24	181.23	Nov 24	241.98
Jan 25	304.29	Mar 25	4.63	May 25	64.08	Jul 25	122.34	Sep 25	182.21	Nov 25	243.00
Jan 26	305.31	Mar 26	5.62	May 26	65.04	Jul 26	123.30	Sep 26	183.19	Nov 26	244.01
Jan 27	306.32	Mar 27	6.61	May 27	66.00	Jul 27	124.25	Sep 27	184.17	Nov 27	245.02
Jan 28	307.34	Mar 28	7.60	May 28	66.96	Jul 28	125.21	Sep 28	185.15	Nov 28	246.03
Jan 29	308.36	Mar 29	8.59	May 29	67.92	Jul 29	126.16	Sep 29	186.13	Nov 29	247.04
Jan 30	309.37	Mar 30	9.58	May 30	68.88	Jul 30	127.12	Sep 30	187.11	Nov 30	248.05
Jan 31	310.39	Mar 31	10.57	May 31	69.83	Jul 31	128.07				
Feb 1	311.40	Apr 1	11.55	Jun 1	70.79	Aug 1	129.03	Oct 1	188.09	Dec 1	249.07
Feb 2	312.42	Apr 2	12.54	Jun 2	71.75	Aug 2	129.99	Oct 2	189.08	Dec 2	250.08
Feb 3	313.43	Apr 3	13.53	Jun 3	72.71	Aug 3	130.94	Oct 3	190.06	Dec 3	251.10
Feb 4	314.45	Apr 4	14.51	Jun 4	73.66	Aug 4	131.90	Oct 4	191.04	Dec 4	252.11
Feb 5	315.46	Apr 5	15.50	Jun 5	74.62	Aug 5	132.86	Oct 5	192.03	Dec 5	253.12
Feb 6	316.47	Apr 6	16.48	Jun 6	75.58	Aug 6	133.81	Oct 6	193.02	Dec 6	254.14
Feb 7	317.49	Apr 7	17.46	Jun 7	76.54	Aug 7	134.77	Oct 7	194.00	Dec 7	255.15
Feb 8	318.50	Apr 8	18.45	Jun 8	77.49	Aug 8	135.73	Oct 8	194.99	Dec 8	256.17
Feb 9	319.51	Apr 9	19.43	Jun 9	78.45	Aug 9	136.69	Oct 9	195.98	Dec 9	257.19
Feb 10	320.53	Apr 10	20.41	Jun 10	79.40	Aug 10	137.65	Oct 10	196.96	Dec 10	258.20
Feb 11	321.54	Apr 11	21.39	Jun 11	80.36	Aug 11	138.61	Oct 11	197.95	Dec 11	259.22
Feb 12	322.55	Apr 12	22.37	Jun 12	81.32	Aug 12	139.57	Oct 12	198.94	Dec 12	260.24
Feb 13	323.56	Apr 13	23.35	Jun 13	82.27	Aug 13	140.53	Oct 13	199.93	Dec 13	261.25
Feb 14	324.57	Apr 14	24.33	Jun 14	83.23	Aug 14	141.49	Oct 14	200.92	Dec 14	262.27
Feb 15	325.58	Apr 15	25.31	Jun 15	84.18	Aug 15	142.45	Oct 15	201.91	Dec 15	263.29
Feb 16	326.59	Apr 16	26.29	Jun 16	85.14	Aug 16	143.41	Oct 16	202.91	Dec 16	264.31
Feb 17	327.60	Apr 17	27.27	Jun 17	86.09	Aug 17	144.37	Oct 17	203.90	Dec 17	265.32
Feb 18	328.61	Apr 18	28.25	Jun 18	87.05	Aug 18	145.33	Oct 18	204.89	Dec 18	266.34
Feb 19	329.62	Apr 19	29.23	Jun 19	88.00	Aug 19	146.30	Oct 19	205.89	Dec 19	267.36
Feb 20	330.63	Apr 20	30.20	Jun 20	88.96	Aug 20	147.26	Oct 20	206.88	Dec 20	268.38
Feb 21	331.64	Apr 21	31.18	Jun 21	89.91	Aug 21	148.22	Oct 21	207.87	Dec 21	269.40
Feb 22	332.65	Apr 22	32.15	Jun 22	90.87	Aug 22	149.19	Oct 22	208.87	Dec 22	270.41
Feb 23	333.66	Apr 23	33.13	Jun 23	91.82	Aug 23	150.15	Oct 23	209.86	Dec 23	271.43
Feb 24	334.66	Apr 24	34.10	Jun 24	92.77	Aug 24	151.11	Oct 24	210.86	Dec 24	272.45
Feb 25	335.67	Apr 25	35.08	Jun 25	93.73	Aug 25	152.08	Oct 25	211.86	Dec 25	273.47
Feb 26	336.68	Apr 26	36.05	Jun 26	94.68	Aug 26	153.04	Oct 26	212.85	Dec 26	274.49
Feb 27	337.68	Apr 27	37.03	Jun 27	95.63	Aug 27	154.01	Oct 27	213.85	Dec 27	275.51
Feb 28	338.69	Apr 28	38.00	Jun 28	96.59	Aug 28	154.97	Oct 28	214.85	Dec 28	276.52
Feb 29	339.69	Apr 29	38.97	Jun 29	97.54	Aug 29	155.94	Oct 29	215.85	Dec 29	277.54
		Apr 30	39.94	Jun 30	98.49	Aug 30	156.90	Oct 30	216.84	Dec 30	278.56
						Aug 31	157.87	Oct 31	217.84	Dec 31	279.58

International Meteor Conference 2004

2004 September 23–26 in Varna, Bulgaria

For the second time the International Meteor Conference will be held in Bulgaria and we are very happy to be the local organizers again. This time it will be in our 'Nicolaus Coperrnicus' Astronomical Observatory and Planetarium in the city of Varna.

'Nicolaus Copernicus' Astronomical Observatory and Planetarium

This is one of the first public astronomical observatories and planetaria in Bulgaria, operating since 1963. It has maintained regular contacts with the International Meteor Organization since 1988.

The weather

September here is normally warm and sunny, and the sea water temperature is above 20°C, so you can enjoy all this. But, just in case, bring your umbrella.

Currency

The monetary unit is the Bulgarian Lev. Since 1998 it has had a fixed rate of €1 = 1.96 Lev. Foreign currency can be exchanged for Levs and vice versa in banks and exchange offices. Information about the exchange rates for other currencies can be found on the web site of the Bulgarian National Bank:
`www.bnb.bg/bnb/rates.nsf/vWebRatesByMonthEN/$First`

Visas and invitations

Visitors from Western Europe and most of the East European countries, including all our neighbouring countries, don't need visas to come to Bulgaria. For people from the countries for which visas are necessary we will gladly send official invitations provided that they inform us about this in time. You can find out whether visas are needed for citizens of your country on the IMC website — see the bottom of this page.

The city of Varna

Varna is the third largest city in Bulgaria. It is located on the Black Sea shore and is sometimes called the sea capital of our country.

Chayka resort

The IMC will be held in the Chayka resort, ten kilometres to the north of Varna. The participants will be accommodated in the buildings of the Varna Free University (`http://www.VFU.bg`). There are a hotel, many lecture halls, well equipped technical equipment, access to the Internet and a nice view of the sea.

Participation fee

The participation fee for IMC 2004 is €100 for people who register before July 1 and €110 for those who register later. A prepayment of €50 should be sent with the registration form to the IMO Treasurer Ina Rendtel. The application form is on the following page.

Preliminary excursion to Byala

On September 23 in the afternoon, a preliminary excursion will be organized to the town of Byala, on the sea coast about 60 km south of Varna. In recent years an exposed geological stratum from 65 million years ago was found there, bearing traces of the mass extinction of living species that is supposed to have been caused by fall of a large meteorite. Those who arrive in Varna early enough can take part. It will cost an additional €5 which should be paid on the day. If you wish to participate, you can stay one more night in the hotel before the conference without any problem. There will also be the traditional excursion (but not to Byala) included in the IMC schedule.

Contact with the Organizers

Eva Bojurova & Valentin Velkov
E-mail: planetarium@triada.bg
Phone: +359 52 684441 Fax: +359 52 684443

Website

`http://www.imo.net/imc2004/files/bulgaria.html`

IMC Registration Form

You can also register online at `http://www.imo.net/imc2004/files/bulgaria.html`

To participate, fill in the form below and return it to Ina Rendtel as soon as possible, with at least the minimum pre-payment of € 50. If you are not yet certain whether to participate, keep reading the website above and register as soon as possible. Payment should be to Ina Rendtel by Giro (details inside the back cover) or as described for WGN subscriptions (see WGN 31:6, p. 170).

For travel information see the IMC website above.

Name ______________________________ Date of birth ____________
Address: ____

____
Phone ______________ Fax ______________ E-mail ______________
In intend to travel by ________ together with ______________________

Additional requests

- I intend to stay in Bulgaria before or after IMC and require extra information.
- I wish to participate in the September 23 excursion to Byala
- I require travel information from ______________ to Varna (see IMC website for frequent routes)
- I wish to give a lecture entitled ______________________________
  lasting ________ minutes; equipment required: ______________________
- I wish to organise a workshop with the title ______________________
- I wish to present a poster ________ metre wide by ________ metre high

Financial Support to Participants of IMC 2004

Communicated by the IMO Council

As last year, the *IMO* makes funds available to support attendance at *IMC*. To apply for support:

1. E-mail your application to the *IMO* President, Jürgen Rendtel, at `president@imo.net`. Include the word 'meteor' in the subject to get past the anti-spam filters. *IMO* cannot be responsible for applications which are lost or arrive late. The application must be submitted by an *IMO* member, but may also request support for other meteor workers. The proposal must state that all the candidates are committed to attend the *IMC* (except for unforeseen circumstances) if the requested support is granted in full.
2. Include an *IMC* Registration Form for everyone seeking support (unless already sent).
3. Include a brief curriculum vitae of everyone seeking support, focusing on aspects relevant to meteor work. Supported participants are expected to present either a talk or a poster at the *IMC*. (Indicate this on the Registration Form.)
4. The application must explain the motivation for attending the *IMC* and the importance of it to the person or group of persons requesting support.
5. Include a budget for travel costs and registration, and the amount of support requested. Other sources of external support, or their absence, must be mentioned. The proposal must indicate to what extent *IMO* support is essential to attend the *IMC*.
6. The applications should reach the President no later than 2004 June 20. The decision of the *IMO* Council will be made as soon as possible, probably within two weeks after the this deadline. If the support is granted in full, the registration forms become final. If the requested support is not granted, or only partially granted, the candidates should inform the President within three weeks after notification of the *IMO* Council's decision if they want to sustain or withdraw their registration. The support granted will be paid in cash at the *IMC*. Any unpaid registration fees will be deducted from the amount paid to the candidates.

Should the application be turned down, the standard conference fee (i.e. without the surcharge for late application) will still apply.

We strongly encourage all meteor workers who want to attend *IMC 2004*, but who are prevented from doing so by financial considerations, to apply for support.

Fireballs

Photographic observations of the EN291103A and B fireballs over the Czech Republic

Pavel Spurný [1]

Two fireballs of 2004 November 29/30 are reported. Photographs and analyses of the trajectories of the meteoroids are presented.

Received 2004 March 24

Figure 1 – Detailed view of the EN290903 fireball from the guided all-sky camera placed at the Ondřejov Observatory and equipped with the fish-eye objective Zeiss Distagon 3.5/30 mm. The fireball flew from the constellation Gemini, crossed Cancer very closely to the M44 Praesepe, and terminated near Regulus, the brightest star of the constellation Leo.

1 Introduction

Two nice fireballs were recorded by all-sky photographic cameras (fish-eye objective Zeiss Distagon $f/3.5$, f = 30 mm) at two Czech stations of the European Fireball Network, Ondřejov and Telč, during the night of 2003 November 29/30. Basic data on atmospheric trajectories and heliocentric orbits are reported for both these fireballs, which flew over central part of the Czech Republic within only one and half hours.

2 Senožaty

The first, EN291103A Senožaty, was not very bright. Its brightness was near the limit of sensitivity for our all-sky cameras, which is about magnitude −3.5. It reached the maximum absolute brightness of only magnitude −4.9 and stayed practically constant during all its flight. In spite of this, its luminous path was 60 kilometers long and lasted 5 seconds. Such a long trajectory was mainly caused by the extremely slow motion of the meteoric body in the atmosphere (initial velocity was only 12.94 km/s) and the low inclined trajectory (25°). The meteoroid orbited the Sun practically in the ecliptic plane on an orbit with perihelion near the Earth and aphelion in the main asteroid belt, and did not belong to any known meteoroid stream.

[1]Astronomical Institute of the Academy of Sciences, Ondřejov Observatory, Fričova 298, 251 65 Ondřejov, Czech Republic. Email: spurny@asu.cas.cz

3 'Chotěboř'

The second fireball was significantly brighter and very spectacular as can be seen on Figures 1 and 2. It reached a maximum brightness of almost absolute magnitude −12. As well as three photographic records (two fixed and one guided images), this fireball was recorded by three radiometers located at the Ondřejov Observatory (two) and the Kunžak station. These records provided us with the exact time of the event: $23^h45^m33\overset{s}{.}4$ UT, which is valid for the maximum brightness of the fireball. Moreover, because the fireball was bright enough and quite close to the radiometers, the lightcurve is one of the most detailed ever obtained from a photographic fireball (Figure 3). The fireball traveled its 52 km luminous trajectory in 2 seconds and terminated at an altitude of 36.4 km. The meteoroid of initial photometric mass of about 11 kg entered the atmosphere with a velocity of 28 km/s at a height of 82.7 km, and during its flight decelerated to a terminal velocity of 12 km/s. Due to its relatively high initial velocity, this fireball terminated high in the atmosphere and therefore practically nothing from the initial mass could land on the ground. Both stations where the fireball was recorded were very favorably situated to the fireball trajectory so that all parameters describing this fireball were determined with very high precision. Before its collision with the Earth, the meteoroid orbited the Sun on a quite eccentric and low inclination orbit. According to its behavior in the atmosphere, this fireball belongs to the type I, usually associated with quite strong material. This, along with its orbit type, supports its asteroidal origin.

All important values describing the atmospheric trajectories and heliocentric orbits of both fireballs are collected in the following tables.

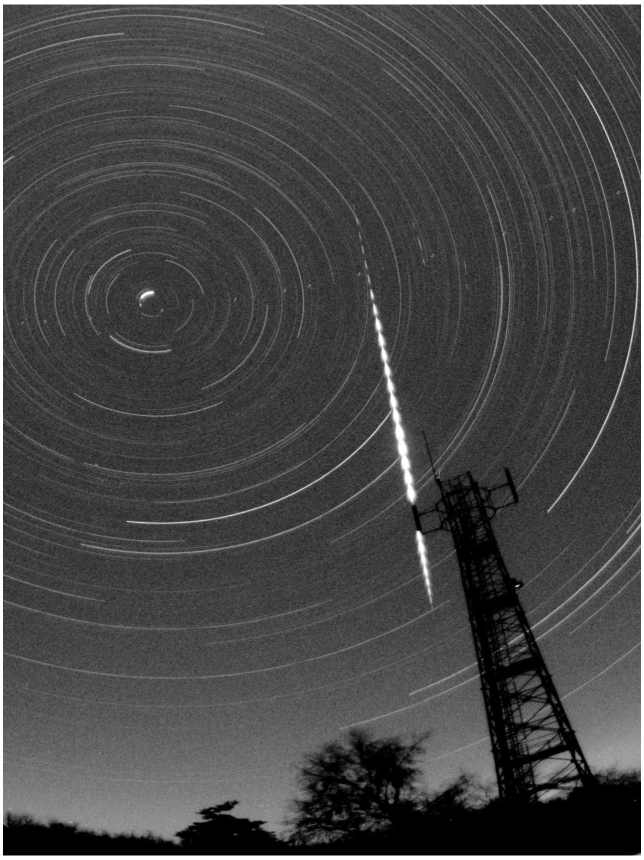

Figure 2 – Detailed view of the EN291103B fireball from the fixed all-sky camera placed at the EN station 15 Telč. This camera is equipped with a Zeiss Distagon $f/3.5$, $f = 30$ mm fish-eye lens. Interruptions of the luminous path of the fireball are caused by a 3-arm rotating shutter placed near the focal plane (15 breaks/s). The fireball started its luminous trajectory 56 degrees above horizon and terminated only 24 degrees above horizon. The distance of the station from the beginning and terminal points was 99 km and 86 km respectively. Part of the fireball trajectory is hidden behind the GSM antenna tower. This figure is also presented in enlarged form on the back cover.

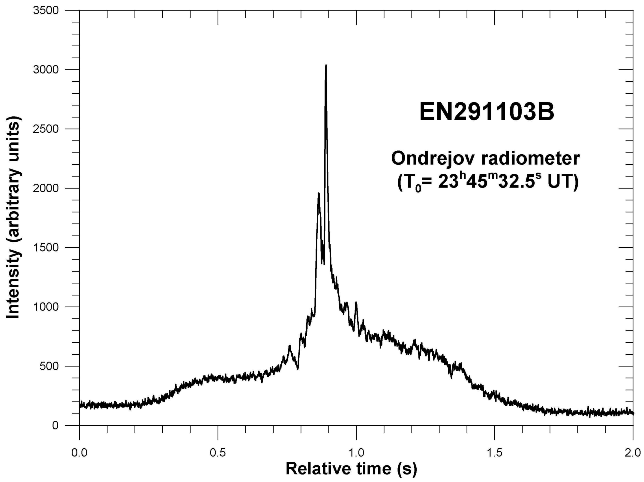

Figure 3 – Radiometric record of the EN291103 fireball from the Ondřejov Observatory. The y-axis is linear in irradiance, the x-axis is a relative time. T=0 corresponds to 23h45m32.5s UT. Time resolution of the radiometric record is 0.833 ms.

Table 1 – Basic data on the EN291103A fireball

EN291103A 'Senožaty'			
2004 November 29, T = $22^h08^m03^s$ UT $\pm 3^m34^s$ *			
Atmospheric trajectory data			
	Beginning	Max. light	Terminal
Velocity (km/s)	12.829 ± 0.007	12.65	9.41 ± 0.06
Height (km)	72.08 ± 0.02	65.8	46.75 ± 0.02
Longitude (° E)	14.5626 ± 0.0002	14.731	15.2456 ± 0.0002
Latitude (° N)	49.4017 ± 0.0002	49.448	49.5881 ± 0.0002
Dynamic mass (kg)	1.3	1.1	0.
Photometric mass (kg)	0.0	0.0	0.0
Absolute magnitude	−3.1	−4.9	−2.8
Slope (°)	25.31 ± 0.02	—	24.83 ± 0.02
Total length (km)		59.78	
Duration (s)		5.07	
Ablation coefficient (s^2km^{-2})		0.012 ± 0.003 (NF solution, $\epsilon = 29$ m)	
PE coefficient		−4.94	
Fireball type		II	
EN stations:		20 Ondřejov (fixed), 15 Telč, 19 Ondřejov (guided)	
Radiant data (J2000.0)			
	Observed	Geocentric	Heliocentric
Right ascension (°)	358.6 ± 0.9	344.6 ± 1.1	—
Declination (°)	5.420 ± 0.013	-11.99 ± 0.11	—
Ecliptical longitude (°)	—	—	338.45 ± 0.19
Ecliptical latitude (°)	—	—	-0.95 ± 0.06
Initial velocity (km/s)	12.942 ± 0.007	7.083 ± 0.015	37.248 ± 0.019
Orbital data (J2000.0)			
a (AU)	2.156 ± 0.008	ω (°)	3.4 ± 0.5
e	0.5429 ± 0.0015	Ω (°)	67.251 ± 0.003
q (AU)	0.9857 ± 0.0002	i (°)	0.95 ± 0.06
Q (AU)	3.327 ± 0.015		

* Time of fireball passage is determined from combination of the fixed and guided images at Ondřejov. It is not so precise as usually because the fireball flew at Ondřejov practically in the direction of daily motion. It was not registered by radiometer because it was too faint.

Table 2 – Basic data on the EN291103B fireball

EN291103B ‘Chotěboř’ 2004 November 29, T = $23^{h}45^{m}33^{s}.4$UT $\pm 0^{s}.3$			
Atmospheric trajectory data			
	Beginning	Max. light	Terminal
Velocity (km/s)	28.04 ± 0.04	26.3	12.0 ± 0.9
Height (km)	82.727 ± 0.016	51.23	36.355 ± 0.014
Longitude (° E)	15.6972 ± 0.0005	15.749	15.7739 ± 0.0004
Latitude (° N)	49.6257 ± 0.0003	49.759	49.8226 ± 0.0003
Photometric mass (kg)	11.3	6.	< 0.01
Absolute magnitude	−3.4	−11.6	−3.0
Slope (°)	63.90 ± 0.04	—	63.72 ± 0.04
Total length (km)		51.67	
Duration (s)		2.06	
Ablation coefficient ($s^2 km^{-2}$)		0.0100 ± 0.0010 (NF solution)	
PE coefficient		−4.64	
Fireball type		I or II	
EN stations:		20 Ondřejov (fixed), 15 Telč, 19 Ondřejov (guided)	
Radiant data (J2000.0)			
	Observed	Geocentric	Heliocentric
Right ascension (°)	73.71 ± 0.04	72.79 ± 0.04	—
Declination (°)	24.08 ± 0.04	22.93 ± 0.04	—
Ecliptical longitude (°)	—	—	21.00 ± 0.06
Ecliptical latitude (°)	—	—	0.30 ± 0.03
Initial velocity (km/s)	28.06 ± 0.04	25.79 ± 0.04	37.49 ± 0.03
Orbital data (J2000.0)			
a (AU)	2.256 ± 0.013	ω (°)	283.27 ± 0.09
e	0.8018 ± 0.0012	Ω (°)	247.233 ± 0.006
q (AU)	0.4471 ± 0.0007	i (°)	0.41 ± 0.04
Q (AU)	4.06 ± 0.03		

Trajectory and orbit of the EN200204 Łaskarzew fireball

Pavel Spurný [1], *Arkadiusz Olech* [2] *and Piotr Kędzierski* [3]

A fireball of magnitude approximately −10 was observed over Poland on 2004 February 20 at 18^h54^m UT. In addition to many visual observations, the event was caught by two photographic stations: one in the Czech Republic and one in Poland. A description, ground track map, atmospheric trajectory and orbital data for the fireball are presented.

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1 Introduction

The European Fireball Network (EN) is a project whose main goal is to study the properties of meteoroids and their relations to meteorites through photographic observations of fireballs. The first all-sky cameras belonging to the EN were put into operation in Czechoslovakia in 1963. The number of cameras quickly grew and now there are about 30 such stations located in several European countries (Spurný, 1997).

Polish meteor observers of the Comets and Meteors Workshop (CMW) have many successes in visual and telescopic observations. It is sufficient to mention that they collect about 2000 hours of visual observations and 200 hours of telescopic observations per year, sending them regularly to the International Meteor Organization (IMO) and publishing the results in WGN (Olech & Jurek, 2000; Olech et al., 2001; Złoczewski et al., 2003). Unfortunately, there is still a lack of regular photographic meteor observations in Poland and therefore this country does not belong to the EN. It is a serious problem, taking into account the fact that area of Poland is only slightly smaller than Germany and four times larger than the Czech Republic.

To change this situation, the CMW decided to buy photographic and video cameras with fast lenses with the aim of regular monitoring of the sky over Poland. The details of this project will be published in a separate contribution to WGN. The first tests with the new photographic equipment were made at the end of 2003 and quite regular observing runs were started in late February 2004. This paper presents the results obtained for the fireball of magnitude approximately −10 which was observed on 2004 February 20 over central Poland and photographed at the Polish station in Ostrowik near Warsaw and the EN station No. 16 Lysá hora in the Czech Republic.

2 Observations

The EN station Lysá hora uses a manually operated all-sky camera with a very precise Zeiss Distagon $f/3.5$, $f = 30$ mm fish-eye objective. Usually one exposure per night is taken on 9×12 cm Ilford FP4 panchromatic sheet film with a sensitivity of 125 ISO.

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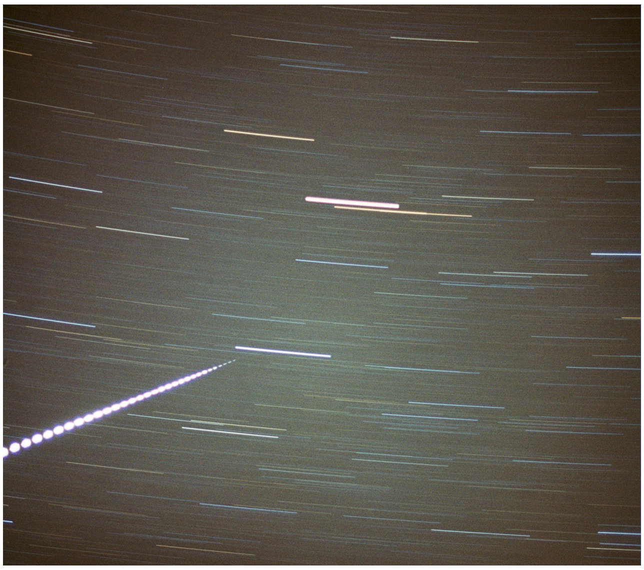

Figure 1 – The picture of the the EN200204 Łaskarzew fireball taken by the Canon T50 camera with a Canon $f/1.4$, $f = 50$ mm lens in Ostrowik near Warsaw. The brightest object in the picture is the planet Saturn. This photo is also presented in colour on the front cover.

The station in Ostrowik uses four Canon T50 cameras equipped with Canon $f/1.4$, $f = 50$ mm lenses and mounted under a two-arm rotating shutter having a frequency of 5 Hz and producing 10 breaks per second. Konica Centuria 800 ISO film with standard C-41 development was used. The typical exposure times were 10–20 minutes.

3 The fireball

The fireball was seen on 2004 February 20 at 18^h54^m UT by many amateur astronomers in Poland. The most detailed description comes from Przemysław Żołądek from Nowy Dwór Mazowiecki who saw the fireball during his telescopic meteor watch. The animation made by him can be downloaded from: `http://ftp.pkim.org/info/202102bolid.gif` and the picture of the event caught in Ostrowik is shown in Figure 1. We would like to point out that the animation is based only on visual observations and in fact the trajectory presented there should be shifted several degrees to the south and terminated much closer to the horizon.

The fireball traveled its 40.46 km luminous trajectory in 3.22 seconds and terminated at an altitude of 36.2 km. In fact, this is not the real terminal point because at both stations the terminal part of the luminous trajectory is either out of the field of view (Ostrowik) or behind objects on the horizon (Lysá hora, where the

Table 1 – Characteristics of the EN200204 Łaskarzew fireball

2004 February 20, T = $18^h54^m00^s \pm 20^s$ UT			
Atmospheric trajectory data			
	Beginning	**Max. light**	**Terminal**
Velocity [km/s]	13.4 ± 0.2	—	10.0 ± 0.4
Height [km]	71.0 ± 0.2	—	36.3 ± 0.2
Longitude [°E]	21.5874 ± 0.0007	—	21.6266 ± 0.0005
Latitude [°N]	51.6324 ± 0.0006	—	51.8130 ± 0.0005
Dynamic mass [kg]	2	—	—
Absolute magnitude	−3	−10*	—*
Slope [°]	59.59 ± 0.04	—	59.41 ± 0.04
Total length [km]		40.46	
Duration [s]		3.22	
Fireball type		I or II	
Stations		Lysá hora, Ostrowik	
Radiant data (J2000.0)			
	Observed	**Geocentric**	**Heliocentric**
Right ascension [°]	90.92 ± 0.10	88.50 ± 0.13	—
Declination [°]	21.40 ± 0.10	12.6 ± 0.5	—
Ecliptical longitude [°]	—	—	66.1 ± 0.2
Ecliptical latitude [°]	—	—	-2.20 ± 0.03
Initial velocity [km/s]	13.4 ± 0.2	7.5 ± 0.4	36.8 ± 0.3
Orbital data (J2000.0)			
a [AU]	2.02 ± 0.11	ω [°]	13.6 ± 0.2
e	0.52 ± 0.03	Ω [°]	151.4310 ± 0.0003
q [AU]	0.9793 ± 0.0006	i [°]	2.20 ± 0.03
Q [AU]	3.1 ± 0.2		

* The fireball left the FOV of the camera when its brightness was still increasing, or at least had not faded significantly. This also implies that at its maximum the fireball could have been brighter still.

end of the fireball is behind the roof of the station; the visible terminal point is there only 5.1 degrees above ideal horizon and 340 km from the station). So it is not impossible that the terminal height could be much lower, possibly below 30 km. This would imply that some smaller part of the initial mass could have survived and landed on the ground, of the order of hundreds of grams at a maximum. This is also supported by the quite high value of the velocity at the photographic end of the trajectory. It is very probable that the body could still decelerate to a velocity of some 5 km/s, which could just reach approximately 30 km altitude. Then the most probable impact area for only very small meteorites would lie northward of the city Garwolin and a little bit south of a small village called Puznów Nowy with the center defined by the following coordinates: $\lambda = 21\overset{\circ}{.}6461$ E and $\varphi = 51\overset{\circ}{.}9095$ N. However the determination of this impact area is not very reliable because we have no data about the real end of the fireball luminous trajectory and we do not know the real atmospheric profile up to some 35 km during the fireball flight over this predicted impact area.

The beginning of the fireball was photographed at the height of 71.0 km over a place located about 10 km NE of Kozienice. The maximum brightness of approximately magnitude −10 was reached over Łaskarzew. The end of the photographed trajectory was seen at the height of 36.3 km. The luminous trajectory of the Łaskarzew fireball is shown in Figure 2 and all important data are collected in Table 1. The orbit of the meteoroid which caused the EN200204 Łaskarzew fireball is shown in Figure 3.

The meteoroid of initial mass of about 2 kg entered the atmosphere with a velocity of 13.4 km/s and during its observed flight decelerated to a velocity of 10.0 km/s. The observed radiant of the event is at $\alpha = 90\overset{\circ}{.}9$ and $\delta = +21\overset{\circ}{.}4$.

4 Acknowledgments.

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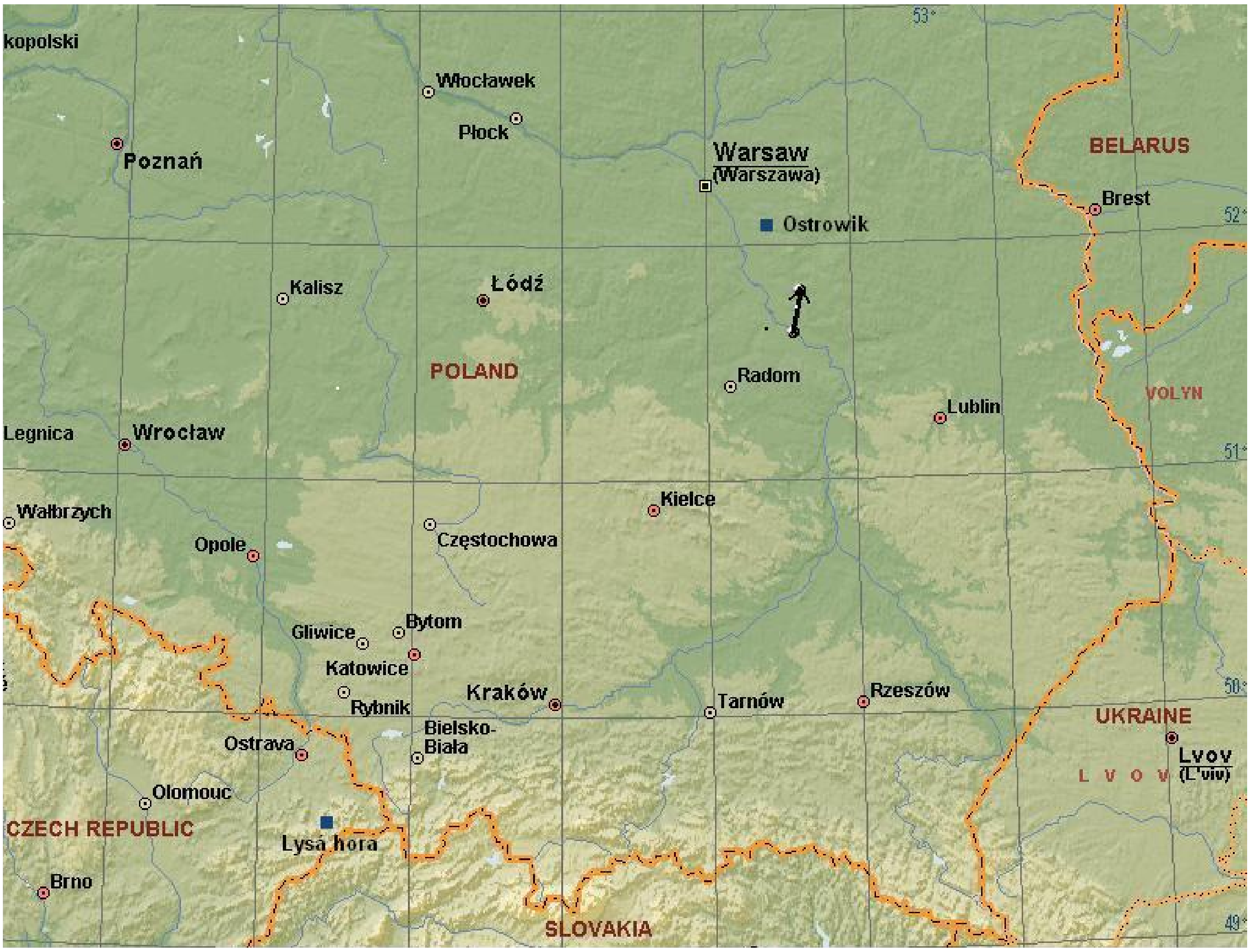

Figure 2 – Luminous trajectory of the EN200204 Łaskarzew fireball.

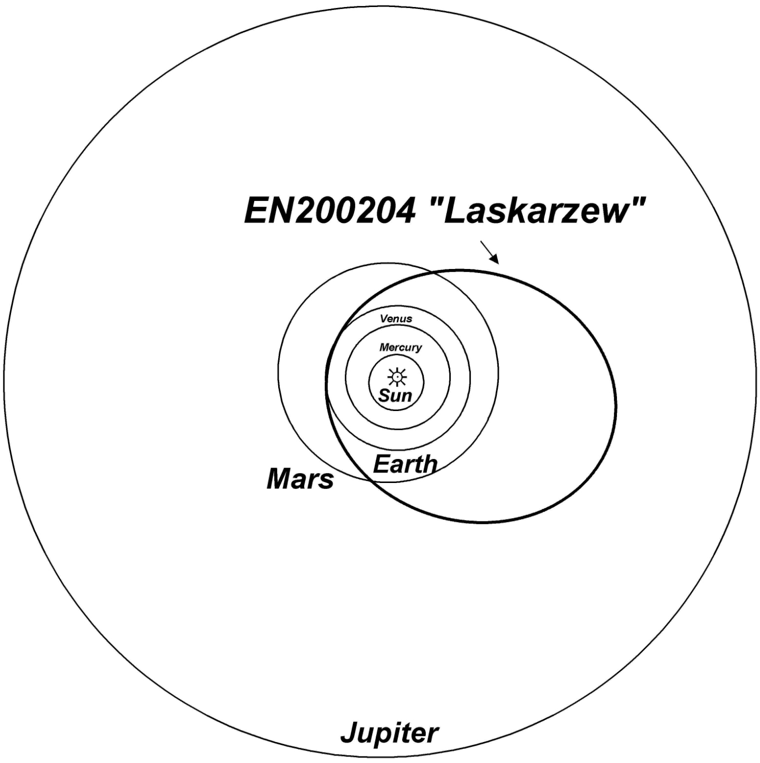

Figure 3 – Schematic display of the EN200204 Łaskarzew fireball orbit projected onto the ecliptic plane.

Persids

Perseid one-revolution outburst in 2004

Esko Lyytinen [1] *and Tom Van Flandern* [2]

In 2004 August 11 at about 21^{h} UT, the one-revolution dust trail of the Perseids' parent comet 109P/Swift-Tuttle is calculated to pass within 0.0013 AU of the Earth's orbit and we expect this to cause a moderately strong, short outburst of mainly visually dim meteors. We have drawn conclusions from our prediction model that has been quite successful in predicting recent Leonids storms. We also discuss the possibility of enhanced annual rates because perturbations by Jupiter will now direct all incoming Perseid meteoroids about 0.01 AU closer to the Sun, which allows the possibility of the Earth passing through the densest core of the annual stream.

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1 Introduction

The Perseids' parent comet 109P/Swift-Tuttle's orbit has been passing a little outside the Earth's orbit for centuries. Because of this there have not been encounters of young meteoroid trails from this comet with the Earth. There may be some weak encounters identified with the old trails. During the two most recent comet returns, Jupiter has changed the situation. The comet's long-term revolution period has increased by about two years, and the orbit for the 1992 return moved a little inside the Earth's orbit. Also at the previous (1862) return the comet orbit passed very close to the Earth's orbit. This means that the incoming one-revolution trail section that passes closest to Jupiter or Saturn will be bent close to the Earth's orbit, or even inside it.

This will be the situation with Jupiter and the one-revolution trail meteoroids in the year 2004. The trail will pass about 0.0013 AU inside the Earth's orbit, leading us to expect some level of meteor outburst to happen this August. Saturn will be responsible for a similar phenomenon in 2009, but the trail will then pass more distant from the Earth (further inside). In this paper we deal with the 2004 encounter in more detail.

If there were a closer encounter in 2004, a very strong storm would probably result. But for the actual circumstances, we expect an outburst of dim to moderately bright meteors with a maximum ZHR of a few hundred. At best, activity might approach meteor storm levels (1000/hour) for a short time. In addition to this, the annual stream activity may be stronger than normal because of this geometry.

2 The encounter in more detail

The trail has been calculated using similar principles as in the Lyytinen-Van Flandern Leonids model (Lyytinen, 1999; Lyytinen & Van Flandern, 2000; Lyytinen et al., 2001). We have the ejection at perihelion and the ejection speed zero, as approximates the effect of solar tidal forces removing debris orbiting a comet nucleus. Radiation pressure is then applied to model particles, starting from zero for the largest particles and increasing in small steps for smaller particles. With this approach we can calculate where the center of the trail is situated. At the same time we can relate the results with our Leonids model via the radiation pressure β value. To some extent, the β value can be compared with that of the Leonids without any numeric computer model, as we will explain shortly.

The solar longitude of the encounter is $139\overset{\circ}{.}440$ and the 'miss-distance' along the ecliptic, i.e. $r_D - r_E$, has the value -0.00132 AU. Starting the forward integrations from the 1862 perihelion, the β value 0.00105 is needed to sufficiently lengthen the particles' orbital periods to cross the ecliptic around 2004 August. The solar longitude corresponds to August 11 at $20^{\mathrm{h}}50^{\mathrm{m}}$ UT. The trail's path relative to the Earth's orbit is shown in Figure 1 with black dots.

With small β values, whose effect on the orbital period can be approximated by a differential linear model, the increase in orbital period in different comet orbits with the same β value is proportional to the semi-major axis to the 2.5 power. This also assumes that the perihelion distances are the same, which is approximately true. Because the Leonids parent comet has a semi-major axis of about 10 AU and the Perseids parent comet about 25 AU, 25/10 to the 2.5 power yields about a factor of 10. This means that the Perseids' one-revolution trail is about ten times longer in time than the Leonids trail. This would also mean that the meteoroid spatial density per unit mass ejected from the parent comet would be about ten times larger for the Leonids than for the Perseids. This comparison also assumes similar trail widths, which is possibly not quite true.

However, Comet 109P/Swift-Tuttle is much brighter than Comet 55P/Tempel-Tuttle (the parent of the Leonids). The difference in absolute magnitude is about 4 or 4.5 magnitudes. If the amount of released meteoroids from comet Swift-Tuttle is about ten times bigger than from Tempel-Tuttle, the net density is not very much different in the Perseids' one-revolution trail than in the Leonids one-revolution trail with the same β value and same distance from the center. Because the difference in the brightnesses is about fifty-fold, there is the possibility of an even denser Perseid trail than Leonid trail. We are cautious and we deal with these as being of similar density in the following. The density

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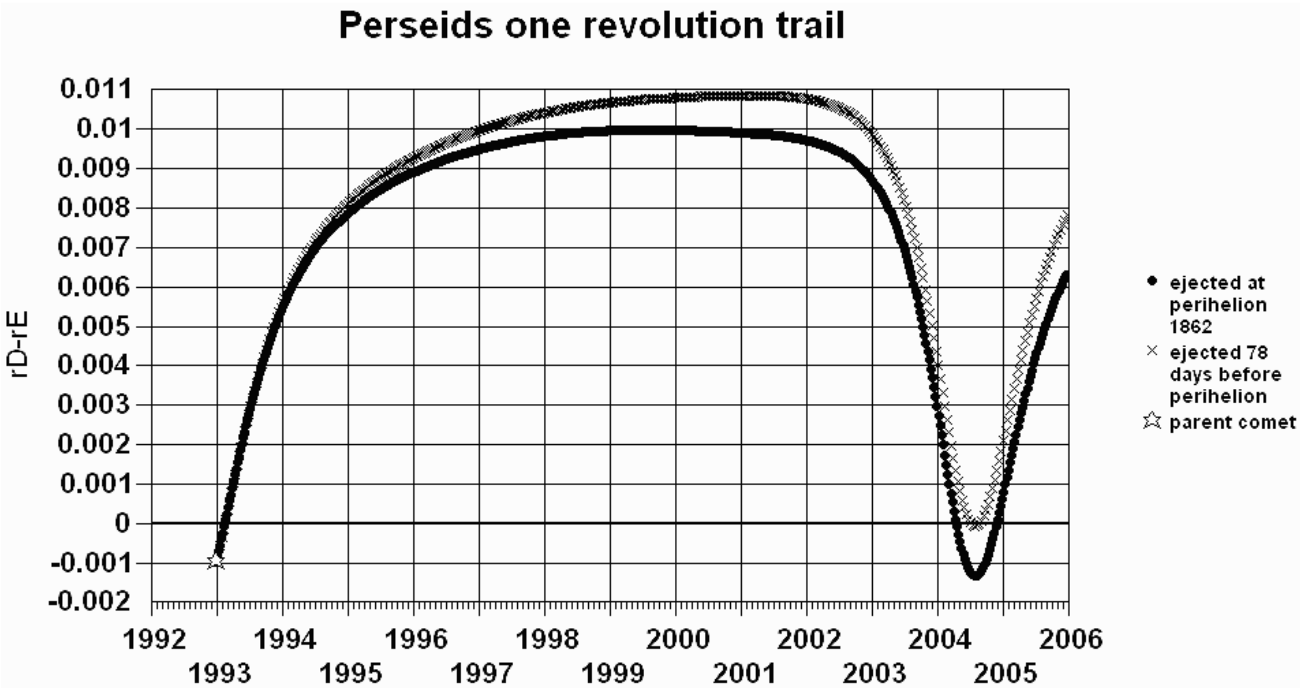

Figure 1 – The Perseids one revolution trail ecliptic crossing relative to the Earth's orbit. Year symbols indicate the start of each year. The black dots mark the nominal trail-center location. The crosses indicate the meteoroids ejected (in 1862) at the distance of 1.7 AU before perihelion.

and distance relationship, however, has one difference arising from the different location of encounter relative to perihelion. We deal more with this in the next section.

The best comparison with the Leonids can be made with the 2000/2-rev data (Arlt & Gyssens, 2000; Jenniskens, 2000). This had the miss-distance of about 0.0012 AU and the β value of about 0.0014. Taking into consideration some effects such as the somewhat smaller speed of the Perseids, we get an estimated ZHR of 400 (plus the annual stream) if Comet Swift-Tuttle releases ten times more meteoroids at each revolution. That would mean it compensates for the ten times stretching mentioned earlier as a result of the longer orbital period of the trail. As mentioned with the brightness comparison above, there is the possibility of an even stronger outburst. Taking into account the different orbital inclinations of the Leonid and Perseids and the principles of our model that affect the ZHR-peak width, we get the predicted half-maximum full-width of the predicted 2004 outburst as a little less than 0.03° or about 40 minutes. However, we will also examine the possible effect on trail width produced by particles ejected before perihelion in the next section. The β value of about 0.001 means fainter-than-average Perseid meteors. Compared with the Leonids, these are expected to be somewhat dimmer than in the 1999 storm but somewhat brighter than in the 2000/2-rev encounter.

3 Ejection before the 1862 perihelion

The solar radiation pressure β value has, among other things, the effect of making the meteoroids spiral a little outside the comet orbit. Without other perturbing factors, this would occur around the whole orbit except close to the point of initial ejection. The effect in general is quite small and, if we observe the meteors not far from the point of ejection, this effect can be neglected for practical purposes or taken as the same as at perihelion. This is the case with the Leonids because these are observed in less than 10° of true anomaly from the perihelion. With the Perseids, the location of encounter is about 27° after the perihelion. The particles that were ejected before perihelion will cross the ecliptic a little more distant from the Sun. We can calculate that particles ejected in 1862 about 78 days before perihelion at a distance of about 1.7 AU will cross the ecliptic very close to the Earth's orbit in August 2004. However, we do not know what percentage of particles were ejected that early.

Secondly, the solar radiation pressure increases the orbital period less than when the ejection is at perihelion. Because of this, the β value needed to increase the orbital period to encounter in 2004 is 0.00188 (instead of the 0.00105 with ejection at perihelion). This means smaller particle size for these particles to encounter the Earth in 2004. This possibly increases the number of meteors. Most of them will be invisible to the unaided eye, but the number of visible meteors also increases. There is therefore a possibility of high meteor rates in sensitive enough video observations and telescopic observations. Because the 'main trail' ejected near perihelion appears widened as observed at the distance of 0.0013 AU, it may be possible that the particles ejected before perihelion will peak more sharply. The course of these particles relative to the Earth's orbit is shown in Figure 1 with crosses.

4 On the annual stream in 2004

While approaching the perihelion and the Earth's orbit in 2004, all the meteors in the Perseid stream will be quite strongly affected by the planet Jupiter. So the annual stream also crosses the ecliptic about 0.01 AU closer to the Sun than in typical years. Because the parent comet has been passing a little outside the Earth's orbit (more distant from the Sun), it is expected that the densest part of the annual stream still passes outside the Earth's orbit. Jupiter will bring those meteors closer to the Earth's orbit, which is expected to result in a stronger-than-typical annual shower. Other experts have noticed this possible effect in previous years, but we do not know who was the first to point this out. If this enhancement happens, it does not mean increased rates for the whole four week time span when Perseids can be observed. Only the main maximum may be more prominent. The maximum may also be shifted in time from the annual peak or possibly appear as a peak distinct from the annual and the one revolution peak.

There may however not be reliable observational support for this prediction. The most recent years with similar conditions were the years 1992 and 1980. Because of the proximity of the parent comet we may only derive reliable conclusions from the year 1980. There was a quite widespread impression of some level of outburst in that year. According to Peter Jenniskens (1994), at least one data set that was responsible for the impression of enhanced rates actually does not support the original conclusion. According to John A. Russell (1982) there was an outburst. The observations that Jenniskens dealt with were not made at the time of the expected peak. Observations reported by Russell were better in this respect but he compares the rates he observed in 1980 to some of the adjoining years at about the same time in UT. The proper years for comparisons would have been 1976 and 1984. However, there may not exist geographically wide enough mapping of observed rates covering the annual peak.

Another factor is that the situation can be different in different locations along the orbit. There may be a denser younger core (filament composed of several trails) that follows the parent comet for a number of years but then gets more weak and indistinguishable before the next return. This kind of encounter may be displaced from the annual maximum, more probably being earlier in time. This is also expected to be briefer than the traditional maximum but wider than possible encounters of single trails (like the encounter with the one revolution trail) and the new maxima in early 1990's.

5 Conclusions

With the Moon at waning crescent phase on August 11, observing conditions for the 2004 Perseid meteor activity should be excellent everywhere. Because the radiant is at a high northern declination (+58°), most northern hemisphere observers may expect to see meteors throughout the night. Observers will not want to be north of 60° latitude or so because of the 'midnight Sun' in summer. Nor will they want to be below about latitude −32° because the radiant will never rise above their horizon.

Using techniques that have had considerable success in predicting the times, locations, and rates for meteor storms and shower peaks for both Leonids and Ursids, we expect that even the annual activity of the Perseids may be better than normal this year. Observations possibly confirming this or rejecting this will be valuable. This will help in mapping the stream and be used in predicting what to expect in the next similar situation in the year 2016. Even before this, in the year 2009 the planet Saturn makes a similar even slightly stronger 'dip' into the incoming meteoroid stream.

But, as Figure 1 shows, conditions for the following years will revert to more typical meteor rates. Perseid activity this strong or better is not predicted again until the year 2028.

In 2004, a possible meteor outburst of mostly fainter-than-average meteors may be seen on August 11 around 21^{h} UT, with the optimum time occurring at $20^{h}50^{m}$ UT. That will be daylight hours for the Western Hemisphere, but in darkness for most of the Eastern Hemisphere. Asia will be best situated for observing this outburst.

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The scatter of orbital semimajor axes from a Perseid stream model

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Modeling of the Perseid stream based on the observations of comet 109P/Swift-Tuttle in 1862 is presented. The model orbital semimajor axes of the test meteoroids calculated for comet tails of different types are analyzed.

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1 Introduction

Unlike other meteoroid streams, the Perseid stream has a wide scatter of the observed meteoroid orbital semimajor axes. The value of the discrepancy is about 20 AU between the comet semimajor axes for large photographic particles in the range $m = -5$ to 0 (Babadzhanov et al., 1969; Babadzhanov et al., 1982), and semimajor axes for smaller television particles in the range $m = 0$ to $+6$ (Ueda et al., 2001). The reasons for the wide orbital semimajor axes scatter are the following. First, the initial size of the meteoroid orbit depends on the magnitude of the particle ejection velocity from the comet parent nucleus. Second, gravitational and nongravitational perturbations change the orientation and size of meteoroid orbits. The extent to which gravitational forces are affected by variations in the meteoroid orbit depends on the orbit orientation in the ecliptic plane. The action of nongravitational effects depends on the density, form and mass of the meteoroid particle. It is not impossible that the significant scatter of the stream semimajor axes is as much the result of the long evolution of the meteoroid stream as the great ejection velocities of the particles from the comet nucleus. Finally, it is necessary to note that the meteoroid orbital elements obtained from the observed data have a number of errors. Greater meteor shower geocentric velocities give greater meteoroid orbital element errors. As is well known, Perseids have very great geocentric velocities close to 60 km/s.

The purpose of this work is simulation of the Perseid stream and analysis of the test particles' semimajor axes values based on the meteoroid ejection from the parent comet under fixed initial conditions. The observations of comet Swift-Tuttle 1862 III at the moment of passing through perihelion during its orbit in 1862 were used as initial conditions for modeling the Perseids.

2 The observations of Comet Swift-Tuttle

Descriptions of comet observations in 1862 are numerous and available. These descriptions give the detailed picture of the comet disintegration process and moreover were analyzed as often in a quantitative as in a qualitative sense. A fuller description of these processes was made by A. Winnecke (Winnecke, 1864) in Pulkovo (near St. Petersburg). On the right are shown some of his drawings; in the original, the 'direction to the Sun is parallel to the vertical edge of the sheet'. Winnecke measured the tail position and its separate ejection di-

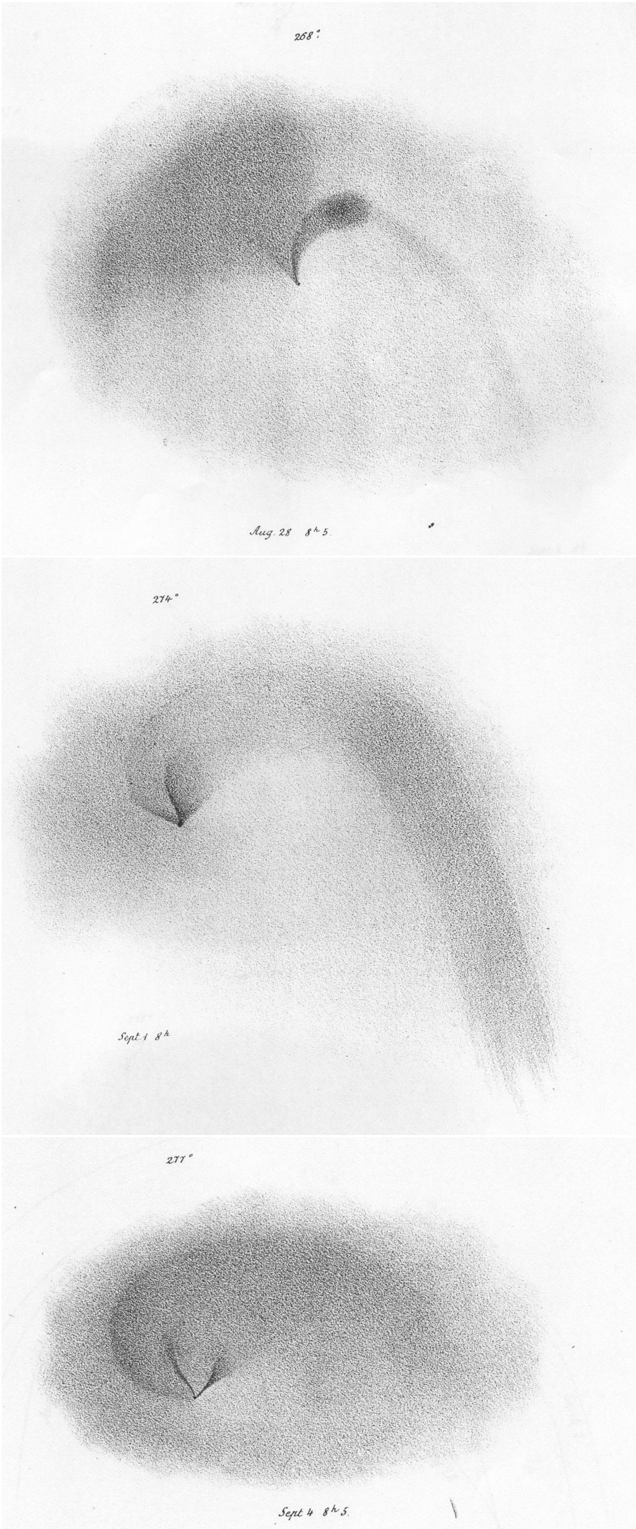

Figure 1 – Comet 109P/Swift-Tuttle 1862 III from drawings by A. Winnecke (1864). Top: on 1862 August 28, middle: 1862 September 1, bottom: 1862 September 4.

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Table 1 – The orbital elements of Comet Swift-Tuttle 1862 III (J2000.0).

T	1862 Aug. 23.4229	1992 Dec. 12.3241
ω	152°.7737	153°.0014
Ω	139°.3714	139°.4444
i	113°.5664	113°.4265
Q	0.962658 AU	0.958220 AU
e	0.962798	0.958220
P	131 (years)	135 (years)
a	25.87025 AU	26.31678 AU

Table 2 – Dates and distances of the approaches of Comet Swift-Tuttle to the major planets.

Planet	Date	Distance (AU)
Jupiter	1991.05.25	1.7
Saturn	2124.03.08	1.5
	2390.01.27	1.2
Earth	1862.08.31	0.3
	1992.10.16	0.9
	2126.08.02	0.2
	2261.09.23	0.6
	2392.11.05	1.1
	2522.08.24	0.08
	2649.01.08	1.4

Table 3 – Orbital elements of the hypothetical particles: type III tail, vector T, $V < 0$.

Number	V (m/s)	e	a (AU)
1	-2	0.9626	25.7425
2	-5	0.9623	25.5533
3	-10	0.9618	25.2441
4	-20	0.9609	24.6476
5	-30	0.9600	24.0789
6	-50	0.9582	23.0169
7	-150	0.9490	18.8633
8	-190	0.9453	17.5953
9	-250	0.9398	15.9854
10	-310	0.9343	14.6471

Table 4 – Orbital elements of the hypothetical particles: type I tail, vector S, $V > 0$.

Number	V (m/s)	e	a (AU)	ω
11	+50	0.9628	25.8721	152°.6364
12	+100	0.9628	25.8778	152°.4991
13	+400	0.9630	25.9915	151°.6754
14	+800	0.9635	26.3622	150°.5779
15	+1200	0.9644	27.0041	149°.4820
16	+1500	0.9653	27.6868	148°.6606
17	+2000	0.9672	29.2863	147°.2969
18	+2500	0.9697	31.6361	145°.9394
19	+3000	0.9727	35.0759	144°.5895
20	+4000	0.9803	48.4985	141°.9211

Table 5 – Orbital elements of the hypothetical particles: the anomalous tail, vector S, $V < 0$.

Number	V (m/s)	e	a (AU)	ω
21	-100	0.9628	25.8778	153°.0522
22	-200	0.9629	25.9005	153°.3305
23	-400	0.9631	25.9915	153°.8863
24	-600	0.9634	26.1447	154°.4409
25	-800	0.9637	26.3622	154°.9943
26	-1200	0.9647	27.0042	156°.0968
27	-1400	0.9654	27.4385	156°.6458
28	-1600	0.9661	27.9573	157°.1932
29	-1800	0.9669	28.5695	157°.7388
30	-2000	0.9678	29.2863	158°.2827

rection. He concluded that the tail position varied from $+5°$ to $-8°$ in the radius vector direction. He noted the presence of jets in the comet tail and the clearly defined nature of the ejections: two nearly mutually perpendicular directions.

The prominent Russian scientist F.A. Bredikhin (1954) called attention to an anomalous tail which existed from July 30 to August 6 before the comet's perihelion passage on 1862 August 23. Furthermore, by Bredikhin's classification the comet had a direct type I tail and a type III tail. On Vsekhsvyatsky's evidence this material was ejected from the comet at velocities of from 300 m/s (the type III tail) to 6000 m/s (the type I tail), and from 1100 to 3000 m/s (the anomalous tail) (Vsekhsvyatsky, 1932). Multiple beam ejection and fluctuations of the comet brightness give grounds to suggest that explosive processes occurred, with a risk of the destruction of the comet.

3 Perseid stream simulation

For Perseid modeling we have used the value for the orbit of Comet Swift-Tuttle obtained by B. Marsden (Marsden, 1995) and given in Table 1. The integration of the comet equations of motion took account of perturbations from the eight planets Venus to Pluto, from 1862 forward for 1000 years, by Cowell's squaring method considering 8 differences and with a variable step from 1.25 to 40 days. Comet Swift-Tuttle had no close approaches to any major planets in the time interval considered (Table 2, where only the comet approaches with planets closer than 1.7 AU are shown). This circumstance allows us to make the model of the particle motion with greater steps in ejection velocity than usual, which leads to a reduction in the number of test particles.

According to the observations described above, Comet Swift-Tuttle had three tails: a nearly direct type I tail which extended along the radius vector from the Sun (vector S, with ejection velocity $V > 0$), an anomalous tail directed along the radius vector towards the Sun (vector S, $V < 0$) and a type III tail directed nearly perpendicular to the radius vector from the Sun, in the orbital plane, and opposite to the direction of comet motion (vector T, $V < 0$). We shall also take into account ejection directed perpendicular to the comet orbit plane (vector W, $V > 0$ to the north pole of the eclip-

Table 6 – Orbital elements of the hypothetical particles: vector W, $V > 0$

Number	V(m/s)	e	a (AU)	ω	Ω	i
31	0	0.9628	25.8702	152°.7737	139°.3714	113°.5664
32	+800	0.9635	26.3622	152°.9831	139°.9054	112°.6074
33	+1000	0.9639	26.6473	153°.0337	140°.0376	112°.3674
34	+1400	0.9649	27.4385	153°.1328	140°.3007	111°.8874

tic). So orbital elements of the hypothetical particles were calculated for the following initial conditions: meteoroid ejection at perihelion for types I and III tails, and ejection with the comet having a true anomaly of 330° for the anomalous tail. The values of the ejection velocities varied in accordance with values derived from comet tail observations in 1862. For each tail type the orbital elements of ten particles were modeled. For the ejection directed perpendicular to the comet orbit plane the orbits of four particles were modeled. The results of the modeling are shown in Tables 3–6.

4 Discussion

As can be seen from Tables 3–6, most of the scatter of semimajor axes corresponds to the particles which were ejected from the nucleus in directions nearly perpendicular to the radius vector in the orbital plane and opposite to the motion of the comet (vector T, $V < 0$, Table 3) and nearly on the radius vector away from the Sun (vector S, $V > 0$, Table 4). From these Tables we have the following distances. Simulated particle minimum: 26 AU (comet) − 14 AU (particle); the scatter is about 10 AU. For simulated particle maximum: 48 AU (particle) − 26 AU (comet) $\simeq$ 20 AU. The average scatter is about 15 AU. This value agrees with the observed dispersion in semimajor axes (see Introduction). It is likely in fact that the dispersion value is slightly less if the great geocentric velocities of the meteoroids (60 km/s for Perseids) cause great errors in the semimajor axis values. At the same time the orbital inclination i changes insignificantly for all hypothetical particles given in Table 3–6. So the character of the approaches of the hypothetical particles to the planets remains as for the parent comet.

Again, it is necessary to note which observed comet tails are gases that have ejection velocities from the comet nucleus greater than dust particles observed by photographic, visual and TV methods. Using different methods, Williams (2001) found a mean value of the ejection velocity for the Perseid stream of the order of 100 m/s. At this value of the velocity, only the type III tail directed against the comet motion ($V < 0$) gives a scatter of the semimajor axis in the range 5 AU (Table 3), and in this case the values of the semimajor axis are less then the value of the comet semi-major axis. Only the actions of gravitational and nongravitational effects cannot compensate for the remaining part of the scatter. Unfortunately, there are problems in the calculation of the meteoroid semimajor axis from the observations with high precision and we do not know the true difference between the semimajor axis of the Perseid meteoroids and the parent comet.

During its apparition in 1862 and 1992, Comet 109P/Swift-Tuttle exhibited dynamical evolution of three types of structure: jets, envelopes and tail bands, indicating distinctive dust phenomena. Probably the ejection velocities of material from the comet nucleus for the Perseids are higher than for other known meteoroid streams.

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Geminids

Almost 50 years of visual Geminid observations

Jürgen Rendtel [1]

An analysis of the activity profile of the Geminid meteor shower from 1955–2002 is made using visual observations of meteors. Currently, the rate maximum occurs at $\lambda_\odot = 262\overset{\circ}{.}16 \pm 0\overset{\circ}{.}04$ (J2000). A shift in the maximum of $0\overset{\circ}{.}008$ per year is derived from a comparison of the 1955 profile and the average profile of the period 1988–1997.

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1 Introduction

The Geminid meteor shower is among the strongest and best known meteor showers currently visible on Earth. It recurs each year around December 14. The radiant is well above the horizon all night for northern hemisphere observers. Hence each individual observer can collect data for up to 13 hours per night. This guarantees a good overlap of data series obtained from different longitudes. However, conditions are poor for Geminid returns coinciding approximately with the Full Moon. The bright moonlight ruins the observing conditions for visual observers and in those years the rate and magnitude data are of limited quality.

For most major showers there are detailed reports of rich appearances which occurred many centuries ago. Yet the Geminids were not noticed before the 19th century. This hints at a rather rapid orbital evolution of the stream and indicates that changes may become detectable within a period of the order of 50 years.

According to modelling, the Earth will continue to intersect the Geminid meteoroid stream until about 2100 (Hunt et al., 1985). Much of the interest in this peculiar shower is due to the fact that the parent object, (3200) Phaethon, is not of obviously cometary nature. This correlates well with the finding that the bulk density of Geminid meteoroids derived from photographic images is higher than for other streams. Recently, Babadzhanov (2002) gave $\varrho = 2.9 \pm 0.6$ g/cm^3 for the Geminids. Furthermore, its orbit is extremely different to all other major showers intersected by the Earth (Table 1).

The unique orbit of the stream in the innermost region of the Solar system should have several consequences. All evolutionary processes are expected to happen on short time scales because the parent object as well as the meteoroids see frequent approaches to Venus and Earth. Furthermore, all effects of the Solar radiation are much stronger than in the case of long-period meteoroid streams. All these effects will change orbital elements, particularly the semimajor axis a and the eccentricity e, within a few orbital periods. In the case of the Geminids we speak about time scales of a decade. Even if there is a periodic particle release from the parent object, we cannot expect filaments as discussed with the Leonids, for example. Consequently, we should not find variations of the spatial density distribution which are stable for a number of consecutive returns. Surprisingly, McIntosh (1974) found periodic variations in radar data (2:1 in radar flux) and associated these with a 3:5 commensurability of the average orbital periods of the Geminids and the Earth. This could be explained with freshly ejected particles which spread rapidly as described above. Hence possibly existing structures in the stream are expected to remain observable only for a short period.

Here we present an analysis of the activity observed with visual techniques of the Geminid meteor shower near its time of maximum for the years 1955–2002 (Table 2). Data from 1988 onwards are stored in the IMO's Visual Meteor DataBase (VMDB). Further reports, mainly from the 1970s, were transformed into VMDB-compatible records. Finally, data from the Czech Ondřejov Observatory (Ceplecha, 1957) and the Slovak Skalnaté Pleso Observatory (Grygar & Kohoutek, 1958) are used. The process of data collection and processing is not yet finished, because some more early data were included recently extending the period further backwards.

2 Observational results & Discussion

The first step to calculate ZHRs is the calculation of the population index r as a function of solar longitude. This way we determine the portion of missed meteors depending on the limiting magnitude for each observer and interval.

As mentioned above, the majority of the Geminid data is collected during moonless returns. Furthermore, this data is not affected by disturbing illumination. Hence we use this in a first step to look for significant variations in the population index r among the individual Geminid returns. Also, the (scarce) moonlit data yield similar values of r, of course with a larger scatter. Consequently, we use an average profile derived from moonless Geminid returns (Figure 1) for the computation of the ZHR profiles.

While the 1988–2002 ZHR profiles are collected and analysed according to the standardized IMO methods, the older data did not include the full information. Therefore we did not apply any perception correction. As pointed out, the status of the analysis of the data prior to 1988 is still preliminary.

At the current stage of the analysis, we determined ZHR profiles for the 1955 return and an average for

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Table 1 – Orbital elements of Geminid meteoroids (averages) and the parent object (3200) Phaethon (from the IMO Visual Handbook, Rendtel et al., 1995).

	Ω	ω	i	e	q	a	P
Geminids							
Lindblad (1971), phot.	260.°3	324.°8	23.°6	0.896	0.140 au	1.466 au	1.57 a
Lindblad (1987), phot.	260.°2	324.°3	23.°5	0.899	0.143 au	1.414 au	1.68 a
Betlem et al. (1994), phot.		324.°5	24.°4	0.900	0.139 au	1.39 au	1.64 a
Porubčan & Gavajdová (1994), phot.	260.°2	324.°7	24.°4	0.901	0.137 au	1.39 au	1.63 a
Ueda & Fujiwara (1994), TV	260.°3	324.°4	24.°1	0.89	0.15 au	1.3 au	1.5 a
Kashcheev & Lebedinets (1967), radar	260°	326°	24°	0.89	0.14 au	1.31 au	1.5 a
1936–1945	261.°1	324.°3	24.°4	0.905	0.137 au	1.456 au	1.76 a
1946–1955	260.°9	324.°3	24.°0	0.899	0.140 au	1.392 au	1.64 a
1956–1965	259.°4	324.°9	23.°3	0.896	0.139 au	1.341 au	1.55 a
1966–1975	261.°5	324.°2	23.°6	0.886	0.148 au	1.309 au	1.50 a
1976–1985	261.°3	325.°1	23.°4	0.883	0.146 au	1.278 au	1.44 a
Photographic data for the 5 decades from Porubčan & Cevolani (1994)							
(3200) Phaethon	265.°4	322.°0	22.°2	0.890	0.139 au	1.271 au	1.43 a

Table 2 – Summary of Geminid data available for the current analysis. The Remarks column includes the data source: AKM = Arbeitskreis Meteore, McLeod = Norman McLeod (Florida), IMO-VMDB = Visual Meteor DataBase of the IMO.

Year(s)	$T_{\mathrm{eff}}(h)$	Geminids	Total	Remarks
1955	160	5757	7227	Czech and Slovak data (see text)
1971–80	112	2764	4041	AKM, McLeod, WAMS
1981–90	1154	27424	42787	IMO-VMDB, AKM, McLeod, WAMS
1991–02	2673	81116	113868	IMO-VMDB
All data	4099	117061	137923	
1991	874	30080	42955	Best observed individual return

1988–1997. Of course, the 10 year period may smear out some short periodic characteristics. Such periodic variations are described as occurring in radar data (e.g. McIntosh, 1974). But one main aspect of this study is the long-term behaviour of the stream's occurrence.

Interestingly, the kind of 'double peak' clearly visible in the 1988–97 data is also visible in the 1955 curve (Figure 2) although the 1955 observations ended close to the peak time and the descending branch of the ZHR profile is missing. This hints at a rather constant shape of

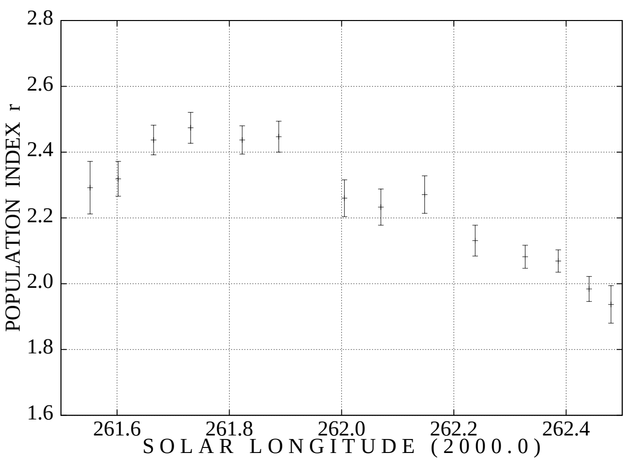

Figure 1 – Average profile of the population index r derived from moonless returns of the Geminids between 1988 and 1997.

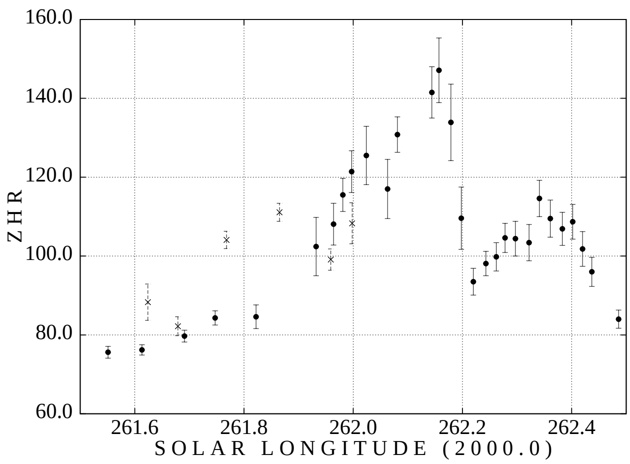

Figure 2 – ZHR profiles of the Geminids, showing the average profile of the 1988–97 returns (dots) and the ascending branch of the 1955 profile (crosses).

the profile. Modelling of the Geminid stream (Fox et al., 1983) yields a shift of the average maximum of the Geminid meteoroid stream as $l_o(\text{mean}) = 260.325 - 0.0126t$ with t the time in years, and $t = 0$ on 11 Feb. 1980. Such a drift of about 0.25 hours per year should become visible in the comparison between the rate profiles of the 1955 and the recent returns. While the general shape of the ZHR profile seems to be very similar, it remains open whether we can compare specific features. For example, we may suspect that the dip in the last three data points of the 1955 curve corresponds with the obvious dip found in the ZHR graph for the 1988-97 period. Assuming that this is the case, we find the position of the first peak of the 1955 Geminids at $\lambda_\odot = 261\overset{\circ}{.}85$. The respective position in the 1988–97 data is $\lambda_\odot = 262\overset{\circ}{.}16$. Since the center of the latter period is 1993, we obtain a shift of approximately $0\overset{\circ}{.}31$ within 38 years, corresponding to about $0\overset{\circ}{.}008$ (≈ 0.2 hours) per year. If the 1955 return represents the average situation at that time, the drift is about 2/3 of the predicted change — but in the wrong direction. Trying to compare the dips in the two rate profiles we may estimate a difference of $0\overset{\circ}{.}26$. Of course, this result is rather preliminary. Furthermore there is another uncertainty: the ZHR values of the 1955 return were computed with the average r-profile shown in Figure 1. Hence we should assume that the r-profile for the 1955 return is similarly shifted. However, with an average limiting magnitude of the order of 6.0, a value of $r \approx 2.4$ instead 2.2 yields a 5% increase of the ZHR, not much exceeding the size of the error bars. With the inclusion of further, as yet unprocessed data, the respective figures will become more reliable.

3 Conclusions

The almost 50-year study of the Geminid stream presented here makes it clear that visual meteor observations provide a useful diagnostic of stream activity as has been found in other cases such as the Perseids (Brown and Rendtel, 1996) and the Leonids (e.g. Arlt et al., 2001). Such systematic studies are currently only possible on the basis of visual and radar data. The general profile of the Geminids seems to remain stable. A shift of the Geminid peak of about $0\overset{\circ}{.}008$ (≈ 0.2 hours) per year is derived from data obtained between 1955 and 1997.

Acknowledgements

The author is deeply indebted to all observers who contributed their observations to this study via the VMDB. Without their dedication this work would not have been possible. Special thanks to Norman McLeod of Florida for sending complete old recordings, and to Vladimir Porubčan of Bratislava for 'old' Slovak Geminid data.

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Ongoing meteor work

The fireball stream of the Tagish Lake meteorite

Alexandra Terentjeva [1] *and Sergej Barabanov* [2]

The fall of the Tagish Lake meteorite was caused by the already known μ-Orionid fireball stream (No. 1 in Terentjeva 1989, 1990). The 60-Orionid meteor stream and the asteroid (4183) Cuno can be connected with this fireball stream and the Tagish Lake meteorite.

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1 Introduction

This brilliant, exceptionally bright detonating fireball was observed on 2000 January 18 over a wide territory of the Yukon, northern British Columbia, and a part of Alaska. This spectacular event happened as the meteorite fall, more precisely the Tagish Lake meteorite shower, occurred. About 500 meteorite specimens were located on the ice of Tagish Lake, however about 200 pieces were recovered. The total collected mass was 5–10 kg. The possible range of initial mass seems to be 50–180 tons (Brown et al., 2001). All observations (photographic data from Earth surface as well as satellite data) were used for an orbit determination of the meteorite (Brown et al., 2000; Brown et al., 2001).

Including the Tagish Lake, therefore, meteor astronomers have obtained five instrumentally determined orbits of meteorites during four decades (Table 1, Figure 1).

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2 Origin of the body

From a study of orbital element catalogues of meteoroid and fireball streams and asteroids, we have deduced that the Tagish Lake meteorite shower is related to the already known μ-Orionid fireball stream, active from January 1 to February 4 (No. 1 in Terentjeva 1989, 1990).

Moreover, the 60-Orionid meteor stream, active from January 3 to January 20, and asteroid (4183) Cuno can be connected with the μ-Orionid fireball stream and the Tagish Lake meteorite. All data are presented in Table 2, orbits are shown on Figure 2. The next column to last of Table 2 contains the value C of Tisserand's constant (the perturbing planet is Jupiter).

Note that the orbits of the Tagish Lake meteorite and the μ-Orionid meteor stream are inclined to opposite sides of the ecliptic plane, and therefore the longitudes of their ascending nodes Ω and arguments of perihelia ω differ by $\pm 180°$, whereas the longitudes of perihelia π and other orbital elements are almost identical. Hence the Tagish Lake meteorite and the μ-Orionid fireball stream form the northern and the southern branches of the same fireball stream. Asteroid Cuno relates to the northern branch of this large fireball stream. Its theoretical radiant and the radiant of the μ-

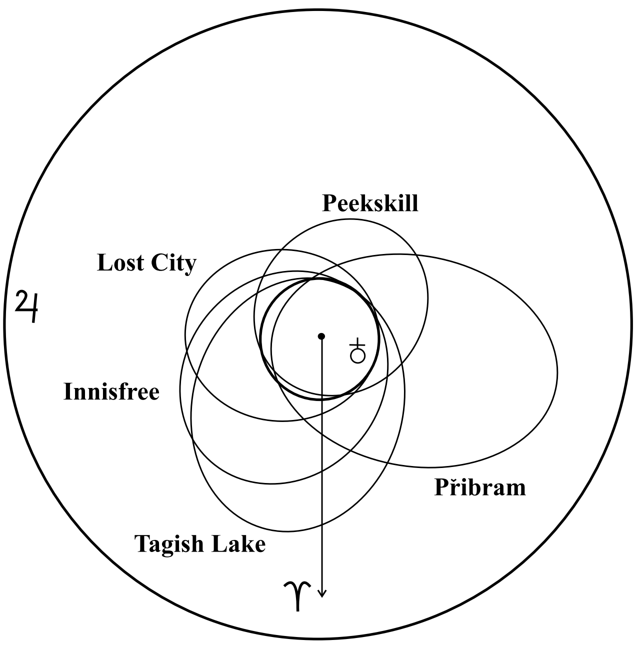

Figure 1 – Meteorite orbits (projection on the ecliptic plane).

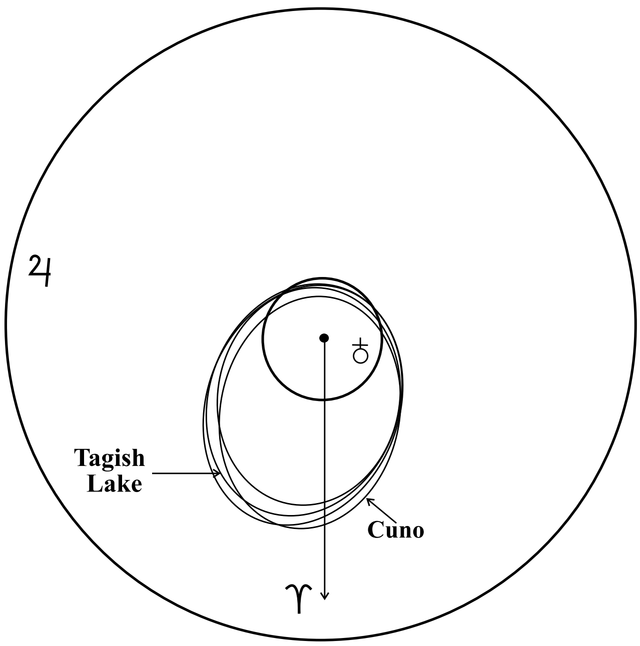

Figure 2 – Family of minor bodies connected with the Tagish Lake meteorite.

Table 1 – Meteoroid orbits

Meteorite name & type	Date (UT)	a AU	e	q AU	q' AU	i	ω	Ω	π	C	Source
Příbram, H 5	1959 Apr 7.81274	2.424	0.6742	0.7899	4.058	10.°42	241.°58	17.°11	258.°69	0.6031	[1]
Lost City, H 5	1970 Jan 4.0931	1.6	0.417	0.933	2.27	11.°98	161.°00	283.°04	84.°04	0.815	[2]
Innisfree, L 4-5	1977 Feb 6.09554	1.872	0.4732	0.986	2.758	12.°27	177.°97	316.°80	134.°77	0.7327	[3]
Peekskill, H 6	1992 Oct 9.9917	1.49	0.41	0.886	2.10	4.°9	308°	17.°030	325°	0.858	[4]
Tagish Lake, CI 2	2000 Jan 18.69703	2.0	0.56	0.885	3.14	2.°0	223.°9	297.°901	161.°8	0.697	[5]

Notes:

Orbital elements of the first three meteorites are given for the 1950.0 equinox; the last two meteorites are given for the 2000.0 equinox.

Sources are as follows: [1] Ceplecha (1961); [2] Lowrey (1971); [3] Halliday et al. (1978); [4] Beech et al. (1995); [5] Brown et al. (2001).

Table 2 – Family of minor bodies connected with the Tagish Lake meteorite

Name	Date (UT)	Corr. geocentric radiant		V_∞ km/s	a AU	e	q AU	i	ω	Ω	π	C	Source
		α	δ										
Northern (N) branch													
Tagish Lake	2000 Jan 18.697	89.°9	+29.°8	15.8	2.0	0.56	0.885	2.°0	223.°9	297.°9	161.°8	0.697	[1]
(4183) Cuno	Jan 1.517	92.°6	+36.°6	20.4	1.981	0.636	0.721	6.°8	235.°4	295.°7	171.°1	0.687	[2]
Southern (S) branch													
μ– Orionids	Jan 1 – Feb 4	88°	+12°	16.4	1.866	0.524	0.854	4.°1	51.°7	112.°5	164.°2	0.731	[3]
60-Orionids	Jan 3 – 20	90°	0°	17.2	2.04	0.58	0.86	9°	49°	112°	161°	0.684	[4]

Notes:

Orbital elements of Tagish Lake and Cuno meteorites are given for the 2000.0 equinox; the μ-Orionid fireball stream and the 60-Orionid meteor stream are given for the 1950.0 equinox.

Sources: [1] Brown et al. (2001); [2] `ftp://cfa-ftp.harvard.edu/pub/MPCORB/MPCORB.DAT`; [3] Terentjeva (1989, 1990); [4] Terentjeva (1966).

Orionid fireball stream are located symmetrically to the ecliptic at distances of 14° and 12° respectively. The 60-Orionid meteor stream belongs to the southern branch.

3 Conclusion

Apparently one can suppose the existence of a minor body family connected to the Tagish Lake meteorite. It is interesting that large bodies form the northern branch of this family, and small ones form the southern branch. The Earth meets this minor body system over the course of about 35 days.

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History

Meteor Beliefs Project: a little light anniversary entertainment

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

Some brief meteoric quotes suitable for April 1st, to celebrate the Meteor Beliefs Project's first anniversary.

1 Introduction

In presenting material for the Meteor Beliefs Project, we are aware that some of the discussions could be seen as rather academic, but we want to show we encourage all sorts of items to be presented, so we give a few short humorously-intentioned meteoric items here. It would be nice to think we might be able to provide some humorous meteor quotes each year in the April issue, in honour of All Fool's Day, April 1st, as well as to celebrate the Project's first announcement in *WGN* **31:2**, but that depends entirely on what you send us, or what we stumble across by-chance ourselves!

2 A Chastushka from Tomsk

Galina Ryabova from Tomsk has forwarded us this folk ditty ('chastushka') in translation, well-known among her colleagues at the University in early 2003:

> A star has fallen from the sky
> In sweetie's pants directly.
> All burned out - it doesn't matter
> If the war never happens.

Sadly, the rhyme is lost in translation...

3 'Bored of the Rings'

Alastair came across this item while re-reading The Harvard Lampoon's parody of J.R.R. Tolkien's fictional masterpiece 'Lord of the Rings' last year (p. 100 of the Gollancz 2001 hardback version; 'Bored of the Rings' is by H.N. Beard and D.C. Kenney, co-founders of National Lampoon). With not a word intended seriously, it is a silly overkill list of portents supposedly foretelling the dire prospects for the heroes of the tale, as they set out on another leg of their adventure:

> As he watched, the moon rose, there was a meteor shower and a display of the aurora borealis, a cock crowed thrice, it thundered, a flock of geese flew by in the shape of swastika, and a giant hand wrote *Mene, mene, what's it to you?* across the sky in giant silver letters.

4 Romanian recollections

Andrei remembered some verse by the great Romanian literary critic George Calinescu, from his poem 'Fire', composed in the 1930s but only published much later in his book *Praise to the Things* (Bucharest, 1963). In this, the author gave his own poetical connection and comparison between fire and a draconic fireball (again, sadly, the rhyme does not survive its English translation):

> Who is that scowling dragon,
> Wrapped in thick red cloth,
> Filled with pride,
> And a gilded comb?

Next, two meteor proverbs, Andrei's own astronomical adaptations of old Romanian ones:

> Every meteoroid eats from the void, but the atmosphere eats every meteor!
>
> Speak of the meteor, and the meteorite knocks on the door!

5 'Treasure Trove' Again: The Crumlin Meteorite

Lastly, a humorous poem from the 'Irish Weekly Independence and Nation' for November 16, 1902, entitled as ' "Treasure Trove" Again', and concerning the complex political situation that existed regarding England's control of Ireland in the early 20th century and before. The full item includes a cartoon, which we regrettably don't have a reproduceable copy of (but see it illustrated as Figure 31 on p. 199 of 'Cosmic Debris: Meteorites in History', by J.G. Burke, University of California Press, 1986). It shows the portly, running figure of England's archetype, John Bull, in top hat, Union Flag waistcoat, and jacket, carrying a walking cane under one arm, puffing and blowing with the effort of carrying a large lump of rock, from which come curlicues of smoke and sparkling four-pointed stars, intended as a meteorite. He is being pursued along a dusty country lane by an irate, lean, Irish farmer, the archetype Pat, shaking his fist at John Bull who, according to a signpost, is hurrying back 'To the British Museum' with his prize.

A caption explains the action: *The British Museum has 'collared' another Irish treasure ... the remarkable meteorite which fell near Belfast during the period of the British Association's visit to that city in September last — Dublin 'Daily Express', November 12, 1902.* The Crumlin Meteorite fell on September 13, 1902 at Crosshill Farm, Crumlin, County Antrim, Northern Ireland, a 4.2 kg stone.

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The caption is followed by the poem:

PAT, shouting after JOHN BULL:-
Come back here, ye spalpeen, ye thief o' the world!
Lave down that big stone; 'tis a meteor hurled
From Vaynus, or Mars, or from Jupiter's Moon.
Sure it's mine, for it fell on my land, ye bosthoon!
Ye stole the goold bracelets I turned with me plough;
Your paw's in me pocket for ever, an' now
When a strange curiosity comes from the skies,
Bedad, but ye grab it right under me eyes!

6 Conclusion

If you think you've found some more amusing or entertaining meteoric quotes than those given here, do please share them with us, so we can present them next April. Remember, the Project can only ever be as good as you help make it.

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