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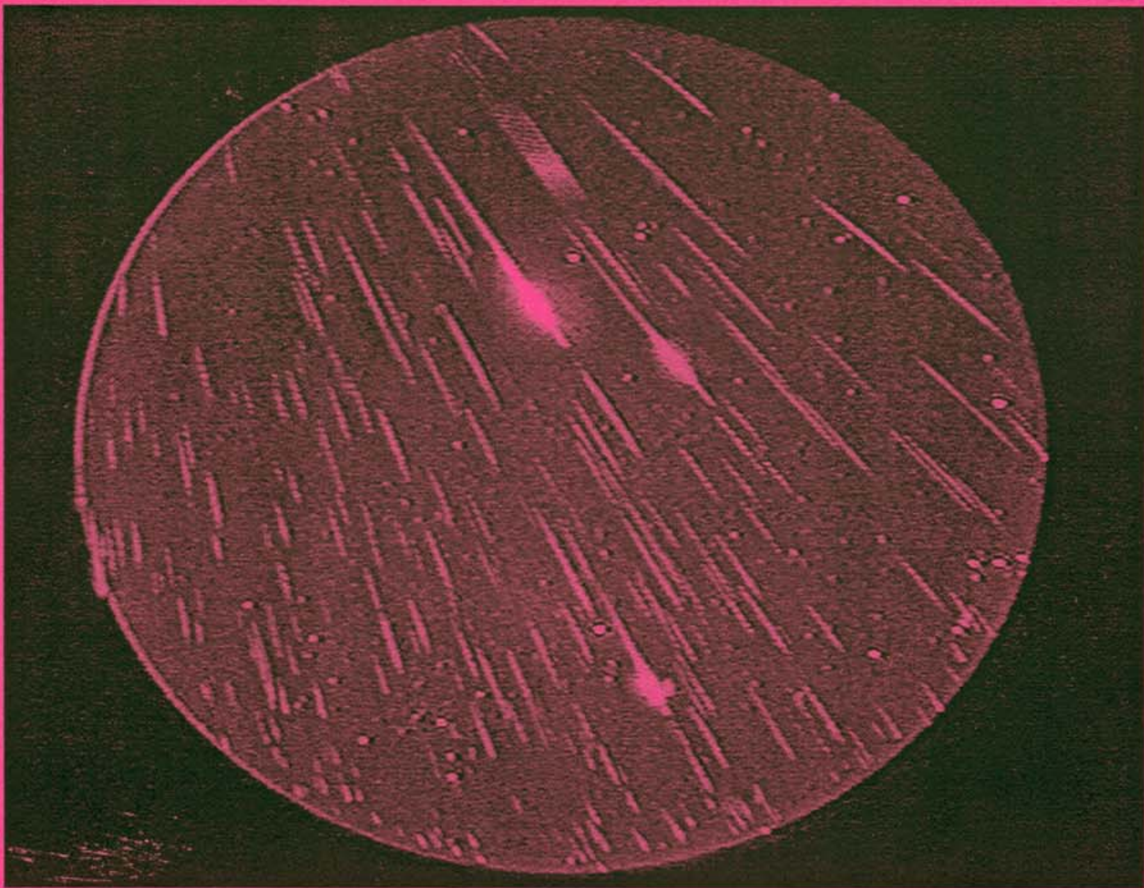

This video image was obtained by Osamu Okamura of the *Nippon Meteor Society*, and processed by Teruaki Kumamori. The video camera consisted of a second-generation MCP, an $f/1.4$ 24-mm wide-angle lens, and a Sony video camera. The picture shows Leonids recorded on November 18, 1999, between 2^h04^m and 2^h11^m UT on a flight from Malaysia to England.

In this issue:

- More news on the 2000 IMC
- Information for meteor observers
- Possible radiant near ξ Bootids?
- Preliminary analysis of the 1999 Geminids
- Daylight Taurids
- Fireballs, natural and artificial
- Observational results from Spain

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Contents

Useful Information

The April issue *(WGN 28:2)*

The *April issue* will be mailed around end-April. Contributions are due on *April 7* at the latest. They should be sent to *Marc Gyssens*.

Subscriptions and ordering of publications

Volume 28 (2000) of *WGN* will contain at least 240 pages and costs 35 DEM or 17.90 EUR, including non-airmail delivery. Ordering other *IMO* publications is done in the same way as paying subscription/membership fees. Changes of address and complaints about not receiving *WGN* should be addressed to the Treasurer, Ina Rendtel.

All addresses can be found on the inside of the back cover.

From the President

Jürgen Rendtel

It is likely that the year 1999 is once mentioned as a year in which meteor astronomy made an important step forward as it has done in 1833—in both cases due to the Leonids. Then, there was a breakthrough in the general explanation of the phenomenon, now, there is the understanding of mechanisms connected with meteoroid stream evolution. Based on analyses of the initial near-comet processes and the subsequent meteoroid stream evolution, a Leonid meteor storm was predicted and observed in November 1999. Furthermore, the calculations explained the 1998 Leonid fireball storm. As in the past, the meteoroids of Comet 55P/Tempel-Tuttle are at the basis of this development. And, a very important fact for the observers, the event was excellently seen by many observers who traveled into the predicted visibility area, and were granted with the best rates ever since 1966.

The Leonid story goes even further, because the data collection and presentation on the IMO*'s web page was done on-line as the meteor storm progressed during the morning of November 18. The subsequent weeks saw Rainer Arlt and a few other people extremely busy with the handling of data of over 1/4 million visual meteors. The publication of an analysis of the 1999 Leonid activity already in the December issue of* WGN*, simultaneously with an extended work on the 1998 return is certainly result of an extraordinary and much appreciated effort.*

Probably all other meteor events in 1999 are overshadowed by this success. However, some developments are closely connected. Video meteor observations became more widespread, especially as on-line analyzing hardware and software became available as well. This was not only used for investigations of the major meteor showers. For example, a regular meteor video patrol was started in Germany in March 1999. This should help to get a better overview over meteor activities throughout the entire year. The cameras can also yield useful data under poor circumstances, e.g., around the period of Full Moon. Especially unexpected events like the June Bootids in 1998 will not be missed if a sufficient number of operators contribute to this new kind of observing program.

Certainly, this will not replace campaigns for double-station investigations, which can yield much more detailed data on individual meteors, especially for obtaining meteoroid orbits. Currently, however, such campaigns only take place during very selected time intervals.

Of course, meetings between the IMO *members continue to play an important role for the success and the motivation of observers. The* IMC *near Rome, Italy, attracted a large number of participants again, although some major astronomical events in 1999, like the total solar eclipse near the Perseid maximum and the already mentioned Leonid peak, required some travel as well.*

As usual, plans are already made for meetings and observational campaigns in the year 2000. Despite the lunar phase, the Leonids will attract a lot of attention again: can we confirm the model predictions also this time? This will have great impact for both the authors of the models and the observers, especially as the prospects for further great Leonid showers in the following years sound extremely interesting. However, do not restrict your activities to a few specific occasions, because there is always a chance for new, surprising, and exciting observations, which you certainly do not want to miss!

A peaceful and healthy year 2000 and good luck to all members and friends of the IMO*!*

The 2000 International Meteor Conference

Pucioasa, Romania, September 21–24, 2000

Valentin Grigore and Andrei Dorian Gheorghe

The last *International Meteor Conference* of the millennium (*IMC 2000*) will be held in the little town, Pucioasa, in Romania, around the 2000 fall equinox, between September 21 and 24. It will be organized by the *Romanian Society for Meteors and Astronomy* (*SARM*), with the cooperation of the town authorities of Pucioasa.

The *SARM* is an astronomical youth organization, the single national astronomical organization in Romania, the founder of the Romanian meteor work. Pucioasa is a spa town, having an old and good reputation in this field. It is located at 400 m altitude and enjoys a very favorable climate. It is situated 100 km north-west of Bucharest, and only 23 km north-west of Târgovişte—the seat of *SARM*. There are many direct trains and buses from Bucharest to Pucioasa, but we will offer an additional free shuttle bus from Bucharest airport/railway station to the conference site.

The accommodation will be in a hotel with double rooms, and all meals will be served at the restaurant of the hotel (please, inform us if you require special meals, such as vegetarian). The conference site, located at 150 m from the hotel, is the new building of the Cultural Center, with a lecture hall of approximately 200 seats, full facilities, and additional room for poster presentations. We intend to install a bar at this site, too.

Thursday, September 21, will be the first day of the *IMC 2000*. Till 3^h pm local time, we will collect the participants in Bucharest from the airport/railway station. Then, our bus will head for Pucioasa, but before our arrival, we will cross Târgovişte (the former Romanian capital) and make a brief stop for a group photo at the Chindia Tower (Dracula's Tower), near the ruins of the Princely Court Palace. The conference will be opened officially after dinner.

During the conference days, in addition to the lectures, we also plan some action. So, the next day, in a break or in the evening, we intend to do a short trip around, visit the town, including a special art gallery and maybe the very famous and unique New Jerusalem Monastery.

The traditional excursion on Saturday will be trip to a very nice place, Sinaia, a mountain resort nicknamed *The Pearl of the Carpathians*. Here we will visit Peles Castle, the most beautiful and interesting palace in Romania (a former royal summer residence of the Romanian kings, built by King Carol I, founder of modern Romania), the old Sinaia Monastery, and also admire the beautiful landscape of the Bucegi Mountains and the Prahova River Valley.

Every evening after dinner, we will organize short astro-artistic programs with many surprises. The conference will officially close on Sunday, September 24, around noon.

The full conference fee is 170 DEM, and covers accommodation in double rooms, meals, and a copy of the proceedings. However, we offer a reduced price for people who might have problems paying the full fee—a reduced fee of 100 DEM will be applied on request in this case.

To obtain a reduced registration fee, please contact the local organizing committee soon at the address indicated at the bottom of this page.

Indicate on your registration form any contributions you want to make to the program (lectures, posters, workshops, group sessions, etc.—do not forget that a paper must be delivered at the *IMC* for the Proceedings, too!) and the equipment required for this purpose. Also, inform the local organizing committee about these requirements! E-mail us for any questions, additional information, or some special requirements. If you want to stay some days before or after the *IMC* in Pucioasa, we can assist you in making arrangements.

Please, register as soon as you can, because Pucioasa is a spa town, and we must confirm our reservations quite some time in advance. Also, the number of participants is limited. We will edit and send via e-mail a bimonthly newsletter, *IMC 2000 News*. You can subscribe to the list by sending an e-mail to `sarm@minisat.ro` with cc to `sarm@romwest.ro` with subject *IMC 2000 News subscribe*. Also, information, pictures, and other relevant items concerning the *IMC*, Romania, entrance into the country, etc. can be found on the upcoming *IMC 2000* web site `http://sarm.romwest.ro/imc2000` or `http://sarm.ccs.ro/imc2000` (mirror site).

Romania is a beautiful country and you must see it. Some participants to the last *IMC* in Frasso Sabino, Italy, suggested us to make arrangements and/or organize for interested participants to the *IMC 2000* a special touristic program of a week or so after the conference to see more interesting places in our country. Although this requires a great effort for us, it is also a pleasure to do this for you.

With the experience of the *EuRo Eclipse 99* project last year (see `http://www.geocities.com/CapeCanaveral/Hall/9794/eclipsa.htm`), when over 170 persons from the USA, Canada, the UK, France, the Netherlands, Scotland, Switzerland, Japan, Hong Kong, Russia, Ukraine, Brazil, and South Africa (some of them famous astronomers) attended our program, we can make an interesting program for you this year, but that depends on what you want to see, and how long you want to stay in Romania.

We can make all arrangements for the trip, accommodation, meals, and transport. Many important places can be visited, such as Bran Castle (the controversial and contested Dracula's palace, built in the 14th century), Bucegi Mountains and Reservation, with the famous natural Romanian Sphinx and Babele, Olt River Valley, Bucharest (the former House of People built by Ceausescu, today the Romanian Parliament, the Village Museum, one of the most beautiful and complete ethnographic museums of Europe), etc. See them and more others at the *IMC 2000* web site. We are awaiting your preferences and proposals.

Please send your registration form as soon as possible to *IMO* Treasurer Ina Rendtel.

For more information on this conference, a unique and exciting opportunity to meet likewise-interested people, contact Valentin Grigore, CP 14, OP 1, Târgovişte 0200, Dâmboviţa, Romania, phone +40-92-829 034, fax +45-45-214 389, e-mail `sarm@minisat.ro` or `sarm@romwest.ro`. Other members of the local organizing committee are Ştefan Berinde and Andrei Dorian Gheorghe.

Figure 1 – David Asher accompanied by some organizers of the 2000 *IMC*, Gelu-Claudiu Radu, Valentin Grigore, and Andrei Gheorge, at the famous Piazza Navona in Rome, after the 1999 *IMC*.

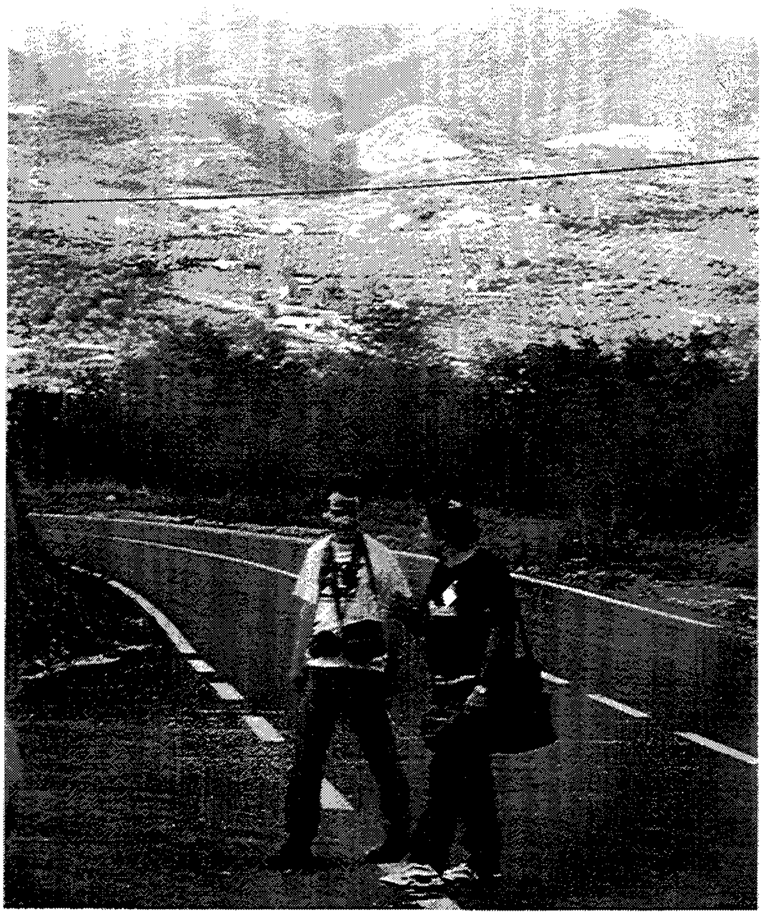

Figure 2 – During the 1999 *IMC* excursion, with the beautiful Sabine Mountains in the background, Cis Verbeeck exchanged some thoughts with 2000 *IMC* co-organizer Andrei Gheorge.

International Meteor Conference

Pucioasa, Romania, September 21–24, 2000

Registration Form

Each individual participant should fill out a form and return it to *Ina Rendtel, Mehlbeerenweg 5, 14469 Potsdam, Germany*, as soon as possible. Your registration will be guaranteed only after Ina Rendtel has received the minimum pre-payment of 100 DEM (51.13 EUR). If you wish to participate, but cannot yet decide, simply return this form with the proper option checked to stay on the mailing list for further circulars.

Name: ______________________________ Birth date: ____________

Address: ____

____

____

Phone: ______________ Fax: ______________ E-Mail: ______________

- ○ wishes to register for the 2000 *IMC* from September 21 to 24;
- ○ intends to participate, cannot yet register, but wishes to stay on the mailing list.

I intend to travel by ________, together with ______________________________

Additional requests:

- ○ I need travel information from ______________ to Pucioasa;
- ○ I wish to stay in Romania before or after the *IMC* and require additional information re. this matter.

For participants wishing to contribute to the program:

Lecture: ____

Duration: ________min. Required equipment: ______________________________

Workshop or discussion: ____

Poster presentation: ______________________________ Space: ________ m^2

Either the entire fee of 170 DEM (86.92 EUR) or a pre-payment of at least 100 DEM (51.13 EUR) should be sent to the Treasurer, *Ina Rendtel*. Follow the payment instructions below. Participants paying only 100 DEM (51.13 EUR) have to pay the remaining 70 DEM (35.79 EUR) upon arrival in Pucioasa.

Date and signature: ____

Please send your payment to the Treasurer or one of her assistants as indicated below:

- in Europe: pay in DEM or EUR to Ina Rendtel, account number 547234107 at Postbank Berlin, bank code 10010010. No bank checks, please! (Bank checks can only be sent to Robert Lunsford, see below).
- in the UK: proceed as above or pay to Alastair McBeath, 12A Prior's Walk, Morpeth, Northumberland NE61 2RF, England.
- in Japan: pay to Masahiro Koseki, 4-3-5 Annaka, Annaka-shi, 379-01 Gunma-ken, Japan.
- all others pay in USD to Robert Lunsford, 161 Vance Street, Chula Vista, California 91910, USA. In case you pay by bank check, make it payable to Robert Lunsford, *not* the *IMO*!

People wishing to pay in other currencies should contact the appropriate IMO *contact person for exchange rates.*

Letters to WGN

compiled by Marc Gyssens

On possible lunar impacts from Leonid meteoroids

Having followed the discussion of these events as posted to the *IMO-News* e-mailing list, as well as the subsequent comments in *WGN* 27:6, I was a little concerned to find the very large masses and sizes being suggested for some of the possible lunar impactors which featured in some of the e-mail messages (of the order of kilograms in mass, perhaps up to a meter in size). These parameters seem necessary because of the very low relative efficiency of an impactor striking the solid lunar surface to create visible light. Obviously, these details are subject to further discussion and refinement, but, as they stand, they do seem large compared to the estimated sizes and masses of Leonid meteoroids as established from Earth-based studies, though we must allow that the small number of visible lunar impactors may be only the very largest objects in the Leonid stream anyway, too rare to be analyzed in detail from Earth.

I wondered if instead of impacting the solid surface (and we should not forget that much of the lunar surface is covered by a variable-thickness layer of tiny pulverized rock fragments, the soil-like regolith), the intense bombardment by the 1999 Leonid storm at the Moon had created a temporary, and doubtless rather tenuous, lunar "atmosphere" of dust and ions thrown up from the surface. The 1998 Leonids managed to create such an "atmosphere" of sodium ions for instance, which was detected after it had been removed from the near-lunar environs by the solar wind, as it receded from the Earth (cf. the brief report in *Sky and Telescope*, October 1999, p. 21). If so, might the reported lunar impact flashes in 1999 have resulted from at least partial ablation of the Leonid meteoroids passing through this, probably thin, layer near the Moon's surface, instead of simply impacting into the Moon itself?

Logically, an "atmosphere" of sorts must have been created on the Moon by the Leonid storm, for the simple reason that the extremely fine lunar surface dust is very easily lifted from the surface, and the initial stages of the storm at least would have encountered no such "atmosphere" to protect the surface in any way. The question is, would the "atmosphere" created have been sufficiently dense, and have extended to a great enough height from the lunar surface, to permit such partial ablation of the Leonid meteoroids before they impacted?

Alastair McBeath, January 20, 2000

Solar Longitudes for 2000

compiled by Rainer Arlt

A conversion table of dates to solar longitudes using [1] is given as every year. The longitudes given are only valid for 2000. The conversion formulae for any time of the day is 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 $\lambda_\odot$ in 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 at `http://www.imo.net/solarlong`.

Reference

[1] Steyaert, C., "Calculating the Solar Longitude 2000.0", *WGN* 19:2, April 1991, pp. 31–34.

Table 1 – Solar longitudes 2000. Dates refer to 0^h UT.

Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$	Date	$\lambda_\odot$
Jan 1	279.87	Mar 1	340.71	May 1	40.93	Jul 1	99.47	Sep 1	158.86	Nov 1	218.87
Jan 2	280.89	Mar 2	341.72	May 2	41.90	Jul 2	100.42	Sep 2	159.83	Nov 2	219.87
Jan 3	281.91	Mar 3	342.72	May 3	42.87	Jul 3	101.38	Sep 3	160.80	Nov 3	220.87
Jan 4	282.93	Mar 4	343.72	May 4	43.84	Jul 4	102.33	Sep 4	161.77	Nov 4	221.87
Jan 5	283.95	Mar 5	344.73	May 5	44.81	Jul 5	103.28	Sep 5	162.74	Nov 5	222.88
Jan 6	284.97	Mar 6	345.73	May 6	45.78	Jul 6	104.24	Sep 6	163.71	Nov 6	223.88
Jan 7	285.99	Mar 7	346.73	May 7	46.75	Jul 7	105.19	Sep 7	164.68	Nov 7	224.88
Jan 8	287.00	Mar 8	347.73	May 8	47.71	Jul 8	106.14	Sep 8	165.65	Nov 8	225.89
Jan 9	288.02	Mar 9	348.73	May 9	48.68	Jul 9	107.10	Sep 9	166.62	Nov 9	226.89
Jan 10	289.04	Mar 10	349.73	May 10	49.65	Jul 10	108.05	Sep 10	167.59	Nov 10	227.89
Jan 11	290.06	Mar 11	350.73	May 11	50.61	Jul 11	109.00	Sep 11	168.56	Nov 11	228.90
Jan 12	291.08	Mar 12	351.73	May 12	51.58	Jul 12	109.96	Sep 12	169.53	Nov 12	229.90
Jan 13	292.10	Mar 13	352.72	May 13	52.54	Jul 13	110.91	Sep 13	170.51	Nov 13	230.91
Jan 14	293.12	Mar 14	353.72	May 14	53.51	Jul 14	111.86	Sep 14	171.48	Nov 14	231.92
Jan 15	294.14	Mar 15	354.72	May 15	54.47	Jul 15	112.82	Sep 15	172.45	Nov 15	232.92
Jan 16	295.16	Mar 16	355.71	May 16	55.44	Jul 16	113.77	Sep 16	173.43	Nov 16	233.93
Jan 17	296.18	Mar 17	356.71	May 17	56.40	Jul 17	114.72	Sep 17	174.40	Nov 17	234.94
Jan 18	297.19	Mar 18	357.70	May 18	57.36	Jul 18	115.68	Sep 18	175.38	Nov 18	235.95
Jan 19	298.21	Mar 19	358.70	May 19	58.33	Jul 19	116.63	Sep 19	176.35	Nov 19	236.96
Jan 20	299.23	Mar 20	359.69	May 20	59.29	Jul 20	117.59	Sep 20	177.33	Nov 20	237.97
Jan 21	300.25	Mar 21	0.68	May 21	60.25	Jul 21	118.54	Sep 21	178.31	Nov 21	238.98
Jan 22	301.26	Mar 22	1.68	May 22	61.21	Jul 22	119.49	Sep 22	179.29	Nov 22	239.99
Jan 23	302.28	Mar 23	2.67	May 23	62.17	Jul 23	120.45	Sep 23	180.27	Nov 23	241.00
Jan 24	303.30	Mar 24	3.66	May 24	63.13	Jul 24	121.40	Sep 24	181.24	Nov 24	242.01
Jan 25	304.31	Mar 25	4.65	May 25	64.09	Jul 25	122.36	Sep 25	182.22	Nov 25	243.02
Jan 26	305.33	Mar 26	5.64	May 26	65.05	Jul 26	123.31	Sep 26	183.21	Nov 26	244.03
Jan 27	306.35	Mar 27	6.63	May 27	66.01	Jul 27	124.27	Sep 27	184.19	Nov 27	245.04
Jan 28	307.36	Mar 28	7.62	May 28	66.97	Jul 28	125.23	Sep 28	185.17	Nov 28	246.06
Jan 29	308.38	Mar 29	8.61	May 29	67.93	Jul 29	126.18	Sep 29	186.15	Nov 29	247.07
Jan 30	309.40	Mar 30	9.60	May 30	68.89	Jul 30	127.14	Sep 30	187.13	Nov 30	248.08
Jan 31	310.41	Mar 31	10.59	May 31	69.85	Jul 31	128.09				
Feb 1	311.43	Apr 1	11.57	Jun 1	70.81	Aug 1	129.05	Oct 1	188.12	Dec 1	249.10
Feb 2	312.44	Apr 2	12.56	Jun 2	71.77	Aug 2	130.01	Oct 2	189.10	Dec 2	250.11
Feb 3	313.46	Apr 3	13.55	Jun 3	72.73	Aug 3	130.97	Oct 3	190.08	Dec 3	251.13
Feb 4	314.47	Apr 4	14.53	Jun 4	73.69	Aug 4	131.92	Oct 4	191.07	Dec 4	252.14
Feb 5	315.49	Apr 5	15.52	Jun 5	74.64	Aug 5	132.88	Oct 5	192.06	Dec 5	253.15
Feb 6	316.50	Apr 6	16.50	Jun 6	75.60	Aug 6	133.84	Oct 6	193.04	Dec 6	254.17
Feb 7	317.51	Apr 7	17.49	Jun 7	76.56	Aug 7	134.80	Oct 7	194.03	Dec 7	255.18
Feb 8	318.53	Apr 8	18.47	Jun 8	77.51	Aug 8	135.76	Oct 8	195.01	Dec 8	256.20
Feb 9	319.54	Apr 9	19.45	Jun 9	78.47	Aug 9	136.71	Oct 9	196.00	Dec 9	257.22
Feb 10	320.55	Apr 10	20.43	Jun 10	79.43	Aug 10	137.67	Oct 10	196.99	Dec 10	258.23
Feb 11	321.57	Apr 11	21.42	Jun 11	80.38	Aug 11	138.63	Oct 11	197.98	Dec 11	259.25
Feb 12	322.58	Apr 12	22.40	Jun 12	81.34	Aug 12	139.59	Oct 12	198.97	Dec 12	260.26
Feb 13	323.59	Apr 13	23.38	Jun 13	82.29	Aug 13	140.55	Oct 13	199.96	Dec 13	261.28
Feb 14	324.60	Apr 14	24.36	Jun 14	83.25	Aug 14	141.51	Oct 14	200.95	Dec 14	262.30
Feb 15	325.61	Apr 15	25.34	Jun 15	84.20	Aug 15	142.47	Oct 15	201.94	Dec 15	263.31
Feb 16	326.62	Apr 16	26.31	Jun 16	85.16	Aug 16	143.43	Oct 16	202.93	Dec 16	264.33
Feb 17	327.63	Apr 17	27.29	Jun 17	86.11	Aug 17	144.39	Oct 17	203.92	Dec 17	265.35
Feb 18	328.64	Apr 18	28.27	Jun 18	87.07	Aug 18	145.35	Oct 18	204.91	Dec 18	266.37
Feb 19	329.65	Apr 19	29.25	Jun 19	88.02	Aug 19	146.32	Oct 19	205.90	Dec 19	267.38
Feb 20	330.66	Apr 20	30.22	Jun 20	88.98	Aug 20	147.28	Oct 20	206.90	Dec 20	268.40
Feb 21	331.66	Apr 21	31.20	Jun 21	89.93	Aug 21	148.24	Oct 21	207.89	Dec 21	269.42
Feb 22	332.67	Apr 22	32.17	Jun 22	90.88	Aug 22	149.20	Oct 22	208.89	Dec 22	270.44
Feb 23	333.68	Apr 23	33.15	Jun 23	91.84	Aug 23	150.17	Oct 23	209.88	Dec 23	271.46
Feb 24	334.68	Apr 24	34.12	Jun 24	92.79	Aug 24	151.13	Oct 24	210.88	Dec 24	272.48
Feb 25	335.69	Apr 25	35.09	Jun 25	93.74	Aug 25	152.10	Oct 25	211.88	Dec 25	273.50
Feb 26	336.70	Apr 26	36.07	Jun 26	94.70	Aug 26	153.06	Oct 26	212.87	Dec 26	274.52
Feb 27	337.70	Apr 27	37.04	Jun 27	95.65	Aug 27	154.03	Oct 27	213.87	Dec 27	275.53
Feb 28	338.71	Apr 28	38.01	Jun 28	96.61	Aug 28	154.99	Oct 28	214.87	Dec 28	276.55
Feb 29	339.71	Apr 29	38.99	Jun 29	97.56	Aug 29	155.96	Oct 29	215.87	Dec 29	277.57
		Apr 30	39.96	Jun 30	98.51	Aug 30	156.93	Oct 30	216.87	Dec 30	278.59
						Aug 31	157.89	Oct 31	217.87	Dec 31	279.61

Meteor Shower Calendar: April–September 2000

compiled by Alastair McBeath and Rainer Arlt

1. April to June

Meteor activity picks up towards the April-May boundary, with showers like the Lyrids (maximum expected between April 21, 22^h UT and April 22, 5^h UT), π-Puppids (peak around April 23, 9^h UT), and η-Aquarids. Both former sources suffer from bright waning gibbous moonlight this year. During May and June, most of the activity is in the daytime sky, with six shower peaks expected during this time. Although a few meteors from the o-Cetids and Arietids have been reported from tropical and southern hemisphere sites visually in past years, sensible activity calculations cannot be carried out from such observations. For radio observers, the expected UT maxima for these showers are as shown in Table 1.

Table 1 – Expected maxima in UT for radio observations of meteor showers in April–June, 2000.

Shower	Maximum	Shower	Maximum	Shower	Maximum
April Piscids	Apr 20, 02^h	May Arietids	May 16, 01^h	ζ-Perseids	Jun 09, 03^h
δ-Piscids	Apr 24, 01^h	o-Cetids	May 20, 00^h	β-Taurids	Jun 28, 02^h
ε-Arietids	May 09, 00^h	Arietids	Jun 07, 03^h		

The ecliptical complexes continue with some late Virginids and the best from the minor Sagittarids in May–June. Visual observers hoping to see any possible June Lyrid peak this year on June 15 will be hampered severely by Full Moon.

η-Aquarids

Active: April 19–May 28; Maximum: May 5, 17^h UT ($\lambda_\odot = 45.5°$); ZHR = 60 (occasionally variable);
Radiant: $\alpha = 338°$, $\delta = -01°$; Radiant drift: see Table 3; $V_\infty = 66$ km/s; $r = 2.7$;
TFC: $\alpha = 319°$, $\delta = +10°$ and $\alpha = 321°$, $\delta = -23°$ ($\beta < 20°$ S).

This is a fine, rich stream associated with Comet 1P/Halley, like the Orionids of October, but it is visible for only a few hours before dawn essentially from tropical and southern hemisphere sites. Some useful results have come even from sites around 40° N in recent years, however, and occasional meteors have been reported from further north, but the shower would benefit from increased observer activity generally. The fast and often bright meteors make the wait for radiant-rise worthwhile, and many events leave glowing persistent trains after them. While the radiant is still very low, η-Aquarid meteors tend to have very long paths too, which can mean observers underestimate the apparent speeds of the meteors, so extra care is needed when making such angular speed estimates.

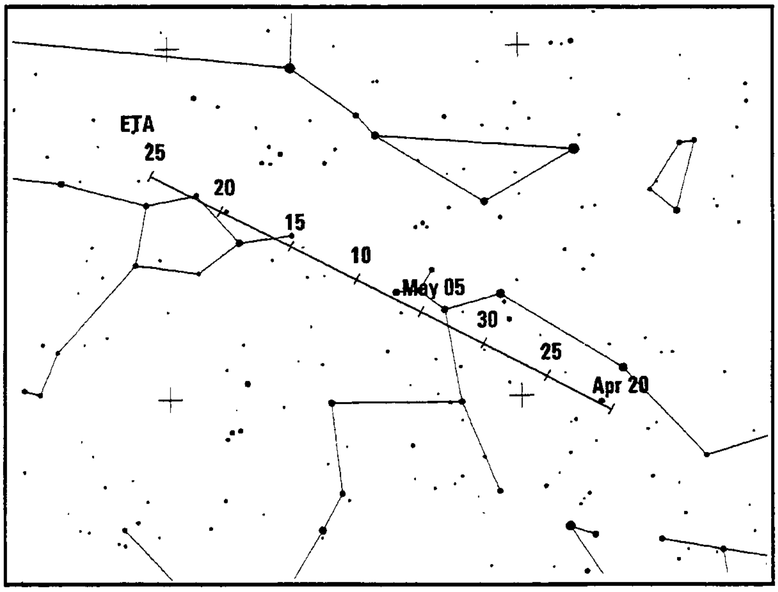

Figure 1 – Radiant position and drift of the η-Aquarids.

A relatively broad maximum, sometimes with a variable number of submaxima, usually occurs in early May. ZHRs are generally above 30 for almost a week centered on the main peak, based on *IMO* observations between 1988 and 1997. With New Moon on May 4, the shower is perfectly placed for watchers in 2000. All forms of observing can be used to study the η-Aquarids, with radio work allowing activity to be followed even from mid-northern latitude sites throughout the daylight morning hours. The radiant culminates at about 8^h local time.

June Bootids

Active: June 26–July 2; Maximum: June 27, 01^h UT ($\lambda_\odot = 95.^\circ7$); ZHR: variable, 0–100+;
Radiant: $\alpha = 224^\circ$, $\delta = +48^\circ$; Radiant drift: see Table 3; $V_\infty = 18$ km/s; $r = 2.2$;
TFC: $\alpha = 156^\circ$, $\delta = +64^\circ$ and $\alpha = 289^\circ$, $\delta = +67^\circ$ ($\beta = 25^\circ$–60° S).

Following the wholly unexpected strong return of this shower in 1998, we are delighted to reintroduce the June Bootids to the *Working List of Visual Meteor Showers* this year, and to encourage all observers to routinely monitor the expected activity period in case of future outbursts. Prior to 1998, only four definite returns of the shower had been detected, in 1916, 1921, and 1927. With no significant visual reports between 1928 and 1997, we were justified in assuming the stream no longer encountered the Earth, and accordingly removed the shower from the *Working List* in 1996. The dynamics of the stream are not well understood. The shower's parent comet, 7P/Pons-Winnecke, was last at perihelion in January 1996, and its orbit currently lies around 0.24 AU outside the Earth's orbit at its closest approach, so we have no way at present to predict likely future activity. In 1998, high June Bootid rates (ZHRs in the range 50–100+) were visible for more than half a day, beginning shortly before the time indicated above, again quite contrary to the short-lived nature of other known shower outbursts. The radiant is at a useful elevation for most of the short summer night in the northern hemisphere (only), and the waning crescent Moon, just four days from new, will present no real problems.

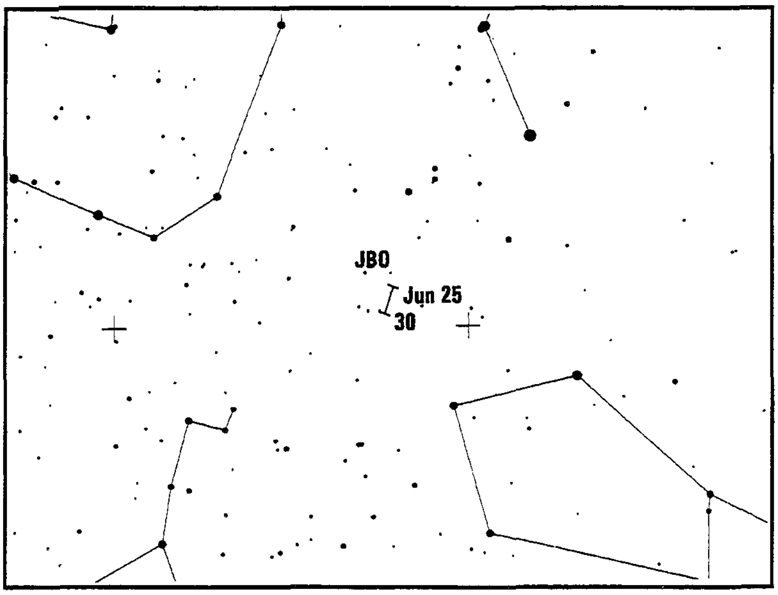

Figure 2 – Radiant position and drift of the June Bootids.

2. July to September

Minor shower activity continues apace from near-ecliptic sources throughout this quarter, first from the Sagittarids, then the Aquarid and Capricornid showers, and finally the Piscids (whose most likely peak on September 19 will suffer from the bright waning Moon) into September. The two strongest sources, the Southern δ-Aquarids and the α-Capricornids are free from moonlight this year, along with the less-active Piscis Austrinids, Southern ι-Aquarids, and Northern δ-Aquarids. Something of the Pegasids should still be seen in early July as well, but the July Phoenicids (peak July 13), Perseids (maxima expected near 5^h and 10^h UT on August 12; if the tertiary peak—seen so far only in 1997—repeats in 2000, that should fall around 19^h UT on August 12), κ-Cygnids (maximum August 17), and Northern ι-Aquarids (peak August 19) all lose their best rates to bright moonlight. The α-Aurigids are much more favorable, and even the δ-Aurigids in early September are not too unfavorable.

For daylight radio observers, the interest of May–June has waned, but there remain the visually inaccessible γ-Leonids (peak due August 25, 3^h UT, though not found in recent radio results), and a tricky visual shower, the Sextantids (maximum expected September 27, 3^h UT, but possibly occurring a day earlier). The latter prediction is perfectly timed for New Moon, though the radiant rises less than an hour before dawn in either hemisphere.

Pegasids

Active: July 7–13; Maximum: July 9 ($\lambda_\odot = 107.^\circ 5$); ZHR = 3;
Radiant: $\alpha = 340°$, $\delta = +15°$; Radiant drift: see Table 3; $V_\infty = 70$ km/s; $r = 3.0$;
TFC: $\alpha = 320°$, $\delta = +10°$ and $\alpha = 332°$, $\delta = +33°$ ($\beta > 40°$ N);
$\alpha = 357°$, $\delta = +02°$ ($\beta < 40°$ N).

Monitoring this short-lived minor shower is not easy, as a few cloudy nights mean its loss for visual observers. The shower is best-seen in the second half of the night, good news as the waxing gibbous Moon will set soon after midnight for the more favorable northern hemisphere sites, to 0^h30^m local time at 35° S. The maximum ZHR is generally low, and swift, faint meteors can be expected. Telescopic observation would be especially useful.

Piscis Austrinids

Active: July 15–August 10; Maximum: July 27 ($\lambda_\odot = 125°$); ZHR = 5;
Radiant: $\alpha = 341°$, $\delta = -30°$; Radiant drift: see Table 3; $V_\infty = 35$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to 360°, $\delta = 00°$ to +15°, choose pairs separated by about 30° in α ($\beta < 30°$ N).

Southern δ-Aquarids

Active: July 12–August 19; Maximum: July 27, 18^h UT ($\lambda_\odot = 125°$); ZHR = 20;
Radiant: $\alpha = 339°$, $\delta = -16°$; Radiant drift: see Table 3; $V_\infty = 41$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to 360°, $\delta = 00°$ to +15°, choose pairs separated by about 30° in α ($\beta < 30°$ N).

α-Capricornids

Active: July 3–August 15; Maximum: July 29 ($\lambda_\odot = 127°$); ZHR = 4;
Radiant: $\alpha = 307°$, $\delta = -10°$; Radiant drift: see Table 3; $V_\infty = 23$ km/s; $r = 2.5$;
TFC: $\alpha = 255°$ to 360°, $\delta = 00°$ to +15°, choose pairs separated by about 30° in α ($\beta < 30°$ N).
PFC: $\alpha = 300°$, $\delta = +10°$ ($\beta > 45°$ N),
$\alpha = 320°$, $\delta = -05°$ ($\beta = 00°$ to 45° N), or
$\alpha = 300°$, $\delta = -25°$ ($\beta < 0°$ S).

Southern ι-Aquarids

Active: July 25–August 15; Maximum: August 4 ($\lambda_\odot = 132°$); ZHR = 2;
Radiant: $\alpha = 334°$, $\delta = -15°$; Radiant drift: see Table 3; $V_\infty = 34$ km/s; $r = 2.9$;
TFC: $\alpha = 255°$ to 360°, $\delta = 00°$ to +15°, choose pairs separated by about 30° in α ($\beta < 30°$ N).

Northern δ-Aquarids

Active: July 15–August 25; Maximum: August 8 ($\lambda_\odot = 136°$); ZHR = 4;
Radiant: $\alpha = 335°$, $\delta = -05°$; Radiant drift: see Table 3; $V_\infty = 42$ km/s; $r = 3.4$;
TFC: $\alpha = 255°$ to 360°, $\delta = 00°$ to +15°, choose pairs separated by about 30° in α ($\beta < 30°$ N).

The Aquarids and Piscis Austrinids are all streams rich in faint meteors, making them well-suited to telescopic work, although enough brighter members exist to make visual and photographic observations worth the effort too, primarily from more southerly sites. Radio work can be used to pick up the Southern δ-Aquarids especially, as the most active of these showers. The α-Capricornids are noted for bright—sometimes fireball-class—events, which, combined with their low apparent velocity, can make some of these objects among the most impressive and attractive an observer could wish for. A minor enhancement of α-Capricornid ZHRs to about 10 was noted in 1995 by European *IMO* observers, although the Southern δ-Aquarids were the only one of these streams previously suspected of occasional variability.

Such a concentration of radiants in a small area of sky means that familiarity with where all the radiants are is essential for accurate shower association for all observing nights. Visual watchers in particular should plot all potential stream members seen in this region of sky rather than trying to make shower associations in the field. The only exception is when the Southern δ-Aquarids are near their peak, when, from southern hemisphere sites in particular, rates may become too high for accurate plotting.

In 2000, the Piscis Austrinid, Southern δ-Aquarid, α-Capricornid, and Northern ι-Aquarid maxima benefit from New Moon on July 31, while the Northern δ-Aquarid peak has only a few problems from the waxing gibbous Moon, which will set between 23^h and 1^h30^m local time in either hemisphere. All these radiants are above the horizon for much of the night.

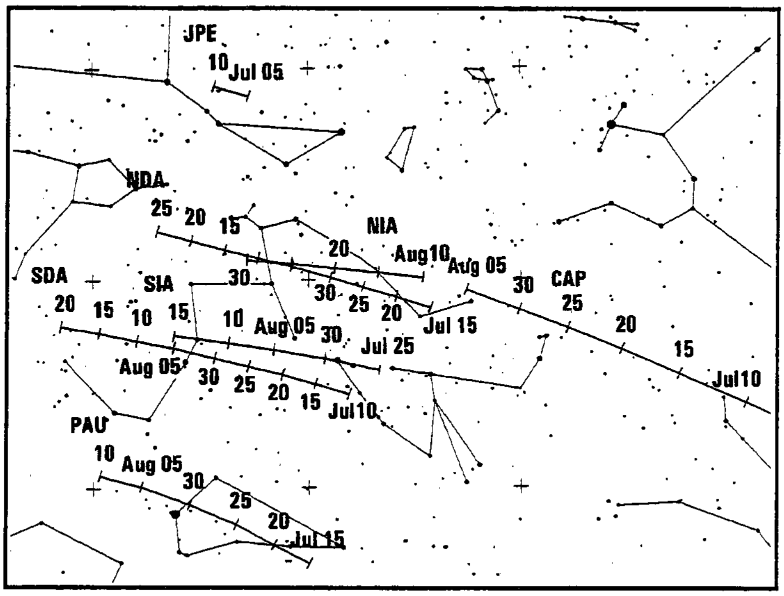

Figure 3 – Radiant position and drift of the Pegasids, Piscis Austrinids, and the Aquarid/Capricornid Complex.

α-Aurigids

Active: August 25–September 5; Maximum: August 31, 18^h UT ($\lambda_\odot = 158.^\circ6$); ZHR = 10;
Radiant: $\alpha = 84^\circ$, $\delta = +42^\circ$; Radiant drift: see Table 3;
$V_\infty = 66$ km/s; $r = 2.5$;
TFC: $\alpha = 52^\circ$, $\delta = +60^\circ$, $\alpha = 43^\circ$, $\delta = +39^\circ$, or $\alpha = 23^\circ$, $\delta = +41^\circ$ ($\beta > 10^\circ$ S).

δ-Aurigids

Active: September 5–October 10; Maximum: September 8 ($\lambda_\odot = 166^\circ$); ZHR = 6;
Radiant: $\alpha = 60^\circ$, $\delta = +47^\circ$; Radiant drift: see Table 3;
$V_\infty = 64$ km/s; $r = 3.0$;
TFC: $\alpha = 52^\circ$, $\delta = +60^\circ$, $\alpha = 43^\circ$, $\delta = +39^\circ$, or $\alpha = 23^\circ$, $\delta = +41^\circ$ ($\beta > 10^\circ$ S).

These are both essentially northern hemisphere showers, badly in need of more observations. They are part of a series of poorly observed showers with radiants in Aries, Perseus, Cassiopeia, and Auriga, active from late August into October. British and Italian observers independently reported a possible new radiant in Aries during late August 1997, for example.

Of the known showers, the α-Aurigids are the more active, with short unexpected bursts having given ZHRs in the range 30–40 in 1935, 1986, and 1994, although they have not been monitored regularly until very recently, so other outbursts may have been missed. The δ-Aurigids typically produce low rates of generally faint meteors, and have yet to be well-seen in more than an occasional year. Both radiants reach a useful elevation only after 23^h–0^h local time, meaning lunar circumstances are near-perfect for the α-Aurigid peak in 2000, with New Moon on August 29, while the δ-Aurigids enjoy dark skies after moonset (which happens between 0^h and 1^h local time north of 20° N).

Telescopic data to examine all the radiants in this region of sky—and possibly observe the telescopic β-Cassiopeids simultaneously—would be especially valuable, but photographs, video records, and visual plotting would be welcomed too.

3. Working list of meteor showers

Table 2 – Working list of meteor showers for the period April–September 2000. Notice that the Perseids may have other or additional peak times; see text. Streams marked with an asterisk are periodically or occasionally active, and therefore no ZHR is cited. The "maximum" dates cited for the Virginids and the Puppid/Velids should be seen as reference dates rather than true maxima.

Shower	Activity	Maximum		Radiant		V_∞	r	ZHR
		Date	$\lambda_\odot$	α	δ	(km/s)		
Virginids (VIR)	Jan 25–Apr 15	Mar 24	4°	195°	−04°	30	3.0	5
Lyrids (LYR)	Apr 16–Apr 25	Apr 21	32°1	271°	+34°	49	2.9	15
π-Puppids* (PPU)	Apr 15–Apr 28	Apr 23	33°5	110°	−45°	18	2.0	
η-Aquarids	Apr 19–May 28	May 05	45°5	338°	−01°	66	2.7	60
Sagittarids (SAG)	Apr 15–Jul 15	May 19	59°	247°	−22°	30	2.5	5
June Bootids* (JBO)	Jun 26–Jul 02	Jun 27	95°7	224°	+48°	18	2.2	
Pegasids (JPE)	Jul 07–Jul 13	Jul 09	107°5	340°	+15°	70	3.0	3
July Phoenicids* (PHE)	Jul 10–Jul 16	Jul 13	111°	32°	−48°	47	3.0	
Piscis Austrinids	Jul 15–Aug 10	Jul 27	125°	341°	−16°	35	3.2	5
Southern δ-Aquarids (SDA)	Jul 12–Aug 19	Jul 27	125°	339°	−30°	41	3.2	20
α-Capricornids (CAP)	Jul 03–Aug 15	Jul 29	127°	307°	−10°	23	2.5	4
Southern ι-Aquarids (SIA)	Jul 25–Aug 15	Aug 04	132°	334°	−15°	34	2.9	2
Northern δ-Aquarids (NDA)	Jul 15–Aug 25	Aug 08	136°	335°	−05°	42	3.4	4
Perseids (PER)	Jul 17–Aug 24	Aug 12	139°8	46°	+58°	59	2.6	140
κ-Cygnids (KCG)	Aug 03–Aug 25	Aug 17	145°	286°	+59°	25	3.0	3
Northern ι-Aquarids (NIA)	Aug 11–Aug 31	Aug 19	147°	327°	−06°	31	3.2	3
α-Aurigids (AUR)	Aug 25–Sep 05	Aug 31	158°6	84°	+42°	66	2.5	10
δ-Aurigids (DAU)	Sep 05–Oct 10	Sep 08	166°	60°	+47°	64	3.0	6
Piscids (SPI)	Sep 01–Sep 30	Sep 19	177°	5°	−01°	26	3.0	3

Table 3 – Radiant positions during April–September 2000 in α and δ.

					VIR			
Apr 10	**SAG**	**LYR**	**PPU**		203° −7°			
Apr 15	224° −17°	263° +34°	106° −44°	**ETA**	205° −8°			
Apr 20	227° −18°	269° +34°	109° −45°	323° −7°				
Apr 25	230° −19°	274° +34°	111° −45°	328° −5°				
Apr 30	233° −19°			332° −4°				
May 5	236° −20°			337° −2°				
May10	240° −21°			341° 0°				
May20	247° −22°			350° +5°				
May30	256° −23°							
Jun 10	265° −23°							
Jun 15	270° −23°							
Jun 20	275° −23°	**JBO**						
Jun 25	280° −23°	223° +48°						
Jun 30	284° −23°	225° +47°	**CAP**			**JPE**		
Jul 5	289° −22°		285° −16°	**SDA**		338° +14°		
Jul 10	293° −22°	**PHE**	289° −15°	325° −19°	**NDA**	341° +15°	**PER**	**PAU**
Jul 15	298° −21°	32° −8°	294° −14°	329° −19°	316° −10°		12° +51°	330° −34°
Jul 20			299° −12°	333° −18°	319° −9°	**SIA**	18° +52°	334° −33°
Jul 25			303° −11°	337° −17°	323° −9°	322° −17°	23° +54°	338° −31°
Jul 30	**KCG**		308° −10°	340° −16°	327° −8°	328° −16°	29° +55°	343° −29°
Aug 5	283° +58°	**NIA**	313° −8°	345° −14°	332° −6°	334° −15°	37° +57°	348° −27°
Aug10	284° +58°	317° −7°	318° −6°	349° −13°	335° −5°	339° −14°	43° +58°	352° −26°
Aug15	285° +59°	322° −7°		352° −12°	339° −4°	345° −13°	50° +59°	
Aug20	286° +59°	327° −6°	**AUR**	356° −11°	343° −3°		57° +59°	
Aug25	288° +60°	332° −5°	76° +42°		347° −2°		65° +60°	
Aug30	289° +60°	337° −5°	82° +42°	**DAU**				
Sep 5			88° +42°	55° +46°	**SPI**			
Sep 10				60° +47°	357° −5°			
Sep 15				66° +48°	1° −3°			
Sep 20				71° +48°	5° −1°			
Sep 25				77° +49°	9° 0°			
Sep 30				83° +49°	13° +2°			

4. Lunar phases

In Table 4, the dates for the lunar phases are the UT calendar dates in which these phases occur. As a consequence, there may be slight variances with tables that are based on local time.

Table 4 – Lunar phases for April–September 2000.

Phase	Calendar dates (UT) on which the phase occurs						
New Moon	Apr 04	May 04	Jun 02	Jul 01	Jul 31	Aug 29	Sep 27
First Quarter	Apr 11	May 10	Jun 09	Jul 08	Aug 07	Sep 05	Oct 05
Full Moon	Mar 20	Apr 18	May 18	Jun 16	Jul 16	Aug 15	Sep 13
Last Quarter	Mar 28	Apr 26	May 26	Jun 25	Jul 24	Aug 22	Sep 21

5. Radiant sizes and meteor plotting

If you are not observing during a major-shower maximum, it is much more essential to associate meteors with their radiants correctly, since the total numbers will be small. Meteor plotting allows the shower association by more objective criteria than the prolongation of paths under the sky. As you plotted the meteors on gnomonic maps, you can trace the radiant by straight lines. If the radiant lies on another chart, you should find common stars on an adjacent chart to extend the backward prolongation there. How large should the radiant be assumed for shower association? The physical radiant size is very small; visual plotting errors cause many true shower meteors to pass the radiant outside this area. We have to assume a larger radiant. The opposite behavior is caused by sporadic meteors—more and more sporadics line up accidentally upon enlarging the radiant. Hence, we have to apply an optimum radiant diameter compensating the loss due to plotting errors, and the sporadic meteor pollution. Table 5 gives the optimum diameter as a function of the distance of the meteor from the radiant.

Table 5 – Optimum radiant diameters ("Diameter") to be assumed for shower association of minor-shower meteors as a function of the radiant distance ("D") of the meteor.

D	Diameter	D	Diameter
15°	14°	50°	20°
30°	17°	70°	23°

The direction of the path is not the only criterion for shower association. The angular velocity of the meteor should match the expected speed of the shower meteors according to the geocentric velocity of the meteoroids. Angular velocity estimates should be made in degrees per second (°/s). In your imagination, you make the meteors move for one second. The path length of this imaginary meteor is the angular velocity in °/s. Note that typical speeds are in the range 3°/s–25°/s. Typical errors of such estimates are given in Table 6.

Table 6 – Error limits for the angular velocity.

Angular velocity (°/s)	5	10	15	20	30
Permitted error (°/s)	3	5	6	7	8

Table 7 gives the angular speeds for a few geocentric velocities, which can be looked up in Table 2 for each shower.

Table 7 – Angular velocities as a function of the radiant distance and the elevation of a meteor for three different geocentric velocities. All velocities are in °/s. The tables are symmetric: you can read radiant distance horizontally and elevation vertically, or vice-versa.

$h\backslash D$	$v_\infty = 25$ km/s					$v_\infty = 40$ km/s					$v_\infty = 60$ km/s				
	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°
10°	0.4	0.9	1.6	2.2	2.5	0.7	1.4	2.6	3.5	4.0	0.9	1.8	3.7	4.6	5.3
20°	0.9	1.7	3.2	4.3	4.9	1.4	2.7	5.0	6.8	7.9	1.8	3.5	6.7	9.0	10
40°	1.6	3.2	5.9	8.0	9.3	2.6	5.0	9.5	13	15	3.7	6.7	13	17	20
60°	2.2	4.3	8.0	11	13	3.5	6.8	13	17	20	4.6	9.0	17	23	26
90°	2.5	4.9	9.3	13	14	4.0	7.9	15	20	23	5.3	10	20	26	30

6. Daytime radio meteor streams

In the working list of daytime radio meteor streams (Table 8, below), the "Best Observed" columns give the approximate local mean times between which a four-element antenna at an elevation of 45° receiving a signal from a 30-kW transmitter 1000 km away should record at least 85% of any suitably positioned radio-reflecting meteor trails for the appropriate latitudes.

Note that this is often heavily dependent on the compass direction in which the antenna is pointing, however, and applies only to dates near the shower's maximum.

Table 8 – Working list of daytime radio meteor streams.

Shower	Activity	Max	$\lambda_\odot$	Radiant		Best Observed		Rate
		Date	2000.0	α	δ	50° N	35° S	
Piscids (Apr)	Apr 08–Apr 29	Apr 20	30°3	7°	+07°	07^h–14^h	08^h–13^h	low
δ-Piscids	Apr 24–Apr 24	Apr 24	34°2	11°	+12°	07^h–14^h	08^h–13^h	low
ε-Arietids	Apr 24–May 27	May 08	48°7	44°	+21°	08^h–15^h	10^h–14^h	low
Arietids (May)	May 04–Jun 06	May 16	55°5	37°	+18°	08^h–15^h	09^h–13^h	low
o-Cetids	May 05–Jun 02	May 19	59°3	28°	−04°	07^h–13^h	07^h–13^h	medium
Arietids	May 22–Jul 02	Jun 07	76°7	44°	+24°	06^h–14^h	08^h–12^h	high
ζ-Perseids	May 20–Jul 05	Jun 09	78°6	62°	+23°	07^h–15^h	09^h–13^h	high
β-Taurids	Jun 05–Jul 17	Jun 28	96°7	86°	+19°	08^h–15^h	09^h–13^h	medium
γ-Leonids	Aug 14–Sep 12	Aug 25	152°2	155°	+20°	08^h–16^h	10^h–14^h	low
Sextantids*	Sep 09–Oct 09	Sep 27	184°3	152°	00°	06^h–12^h	06^h–13^h	medium

7. Additional information

More information can always be obtained by addressing yourself to the relevant *IMO* Commission. Addresses (including e-mail addresses) are mentioned on the inside back-cover.

Ongoing Meteor Work

Possible New Radiant in Early February

Jürgen Rendtel and George W. Gliba

Based on visual observations in 1997 and 1999, the existence of a radiant in Bootes near $\alpha = 220°$, $\delta = +15°$ is suspected. Visual and video meteor recordings in early February 2000 reveal a situation which looks more complex. The video data hint on a radiant at a more easterly position at $\alpha = 233°$ and $\delta = +12°$ for the period February 1 to 10. Detectable activity from that region may last from end-January until mid-February. The scattered radiant positions derived from visual meteor plots are discussed. Other sources give little hint on a radiant in the Bootes region.

1. Introduction

Visual observations on February 5-6, 1997, suggested the existence of a minor meteor shower called the ξ-Bootids [1]. George W. Gliba saw 14 meteors of medium speed in 2.5 hours coming from the area near the star ξ Bootis during the Winter Star Party in the Florida Keys. Further observations were done on the three following nights. In a total of 7.5 hours, from the morning of February 6 to 9, a total of 26 meteors was seen coming from this suspected radiant area.

Then, two years later, in the morning of January 26, 1999, four possible ξ-Bootids were plotted by the Canadian meteor observer Pierre Martin in 1.6 hours, fitting a radiant at $\alpha = 209°$ and $\delta = +22°$, which may have been a confirmation that the shower was an annual one, and started in late January.

2. Recent observations and radiant position

This year, more observations became available, applying both visual and video techniques. Robert Lunsford from Southern California plotted meteors on February 1-2. He wrote to the *NAMN Meteorobs Newsgroup*: *"...plots revealed no less than 5 areas in or near Bootes that produced at least 3 meteors each. Four of the five are most likely chance alignments. The other area may be confirmation of the ξ-Bootids. An area centered near $\alpha = 211°$, $\delta = +16°$ produced 5 meteors with acceptable velocities."* Further reported radiant positions are summarized in Table 1.

Table 1 – Summary of the reported radiants in the Bootes region in early February 2000. The number of plots in each sample is quite low, hence plotting errors may have a great effect on the derived radiant position. There is also no accuracy information for the positions except the video data (±0°5 in both coordinates). The last entry is calculated with the RADIANT software, including the full available velocity information [2].

Date	α	δ	Meteors	Observer and remarks
February 1-2	211°	+16°	5	R. Lunsford, California
February 2-3	212°	+12°	3	K. Youmans, Georgia; 2.00 h
February 4-5	212°	+14°	5	K. Youmans, Georgia; 3.25 h
February 5-6	221°	+28°	6	J. Atanackov, Slovenia
February 5-6	220°	+15°	14	M. Linnolt, Hawaii
February 5-6	213°	+16°	10	K. Youmans, Georgia; 3.07 h
February 5-6	218°	+21°	5	G.W. Gliba, Maryland; 1.95 h
February 1–10	234°	+12°	42	AVIS, CARMEN, Germany

On February 3, Bob Lunsford sent a note to Sirko Molau and Jürgen Rendtel, asking to include the ξ-Bootids into the list for their automated video meteor cameras. Both the AVIS and CARMEN video meteor cameras were running in different nights between January 25 and February 17. A total of 256 meteors was available for our radiant analysis. A first calculation using Rainer Arlt's RADIANT software [2] was carried out with a small data set of the CARMEN camera obtained in the nights of February 3-4 and 5-6 only. The 18 meteors contributing to this display yielded a distinct radiant at $\alpha = 229°$ and $\delta = +14°$, assuming a geocentric velocity of 50 km/s. Peter Gural recorded two ξ-Bootids with poor weather conditions on February 5-6 in Northern Virginia. So it seemed that the radiant was well confirmed.

Now, with the larger data sample mentioned above, we expected an improvement of the result. We used the entire data set of 256 video meteors, of which 145 contributed to a display showing the region of Bootes (Figure 1). The radiant at the above mentioned position obviously shifted further east to $\alpha = 236°$ and $\delta = +14°$, even if a lower or higher geocentric velocity was assumed. Moreover, we obtained a significant radiant at $\alpha = 233°$ and $\delta = +30°$ in Corona Borealis, which is stronger for $V_\infty = 70$ km/s than for 50 km/s. The radiant between δ and β Serpentis is more than 15° east of the position given by the visual observers.

Since the most activity was reported around February 5, we looked in more detail at the data collected in the period between February 1 and 10. Since most of the visual observers probably prolongate the meteor trails backwards and look for intersections, we did the same with the video data. This means, we ignored the velocity information. This display (Figure 2) nicely shows the suspected radiant at $\alpha = 221°$ and $\delta = +18°$. Including the angular velocity data and using the same 34 meteor trails, we obtained the display shown in Figure 3, with the same radiants found from the complete sample.

The video meteor data obtained between February 5 and 17 indicate that the radiant in Serpens weakens, while the radiant in Corona Borealis (again better if a geocentric velocity of 60 km/s is assumed) continues to exist (Figure 4).

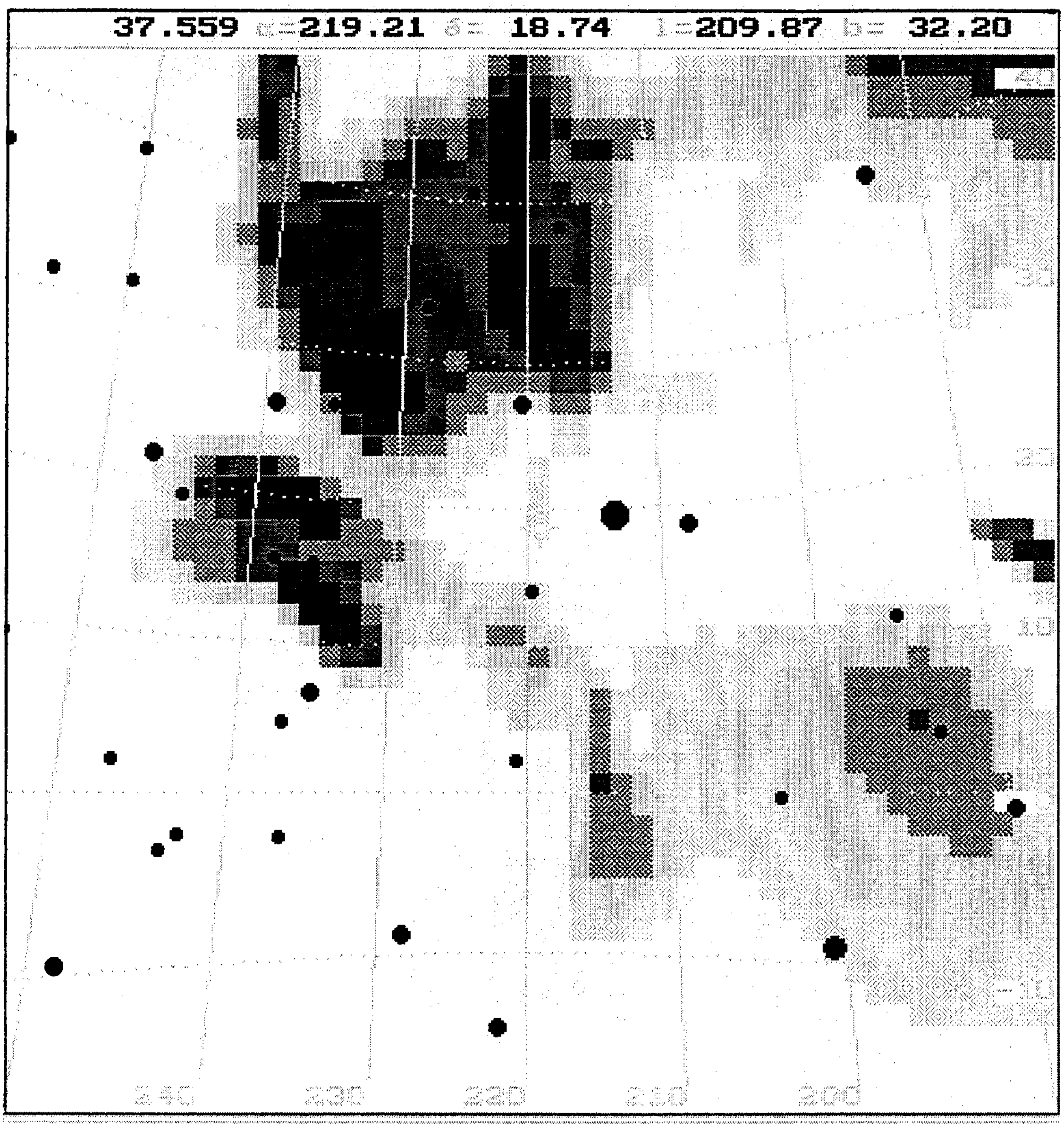

Figure 1 – Radiant display obtained from all 256 video meteors observed by the AVIS camera (Sirko Molau) and the CARMEN camera (Jürgen Rendtel) between January 25 and February 17, 2000. The assumed geocentric velocity is 50 km/s. The main radiant is at $\alpha = 233°$ and $\delta = +30°$; the standard deviation of the coordinates is $0.^{\circ}45$. The other significant radiant is at $\alpha = 236°$ and $\delta = +14°$ between δ and β Serpentis east of the position given by the visual observers.

3. Conclusions

Determining a radiant position from backwards prolongations of the meteor trails may be the case for the difference in positions given by visual and video observers. However, the intersection of these lines is only a necessary condition. The angular velocity of a meteor has to fit the geocentric velocity, the distance of the meteor from the radiant, and the position in the sky as described in detail in [3]. The radiant image will look quite different from a simple backwards prolongation display if the trail lengths and angular velocities as well as the plotting accuracies are included.

Seeing the scatter of positions listed in Table 1 and considering the accuracy of visual plots, the position of the radiant in Bootes remains uncertain as for now.

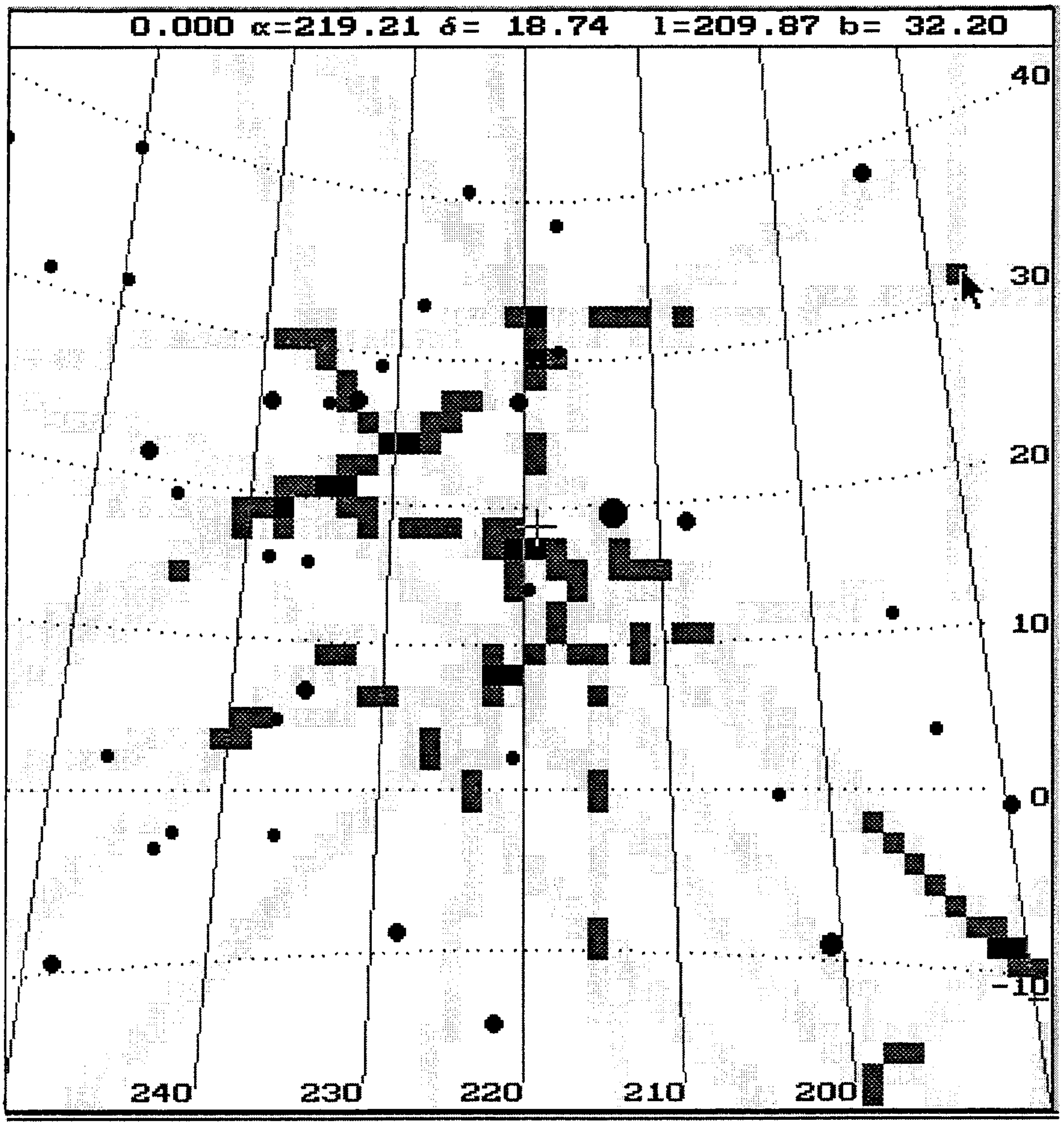

Figure 2 – Here, we considered meteors observed between February 1 and 10, and used just backwards prolongations. Interestingly, we find two positions which suggest the existence of a radiant. The northern one at $\alpha = 221°$ and $\delta = +18°$ is very close to the originally suspected ξ-Bootid radiant position. This may be a hint on the nature of the radiant reported by visual observers.

The position derived from the video meteors observed in the period February 1–10 is in Serpens rather than in Bootes. Hence the designation "ξ-Bootids" seems inappropriate, and further data is needed to clarify the radiant as well as the activity. A radiant in Corona Borealis may exist during the entire period.

Additionally, we were checking other sources for confirmation of earlier activity from the radiant. Not too much surprising is the fact that the number of radiants in February listed in different compilations is quite small.

Recently, Trevor Pendleton has communicated to the *Meteorobs* list a mention of a ξ-Bootid radiant in the *British Meteor Society*'s *Radiant Catalogue* [4]. This activity is listed from January 31 to February 5, with a radiant position at $\alpha = 218°$ and $\delta = +21°$. This may be interpreted as a hint on the annual nature of this possible stream, although the references for the data included in this catalog are insufficient.

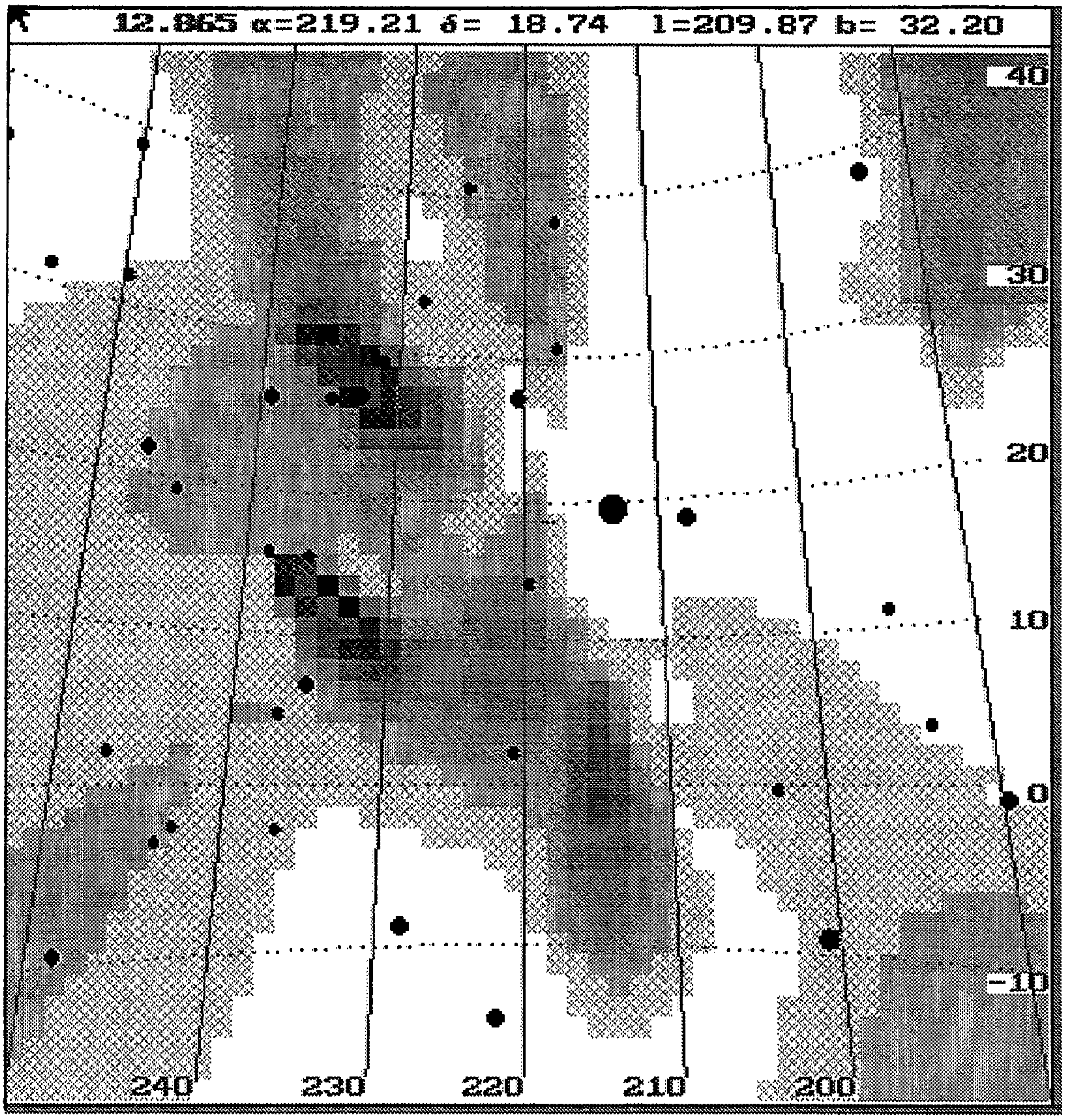

Figure 3 – From the same 34 meteor trails used to calculate the display shown in Figure 2, but now, considering the angular velocity data, we obtain this display. Here we find the two radiants already derived from the entire sample (Figure 1). Since the radiant in Serpens ($\alpha = 234°$ and $\delta = +12°$) appears stronger in this subset, we may conclude that a related activity is higher in the period February 1–10.

Hoffmeister's radiant search [5] does not include any hint at all on a corresponding activity in his lists.

Most video observations so far were restricted to activity periods of major showers. Japanese observers carried out double-station video observations in January and February 1996 and 1999 [6], but among these are no radiants fitting the Bootes region (see: *MSSWG Meteoroid Orbits* (multi station) from Shigeno et al., accessible via the *IMO*'s web site.) Their current catalog does not include any meteor with a radiant in the vicinity of the investigated region.

Currently, the data are not sufficient to come to a decisive conclusion. Based on the current analysis, however, it now looks like the ξ-Bootids were only an artifact, due to the limitations of visual means to resolve two close radiants. Plus, as most observers were facing south-east, the sample of meteors they got also contributed to the appearance of a false radiant in Bootes. Nevertheless, it seems worth checking other positional data collected in previous years.

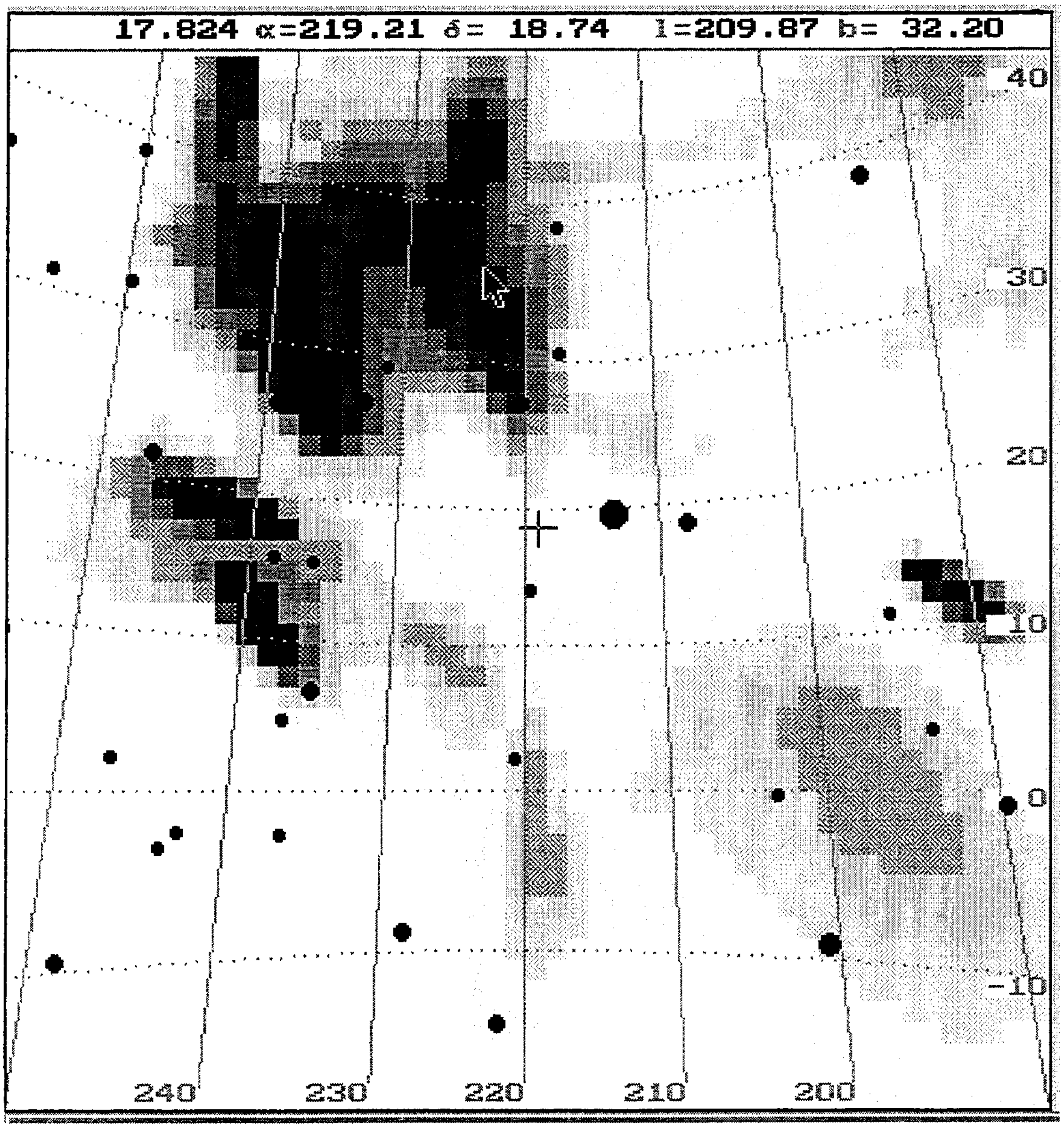

Figure 4 – This display is calculated from video meteors observed between February 5 and 17 (91 meteors displayed). The radiant in Serpens is weaker now, while the radiant in Corona Borealis remains relatively strong.

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First Analysis of Global Data of the 1999 Geminids

Jürgen Rendtel

A very preliminary analysis of global visual data collected from the 1999 Geminids is based on 6969 shower meteors recorded by 59 observers within 200 hours of effective observing time. The population index profile of the central region shows a decrease from $r = 2.75 \pm 0.06$ to $r = 1.85 \pm 0.10$. This covers the entire 13-hour interval with a ZHR exceeding 80. The peak ZHR of 122 ± 6 occurred at $\lambda_{\odot} = 262^{\circ}.2$ (eq. J2000.0), corresponding to December 14, 1999, $17^{\rm h}$ UT. The profiles are compared with results obtained from previous Geminid returns.

1. Introduction

This first and very preliminary analysis of global visual Geminid data collected in December 1999 is based on reports of 59 observers from 17 countries who sent their data immediately after the observations. The material comprises 8449 meteors, of which 6969 were Geminids, observed within 200.5 hours effective observing time. The 1999 Geminid return was favorable with regard to the Moon's phase. However, many observers reported bad weather conditions. Therefore, the data set looks less impressive than the "famous" Geminid data from 1996 [1] or 1993 [2]. The lunar conditions and the spread of the observers' locations over the geographic longitudes gives a relatively good temporal coverage. Below, we print the list of observers who sent their data by end December 1999 (effective observing time given in brackets). Several other reports have reached us since, though.

> Jure Atanackov ($0^{\rm h}.90$), Juan Aveledo ($1^{\rm h}.55$), Neil Bone ($8^{\rm h}.13$), Amol Chitale ($1^{\rm h}.00$), Ian W. Cooper ($1^{\rm h}.00$), Tim Cooper ($7^{\rm h}.00$), Mark Davis ($2^{\rm h}.00$), Peter Detterline ($5^{\rm h}.49$), Asdai Díaz Rodriguez ($1^{\rm h}.33$), Frank Enzlein ($2^{\rm h}.08$), Yuwei Fan ($8^{\rm h}.40$), Sandy Ferguson ($2^{\rm h}.41$), Mildred Formosa ($1^{\rm h}.00$), Kai Gaarder ($4^{\rm h}.92$), Martin Galea ($1^{\rm h}.18$), Christoph Gerber ($1^{\rm h}.00$), George W. Gliba ($1^{\rm h}.00$), Roberto Gorelli ($1^{\rm h}.00$), Michal Haltuf ($4^{\rm h}.42$), Sun Hao ($0^{\rm h}.97$), Takema Hashimoto ($7^{\rm h}.00$), Roberto Haver ($3^{\rm h}.36$), Kamil Hornoch ($2^{\rm h}.16$), Richard Huziak ($2^{\rm h}.50$), Rahul Jani ($1^{\rm h}.11$), He Jingyang ($1^{\rm h}.00$), Javor Kac ($1^{\rm h}.32$), Albert Kong ($3^{\rm h}.35$), Wen Kou ($4^{\rm h}.30$), Andrew Krochko ($0^{\rm h}.50$), Adrian Lelyen ($1^{\rm h}.57$), Robert Leyland ($1^{\rm h}.93$), Mihir Limaye ($0^{\rm h}.75$), Mike Linnolt ($4^{\rm h}.70$), Vladimir Lukić ($2^{\rm h}.08$), Robert Lunsford ($6^{\rm h}.33$), Michael Matiazzo ($2^{\rm h}.04$), Francisco Munhoz ($1^{\rm h}.48$), Sven Näther (18.06), Prakash Nitsure ($1^{\rm h}.49$), Arvind Paranjpye ($1^{\rm h}.47$), Trevor Pendleton ($4^{\rm h}.00$), Tushar Purohit ($1^{\rm h}.25$), Rui Qi ($11^{\rm h}.20$), Jürgen Rendtel ($14^{\rm h}.67$), Mileny Roche Lamas ($1^{\rm h}.99$), Francisco Rodriguez Ramirez ($3^{\rm h}.82$), Wade Selvig ($1^{\rm h}.09$), Miguel Serra Martin ($1^{\rm h}.25$), Mike Stephens ($2^{\rm h}.00$), Chensheng Sun ($7^{\rm h}.11$), Gabriela Triglav ($2^{\rm h}.96$), Mihaela Triglav ($2^{\rm h}.10$), Di Wang ($7^{\rm h}.28$), Roland Winkler ($1^{\rm h}.52$), Nikolai Wünsche ($0^{\rm h}.50$), Xiangdong Yin ($6^{\rm h}.10$), Kim Youmans ($4^{\rm h}.19$), and Ilkka Yrjölä ($2^{\rm h}.23$).

The 59 observers were based in these 17 countries:

> Canada, China, Cuba, Czech Republic, Finland, Germany, India, Italy, Japan, Malta, New Zealand, Norway, Slovenia, Spain, South Africa, the United Kingdom, and the United States.

2. Population index profile

First, we calculate the population index profile. As in other recent shower activity analyses, we use the procedures for computing the population index r briefly described in [3]. Figure 1 shows the r-profile for the period between $\lambda_{\odot} = 259^{\circ}$ and $\lambda_{\odot} = 265^{\circ}$, i.e., between December 11, $12^{\rm h}$ UT and December 17, $10^{\rm h}$ UT.

During the first and last day of this period, the rates are generally below 10. The r-profile shows the known shape derived from many previous returns [4]. The first maximum at $\lambda_{\odot} = 261^{\circ}.2$ (December 13, $16^{\rm h}$ UT) with $r = 2.75 \pm 0.06$ occurred earlier and was somewhat higher than the average of $r = 2.47 \pm 0.05$ at $261^{\circ}.73$ found from past moonless returns [4]. At this preliminary stage of the analysis, it is not clear whether this is caused by the limited data sample. Then, the value of r continuously decreases to 1.85 ± 0.10 at $\lambda_{\odot} = 262^{\circ}.8$ (December 15, $6^{\rm h}$ UT). Again, this is a longer period of downslope as compared to the analysis presented in [4], when the minimum is reached at $\lambda_{\odot} = 262^{\circ}.48$ with $r = 1.94 \pm 0.06$. This makes the mass segregation within the meteoroid stream obvious, and we may suspect that the period over which this particle sorting took place lasted longer in 1999 than observed at previous returns. However, completing the data set with reports arriving later may alter the details derived from the present sample.

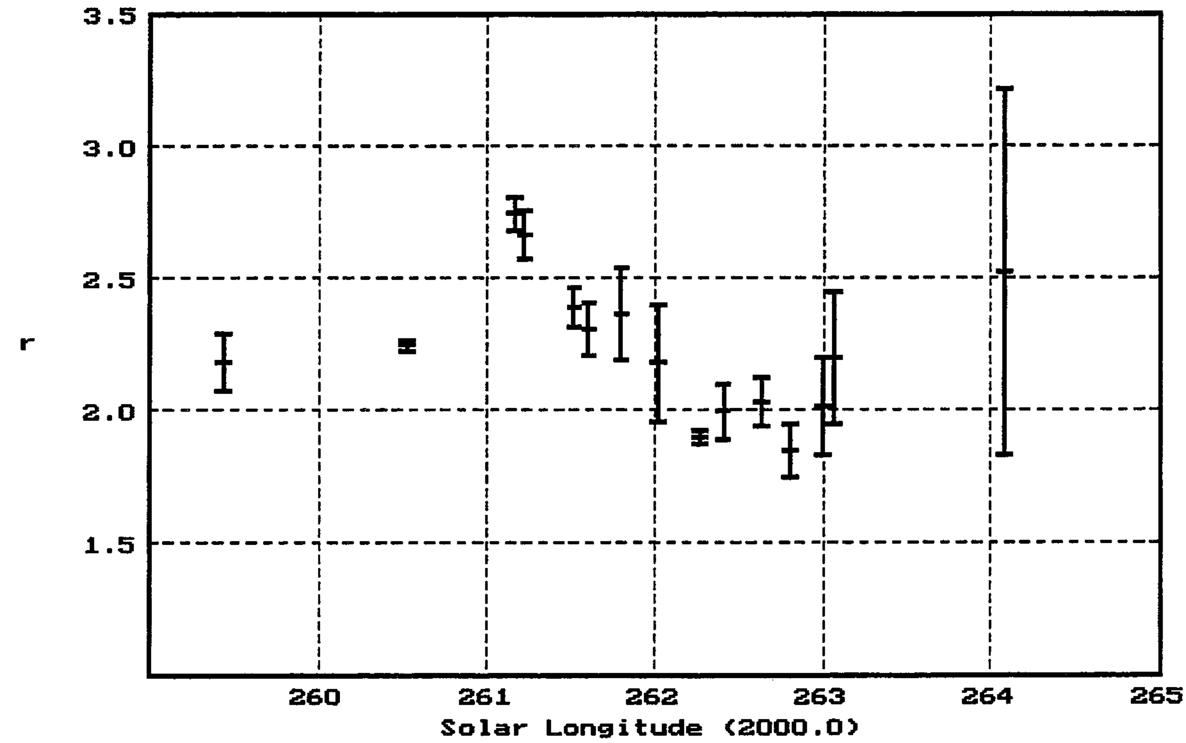

Figure 1 – Profile of the population index r of the 1999 Geminids calculated from the meteor magnitude data. More than 1°5 in solar longitude before and after the activity peak, we can assume $r \approx 2.2$, while the value of r shows a strong variation during the passage of the central region of the stream. It starts with $r = 2.75 \pm 0.06$ while entering the stream's core, and decreases steadily

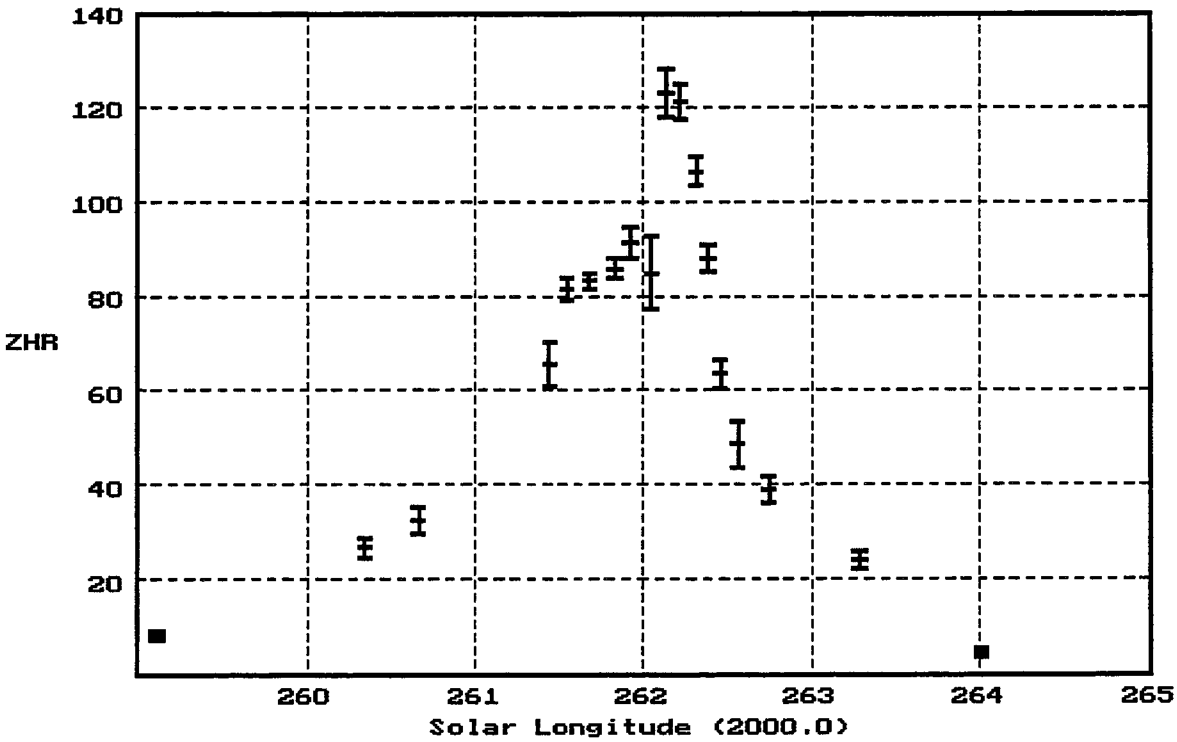

Figure 2 – Activity profile of the 1999 Geminids. The ZHR exceeds 80 for about 13 hours and reaches a sharp peak at $\lambda_{\odot} = 262°2$ with ZHR = 122 ± 6, corresponding to December 14, 1999, at 17^{h} UT.

3. ZHR profile

The hourly sporadic rates in mid-December are of the order of 15. Calculating the ZHR profile from the observed data by using the derived r-profile, we find that the Geminids exceed the sporadic activity level from December 12.0 to December 16.0 (Figure 2).

The ZHR profile is skew with a sharp decrease of rates after the peak at $\lambda_\odot = 262\overset{\circ}{.}2 \pm 0\overset{\circ}{.}1$ (corresponding to December 14, 17^h UT) with a ZHR of 122 ± 6. This fits very well with the time of previous peaks (see summary table in [1]). We also find a period of high ZHRs before the peak, although the shape is somewhat different as compared with previous returns. The activity plateau with ZHRs exceeding 80 starts at $\lambda_\odot = 261\overset{\circ}{.}6$ (1999 December 14, 4^h UT) as found in other analyses [1,4] and ends at $\lambda_\odot = 262\overset{\circ}{.}3$ with a steep decrease of the ZHR. With a duration of 13 hours, the activity plateau fits well with the results derived from previous returns with a temporal resolution of the order of $0\overset{\circ}{.}05$ in solar longitude. The timings and rate levels published in recent publications (see [1,2,4] and references therein) also suggest that the general particle distribution within the Geminid meteoroid stream did not significantly change over a period of at least 13 years.

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Daytime Taurid Complex Stream Activities, May–July 1999: A Provisional Report

Alastair McBeath

Details of various meteoric and associated events and observations which occurred during the expected active epochs of the daylight ζ-Perseids (May 20 to July 5) and β-Taurids (June 5 to July 17) are presented and discussed. The evidence for a possible recurrence of the Taurid Complex "swarm" during either shower in 1999 is found to be generally inconclusive, but some anomalous events are highlighted for future investigations.

1. Introduction

In [1], David Asher described a theoretical resonant swarm of particles within the Taurid/β-Taurid stream which could account for various meteor shower enhancements, increased fireball fluxes, and even meteoritic impacts associated with the Taurid Complex of meteoroid streams, asteroids, and comets. He also suggested times when future returns of this "swarm" might yield increased activity from the Taurids of October–November, and the daytime β-Taurids in June–July. He indicated that 1999 might bring a return of the swarm during the β-Taurids, and, following consultations with him, I issued a further warning notice in mid-June 1999 on the *IMO-News* e-mailing list [2]. The importance of covering the predicted swarm return in June–July 1999 was heightened following the discovery of an enhanced Taurid period detected by radio and visual observers in the closing days of October 1998, coupled with an increased flux of minor Taurid fireballs [3]. This unusual activity was subsequently confirmed from the *IMO*'s *Visual Meteor Data Base* [4], showing combined Taurid ZHRs of 8–12 between October 28 and November 1. There is an indication in the *IMO* observations that most of the enhancement may have come from the Southern Taurids. October–November 1998 was another time highlighted by Asher as one when a swarm reappearance might be encountered. As this enhancement was detected by forward scatter radio methods, it was hoped any daylight swarm appearance might also be recorded in this way in 1999.

Subsequent discussions of events observed in June–July 1999 prompted David Asher to suggest that perhaps the ζ-Perseids, another daylight shower peaking in June associated with the Taurid Complex, might also show enhanced activity due to the swarm [5]. The next section discusses some of the known features of both showers.

2. ζ-Perseids and β-Taurids

Neither shower has been seriously examined in recent times, with the most up to date published radar observations dating to 1969 ([6, pp. 107–109 and 115–118] references all the important publications for both showers up to the mid-1980s. No later useful material has yet been found). Consequently, all the parameters given here must be regarded in this light. For example, examining radio results from 1994–1997 [7], there was good agreement between the expected ζ-Perseid maximum at $\lambda_\odot = 79°$ (eq. J2000.0) and a significant peak in echo counts near the same solar longitude, but for the predicted β-Taurid peak around $\lambda_\odot = 97°$, the nearest echo count maximum of suitable strength was found 3–5 days earlier than anticipated, between $\lambda_\odot = 91°$ and $\lambda_\odot = 93°$. There were also signs of weaker activity bracketing this "peak" during the period $\lambda_\odot = 89°$–$99°$, though it is not clear if this activity belonged to the β-Taurids, nor whether it represented a shift in the maximum time by several days if so. The $\lambda_\odot = 89°$–$99°$ spell is at least comparable in length to the Taurid maximum period in early November.

There is some disagreement in the literature concerning the shower parameters for both the ζ-Perseids and the β-Taurids. Reasonable average radiant positions, maximum dates and active periods are given for them in the *IMO Meteor Shower Calendar* annually, and are repeated here as Table 1. The discussion by Kronk [6], referred to above, gives useful summaries of the uncertainty regarding these features. The times of maxima have been unexpectedly problematical, and often seem dependent on an assumed nodal crossing time, when the radar equipment in question was not operational for long enough during the shower to determine the peak by observation. With regard to the ζ-Perseids, "peaks" around June 2, 8–9, and 12 have been suggested, while the β-Taurids have been generally accredited with a long, flat maximum running between the last week of June into the first week of July. The β-Taurid radiant may well be large and diffuse, making it harder to pin down precisely. This may also account for seeming variations in the ζ-Perseid radiant found in different radar surveys, if its radiant too is larger than most other showers.

Table 1 – Assumed shower parameters for the ζ-Perseids and β-Taurids.

Shower	Period	Maximum	$\lambda_\odot$	Radiant	
		(1999)	(J2000.0)	α	δ
ζ-Perseids	May 20–Jul 05	June 09	78°6	62°	+23°
β-Taurids	Jun 05–Jul 17	June 28	96°7	86°	+19°

Both streams have orbital characteristics that tie them in with the Taurids of October-November, and thus Comet 2P/Encke and the other bodies and meteoroid streams of the Taurid Complex. The matches are not precise enough to determine whether the Taurids and ζ-Perseids/β-Taurids represent two encounters by the Earth with the same stream, or as separate streams following very similar orbits. However, the apparently comparable behavior between the β-Taurids and Taurids especially suggests we may use our more detailed knowledge of the Taurids to infer avenues to explore with the β-Taurids at least. For instance, the Taurid enhancement of late October 1998 could indicate any similar swarm-related enhancement of the β-Taurids might occur up to 5–8 days before their expected maximum.

3. Observations examined

It was felt advisable to examine events which happened during the whole period the ζ-Perseids and β-Taurids were liable to be active from the discussion above, and thus defining dates for this investigation of May 20 to July 17 were set.

The nature of any swarm recurrence from the daytime Taurid Complex streams of May–July is uncertain. The late October 1998 event produced only about twice the expected percentage of Taurid fireballs, none of which were brighter than magnitude −8, and most were around magnitudes −3 to −5 in *SPA Meteor Section* (*SPAMS*) data. The ZHR enhancement brought combined Taurid activity up to the normal maximum level for visual observers, but was obvious in the radio observations chiefly because just the declining Orionid activity, plus steady minor shower and sporadic rates, were in competition with it.

In May–July, there are often problems for radio observers because of the occurrence of ionized sheets or clouds in the upper part of the meteor ablation zone, Sporadic-E, abbreviation "Es" (cf. [8] for a description and discussion of Es). Furthermore, May–June brings the single-most active spell for daytime meteor showers in the whole year, with six sources having radiants drifting through the Aries-Cetus-Taurus-Perseus region between late April and mid July, none of which can be reliably observed using normal optical techniques. However, despite these drawbacks, radio meteor detection was the single most useful tool available to employ, so radio results from *Radio Meteor Observation Bulletins* (*RMOB*s) 70 to 73 (June to September 1999) were examined in preparing this report. The full list of observers will be published in the normal bi-monthly *SPAMS* results articles in *WGN* in due course. Figure 1 shows a representative radio data set obtained from Europe.

Es was a particular problem for all observers throughout the entire period investigated here, as demonstrated by Figure 2, which gives some details from Europe and Japan. There is a general coincidence with notably bad Es dates in both regions, though the Japanese had fewer, and less extensive, Es events overall. Es sometimes occurs during or soon after an unusual meteoric event (e.g., the 1946 Draconids, 1991 Perseids, or 1996 Leonids), and has more generally been known to show influence due to fluctuations in meteor activity (for references and discussion, see [8]), so a list of the stronger or more widespread Es events was also compiled from *RMOB* data.

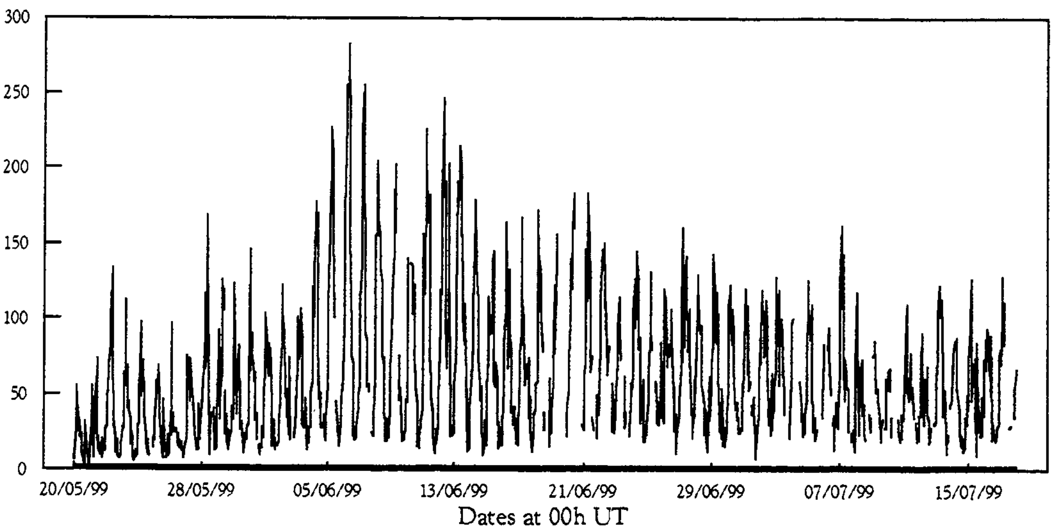

Figure 1 – Raw hourly radio meteor percentage reflection time echo counts (×10) from data collected by Ghent University in Belgium, between May 20 and July 17, 1999. Breaks in the data are due to non-operation of the equipment, often because of Es interference, which was especially problematical during June. Data taken from reports in *RMOB*s 70–72 (June–August 1999)

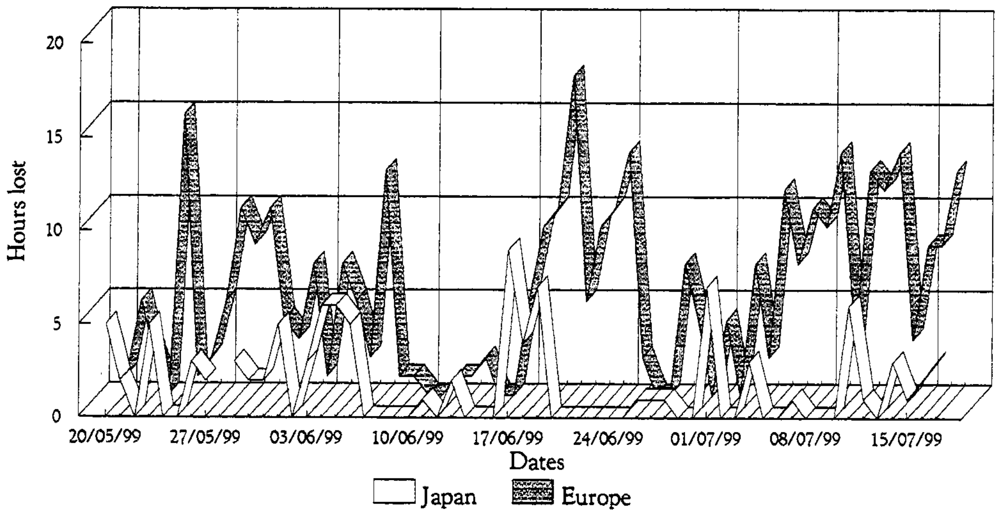

Figure 2 – Representative hours of radio observation lost to Es per day from May 20 to July 17, 1999. Data collected by Werfried Kuneth in Europe and Sadao Okamoto in Japan, the two regions most of the radio data was secured from. The gap in Okamoto's data on May 27–28 was due to equipment failure. Data extracted from reports in *RMOB*s 70–72 (June–August 1999).

A similar phenomenon to Es, but found nearer the base of the meteor ablation zone in the atmosphere is noctilucent clouds (NLC), which I discussed at length in [8]. NLC are thin ice-crystal clouds formed when water vapor condenses and freezes around minute dust particles and ions, primarily believed to be of meteoric origin. There is some debate as to how much influence variations in meteoric activity have on NLC occurrence, though very little detailed work has been done in this area. Gadsden [9] for instance sees no meteoric influence at all, preferring instead to invoke only an influence from the troposphere or stratosphere, 40–90 km below the NLC formation region. Archenhold [10], however, maintained there was a meteoric influence on NLC appearance, commenting that June 30 ± 1 ($\lambda_\odot \approx 97°$) was a particularly prevalent time for NLC to happen.

The location of the NLC zone within the main meteor ablation region makes it almost inconceivable there can be absolutely no meteoric influence on NLC formation, but as I examined in [8], the influence may be more subtle and less immediate than might be supposed. Allowing that there may be some meteoric effects on NLC formation, provisional details for all unusual NLC nights from May to July were obtained from Tom McEwan [11], who compiles regular international summaries of NLC events each northern summer, for use here.

Visual meteor observers were faced with a very difficult prospect as the ζ-Perseid and β-Taurid radiant centers lie about 15° west of the Sun on June 9 and about 10° west of the Sun on June 28, respectively. Bright meteors and fireballs have been seen during several possible Taurid swarm events previously, thus could be looked-for from the ζ-Perseids and β-Taurids too, either from tropical or near-equator sites shortly before sunrise, or conceivably during daylight even from other, notably northern hemisphere, locations.

Daytime fireballs naturally need to be exceptionally bright to be readily seen, probably of about magnitude -10 or more, with only those in the superbolide class (defining brilliance: magnitude -17 [12]) being easily detected by the American DoD satellite sensors. The nighttime Taurids do not have an especial reputation for producing such superbolides, but the β-Taurids may be capable of doing so, assuming a significant clustering of large (about 10 kg or more) impacts on the Moon detected by the Apollo program's lunar seismometers from June 17 to 27, 1975 ($\lambda_\odot = 85°$–$95°$, eq. J2000.0) due to an encounter with the Taurid Complex swarm, as proposed by Asher [1]. This event-series coincided in time with an enhanced level of electron production in the Earth's upper atmosphere detected using changes in VLF radio transmissions.

Two lesser lunar impact enhancements around June 27–30, 1972 ($\lambda_{\odot} = 95°–98°$, eq. J2000.0) and July 2.0 ± 4.5, 1974 ($\lambda_{\odot} = 100\overset{\circ}{.}0 \pm 4\overset{\circ}{.}5$, eq. J2000.0) were also found in the Apollo seismic records, though again it is not known if these were definitely associated with the β-Taurids [13]. It is worth commenting that no daylight fireball sightings coincident with any of these times have so far been uncovered. However, fireball and other unusual meteoric activities were examined from the appropriate period in 1999, in case anything possibly related had taken place.

4. Diary of selected events, May 20 to July 17, 1999

Having collected the data described above, with follow-up enquiries where necessary, the following annotated timeline giving dates and rounded-off solar longitudes (for eq. J2000.0) for the main events found was prepared. The radio meteor peak comparisons were all drawn with respect to those in [7], unless noted.

May 23 ($\lambda_{\odot} = 61°$). Minor radio peak around $\lambda_{\odot} = 60°–61°$, first found in 1998 [14]. Detected weakly in 1999, especially on this date.

May 23–24 ($\lambda_{\odot} = 61°–63°$). Strong Es events over Europe and Japan.

May 24–28 ($\lambda_{\odot} = 62°–66°$). Minor radio peak, found in previous results. Most noticeable around $\lambda_{\odot} \approx 64°$ in 1999 (May 26), but weak even so.

May 27–June 2 ($\lambda_{\odot} = 65°–71°$). Moderate to strong Es events on most days over Europe and probably Japan as well (some data here lost due to equipment failure on May 27–28).

May 31 ($\lambda_{\odot} = 69°$). Minor radio peak, previously detected, somewhat more significant in long-duration echo counts ($D > 5$ s) on May 30, 1999 ($\lambda_{\odot} \approx 68°$). In 1998, a more extended peak around $\lambda_{\odot} = 67°–69°$ was found.

June 2 ($\lambda_{\odot} = 71°$). Moderate radio peak, as previously noted.

June 4 ($\lambda_{\odot} = 73°$). Minor radio peak, detected before, but blending into the rising branch of the $\lambda_{\odot} = 75°–82°$ maxima associated with the expected Arietid and ζ-Perseid peaks in several data sets. Previous results suggest this enhancement can begin as early as $\lambda_{\odot} = 72°$, however.

June 4–7 ($\lambda_{\odot} = 73°–76°$). Strong Es events over Europe and Japan, most evident over Japan on June 4–6, Europe on June 7.

June 6–7 ($\lambda_{\odot} = 75°–76°$). Strong radio peak, as found in all years available (1994–1999), probably due to the Arietids.

June 9–10 ($\lambda_{\odot} = 78°–79°$). Moderate to strong radio peak, noted in all years since 1994 at least, most likely produced by the ζ-Perseid maximum.

June 12–13 ($\lambda_{\odot} = 81°–82°$). Moderate to strong radio peak, found in all earlier years investigated, though not always quite as strongly in every year. Possibly a secondary peak from either the Arietids or ζ-Perseids, or perhaps a combined enhancement from both sources (or an unknown one).

June 13–17 ($\lambda_{\odot} = 82°–85°$). Minor to moderate radio peak, as found weakly before (an enhancement of the $\lambda_{\odot} \approx 84°$ peak lasting from $\lambda_{\odot} = 81°$ to $\lambda_{\odot} = 87°$ was noted in some data sets used in [7]), though the 1999 event was slightly stronger in most results than was seen in the 1994–1998 data.

June 17–24 ($\lambda_{\odot} = 85°–92°$). Moderate to strong Es events, especially over Europe. Notably strong on June 18–20 ($\lambda_{\odot} = 86°–88°$) In Japan, generally weaker episodes of Es were recorded, rather less consistently.

June 20–21 ($\lambda_{\odot} = 88°–89°$). Moderate radio peak, seen previously as an early part of the $\lambda_{\odot} = 89°–97°$ enhancement, probably due to the β-Taurid maximum. Though the difference between this peak and those seen at this time before was relatively slight, the June 20 enhancement was more obvious than past events. The long-duration echoes ($D > 5$ s) suggest this peak may have begun as early as June 19 ($\lambda_{\odot} = 87°$), but there are problems in the European data thanks to Es. The highest raw echo counts for this peak were generally between 6^h and 9^h local time, as the β-Taurid radiant (and also that of the ζ-Perseids approximately) was rising optimally for detection in the eastern sky.

June 21-22 (overnight; $\lambda_\odot = 90°$). Possible NLC display seen from Verona, Italy, at $\varphi \approx 45\overset{\circ}{.}5$ N, close to the most southerly locations ($\varphi \approx 45°$ N) definite NLC sightings have been recorded at. Unfortunately, the observation has not been confirmed by others, and even the date was found to be uncertain on closer inspection [11].

June 22-23 (overnight; $\lambda_\odot = 91°$). Bright and extensive NLC display, widely seen across Europe and North America. A sighting was made from Schlägl in Austria ($\varphi = 48°38'$ N), the most southerly report from Europe, but, far more significantly, there were visual and instrumental observations made from three sites in Utah and Colorado, USA, between $\varphi = 41\overset{\circ}{.}75$ N and $\varphi = 39\overset{\circ}{.}58$ N, much further south than any definite NLC sightings have ever been made as far as is known. The earliest and latest timings for observations were 20^h40^m UT (Austria and Germany) to 6^h30^m UT (Canada), which equates to $\lambda_\odot = 91\overset{\circ}{.}00$–$91\overset{\circ}{.}39$.

June 23–24 ($\lambda_\odot = 91°$–$92°$). Moderate radio peak, usually noted as one of the best late June radio maxima from past results.

June 27–28 ($\lambda_\odot = 95°$–$96°$). Generally moderate radio peak, previously seen as somewhat weaker, except in 1998 during the June Bootid outburst. Two radio observers, one in Europe, one in Japan, recorded the peak strongly, with virtually identical raw echo counts on one of these dates in 1999 to what they obtained in 1998, but the two were not coincidental in time, and neither peak time was confirmed in other 1999 data. The best counts overall occurred between 7^h and 10^h local time, thus indicating this peak was most unlikely to have resulted from the June Bootids, whose radiant is low or below the horizon at such times. The β-Taurids would be a more probable source. The absence of any significant June Bootid rates in the preliminary visual results [15] appears well-supported by the radio data.

June 29–30 ($\lambda_\odot = 97°$–$98°$). Moderate radio peak, which has been seen before, though perhaps not quite so clearly. Most data sets show an enhancement which persists through to $\lambda_\odot = 99°$–$100°$ (July 1–2). This has also been found weakly before.

July 1–2 ($\lambda_\odot = 99°$–$100°$). Moderate radio peak, previously detected as sometimes blending with the $\lambda_\odot = 89°$–$97°$ period, or possibly an early part of an extended $\lambda_\odot = 107°$ spell (which has been noted as running between $\lambda_\odot = 100°$ and $\lambda_\odot = 109°$ before). Generally somewhat weaker than was seen in 1999 however, with the peak at $\lambda_\odot = 100°$ (July 2) unusually well recorded in 60% of the data sets covering early July. Werfried Kuneth in Austria commented [16] that he had detected a daytime meteor outburst in long-duration echoes ($D > 6.5$ s) on July 2 between 7^h and 15^h UT ($\lambda_\odot = 100\overset{\circ}{.}0$–$100\overset{\circ}{.}3$; 8^h–16^h local time), suggesting it could have been due to the June Bootids. However, although the June Bootid radiant is circumpolar for Werfried's site ($\varphi = 46°45'$ N; Bootid radiant declination $\delta = +48°$), it is at its lowest for the day between 7^h and 11^h local time, returning to a reasonably useful elevation only after 13^h–14^h. By contrast, the β-Taurid radiant is at a useful elevation between 5^h and 17^h local time daily in late June to early July for such a location. Checking the other active radio observers' data, Ghent University, Belgium, recorded marginally enhanced echo counts between roughly 4^h and 6^h, 10^h and 12^h, and 18^h and 20^h UT on July 2 compared to dates on either side, though the difference was not great. In Japan, Chikara Shimoda noted a slight, but not convincing, enhancement around 17^h–23^h UT (2^h–8^h local time) then, while Sadao Okamoto detected overall lower raw echo counts in both his long duration ($D > 5$ s) and all-echo results than on July 1 or 3. Both Japanese observers had problems with Es around these dates too.

July 2-3 (overnight; $\lambda_\odot = 101°$). Moderate NLC display seen across central-eastern Europe north into Scandinavia, from 20^h15^m to 2^h30^m UT ($\lambda_\odot = 100\overset{\circ}{.}51$–$100\overset{\circ}{.}76$). Most southerly latitude was $\varphi = 48°38'$ N, in Austria. No reports from North America.

July 3–10 ($\lambda_\odot = 101°–107°$). Moderate to strong, but patchy, Es events especially over Europe, but also some over Japan. In Japan, Es was strong on July 1 as well, but all reports suggest little consensus as to the strongest times between the two main regions.

July 4-5 (overnight; $\lambda_\odot = 103°$). Weak to moderate NLC display seen from Europe and North America between 21^h50^m and 3^h45^m UT ($\lambda_\odot = 102.°48–102.°72$). The most southerly observation was made from New Jersey, USA, $\varphi = 40°01'$ N, significantly south of the typical NLC visible-zone, but reported only as a "possible" sighting [11].

July 5–8 ($\lambda_\odot = 103°–105°$). Weak radio peak, seen before but commonly not well recorded. A dominant minor peak around $\lambda_\odot = 104°$ (July 6–7) was reported in all available data sets, not noted as clearly earlier.

July 7 ($\lambda_\odot = 104.°648$). At $4^h14^m42^s$ UT, a superbolide was detected by DoD sensors over North Island, New Zealand. Though still before local sunset, the object was widely seen from North and South Islands, with a near-terminal detonation whose acoustic blast shook buildings and the ground, and produced thunder-like sounds that continued for almost a minute. The burst occurred at around 37 km altitude. Typically, early reports were confused, but suggested the event might have been a β-Taurid (though the radiant would have set when the bolide took place). Later analysis suggested the trajectory was in a roughly east to west orientation, which, if correct, would rule out the meteor being a β-Taurid [17,18].

July 11–13 ($\lambda_\odot = 108°–110°$). Patchy, moderate to strong Es events, more especially over Europe, coincided with a weak radio peak detected at about the usual minor level, generally seen around $\lambda_\odot = 107°–109°$ (July 10–12) in past years. Of more significance was Bev Ewen-Smith's report from Portugal [19] of enhanced radio meteor activity producing many persistent trails between at least the interval $13^h00^m–13^h45^m$ UT on July 11 ($\lambda_\odot = 108.°81–108.°84$). Bev suggested the source-radiant's right ascension as $\alpha \approx 120°$. Unfortunately, none of the other active radio observers recorded any unusual activity at this time, and, although Es was detected from Europe near this time, it seems an inadequate explanation for what appeared to be distinctly meteoric events. The β-Taurid radiant by July 11 would be around $\alpha = 95°$, though the radiant drift is not well-established. The uncertainties in Bev's estimate of the probable source for what he detected are quite large, plus the β-Taurid radiant may also be elongated in right ascension (the Taurid radiants are normally assumed to cover about 20° in right ascension, for instance), a combination of which could suggest a β-Taurid origin for this event. The fact it could not be confirmed (Bev indicated he received no additional reports on it either [20]) means it remains a mystery.

July 14–17 ($\lambda_\odot = 111°–114°$). Minor radio peak, detected much as usual around this time, particularly near $\lambda_\odot = 112°$ and $\lambda_\odot = 114°$ (July 15 and 17, respectively). There were weak signs of an enhancement on July 18 ($\lambda_\odot = 115°$) in the Japanese results, as was found in a stronger, short-lived outburst over Europe in 1998 [21]. However, the timing of the 1998 event, at around $1^h–2^h$ UT, means it cannot have been due to the β-Taurids, while the equivalent solar longitude interval in 1999 ($7^h–8^h$ UT on July 18) revealed no unusual activity.

July 17–18 ($\lambda_\odot = 114°–115°$). Moderate to strong Es events, recorded by most observers in Europe and Japan, with some starting as early as July 15 ($\lambda_\odot = 112°$).

5. Discussion

As has become clear from the above section, the radio meteor results made during the examined period showed no activity peaks not previously reported. There were a few slightly unusual peak spikes around several dates, most notably at $\lambda_\odot = 82°–85°$, $\lambda_\odot = 88°–89°$, $\lambda_\odot = 95°–96°$, $\lambda_\odot = 99°–100°$, $\lambda_\odot = 103°–105°$, and the event found by Bev Ewen-Smith around $\lambda_\odot = 108.°8$.

The first of these seems not significantly different to normal, and could result from late post-maximum ζ-Perseid activity anyway. The second may be more interesting, especially with its coincidence in time to several Es events and its near-equivalence with the mid-point of the 1975 lunar impact series. It is intriguing that it should be followed quite closely by the unique widespread southerly sightings of an NLC display near $\lambda_\odot = 91°$. It will be necessary to establish in future years when or if such southerly NLC observations become more commonplace, and to press the on-going investigations into the 1999 display to try to discover whether a special series of non-meteoric events in the upper atmosphere could have created what was seen alone, or if an extra, meteoric, source was required. Notices e-mailed after news broke of this event to friends and colleagues in southern Europe produced no additional reports, but all interested observers in these areas are encouraged to maintain a watch for NLC during June and July in future years. Details on what NLC looks like and how to observe it are available at `http://www.u-net.com/ph/spa/sections/aurora.htm`.

The $\lambda_\odot = 95°–96°$ radio peak was perhaps not too different to normal, but the suspected outburst around $\lambda_\odot = 100°$ noted by Werfried Kuneth could be more important. The inconclusive supporting evidence is far from helpful in deciding, unfortunately. The $\lambda_\odot = 103°–105°$ period again brought a suspected very southerly NLC sighting from the USA, though the near-accompanying radio peak was not dissimilar to that seen in former years. It would be useful to establish a firmer trajectory for the July 7 superbolide over New Zealand in this regard. Finally, the $\lambda_\odot = 108\overset{\circ}{.}8$ event must remain only a curiosity in the absence of other supporting data.

Overall, the evidence for a recurrence of the proposed Taurid Complex swarm during the ζ-Perseids or β-Taurids in 1999 is highly inconclusive. The June 20–24 period, with its series of unusual events is perhaps the most likely time for anything swarm-related to have happened, but whether some or all of the identified occurrences then were because of the swarm's reappearance cannot be demonstrated with any certainty, so it would be wisest to note the dates and events, and keep an open mind. The next opportunity to check for a predicted swarm return is in June 2002 [1].

Addendum

Since submitting the above report, Tom McEwan has forwarded me the results from the North American NLC surveillance network *NLC CAN AM* which covers the USA and Canada, coordinated by Mark Zalcik, for the 1999 season (published by *NLC CAN AM*, December 28, 1999). This provides additional details on the June 22-23 NLC event in particular, which Mark Zalcik comments was *"perhaps the most southward-invading NLC display ever witnessed on the continent."* The southernmost sightings are now reported as coming from Durango, Colorado, at $\varphi = 37°05'$ N, with several observers around $\varphi = 40°$ N and northwards recording NLC in their south-western skies on this night. Mark goes on to suggest this was a wedge of NLC perhaps driven south by a strong mesospheric wind, and also noted that, on June 22-23, 1997, he observed NLC from Montana at just south of $\varphi = 45°$ N latitude, which could indicate a periodicity in NLC recurrence. From a meteoric perspective, we should note that Asher's list of possible Taurid Complex swarm reappearance years in [1] features only 1995 and 1999 for any June–July event, however.

One final point, Mark mentions that, to the date of the report, he had not received any possible NLC sightings related to the 1999 Leonids, nor are there any such observations from European sites as yet.

Acknowledgments

Apart from, as usual, sending my grateful thanks to all the observers who contributed to this report, I would also like to thank David Asher for allowing me to distract him with most invaluable discussions during a period when the Leonids should really have occupied all of his attention, and Rainer Arlt for preparing extra details on the 1998 Taurids as seen by *IMO* observers, at very short notice.

I would also like to thank Tom McEwan for his regular NLC updates; John Lambert and Tony Markham for their assistance in checking various newsgroups and keeping me updated on developments; and Bev Ewen-Smith for further discussion of his July 11 observations.

Finally, I would like to thank Joel Schiff of the Auckland Observatory, New Zealand, for his prompt and ready assistance in tracing details of the July 7 superbolide.

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Meteors in Romanian Divination and Exorcism

Dan Mitruţ

Some brief notes on Romanian meteor mythology, additional to those in [1], are presented.

Meteors—
Celestial manna
In conservation.
A sign that the stars
Have abandoned their belief
In the gravitation law.

Meteors—
They never know that
Matter's selfishness
Gives birth to the martyrs.

Meteors—
The crusades
Of the galactic children
Hitting the Earth.
All of them, anonymous elements
On the orbit of Atmos.
Dan Mitruţ

In Romanian mythology, the Cosmic Tree is described in carols like this one:

Up on the mountain top,
The Pine Tree of the pine trees grows up.
It is so big and swollen
That it fills up all the sky:
The Sun in its needles,
The Moon in its branches,
Thousands and thousands of stars
Among its twigs.

The Cosmic Tree is found in mythologies across the world. It usually represents the support of the heavens, about which the sky revolves. Sometimes it is on a high mountain, as here; sometimes the tree itself is replaced by a great mountain.

In the Romanian conception, we have the stars as drops of light clinging to the Cosmic Tree, as the Tree emerged phosphorescent from the primordial waters. These drops remain on its branches and twigs, but sometimes, irregularly, they detach themselves, and become falling stars. The beauty of the celestial spectacle of these falling stars must have been partly what inspired the ancient Romanians to polarize meteors into two chief magical aspects: for divination or foretelling the future, and exorcism.

The study of divination by watching the heavens and interpreting the events seen there is called astromancy. The Romanian astromancers studied the color, speed, and length of the meteor, as well as its place of appearance and the direction of its fall. From this information, and a pre-prepared question, the astromancer would construct an appropriate answer for his client. So, if we ignore his intentions, we can consider this fortune-teller as an early empirical meteor observer.

In an exorcism, the meteor or meteorite was seen as a wonderful object,

The girl to be
Clean
And illuminated
Like the stone falling
From the sky,

or like a mythical flying being with magic powers,

Dragon-laurel
With a golden tail.

Here, the event or object becomes a tool connecting Heaven and Earth, seen as concentrating magical power into achieving the desired effect.

A further conception of what meteors are was offered by an old Romanian exorcist: *"Up there in the sky, we cannot yet see Paradise. The stars were also created by God, and afterwards put on the canopy of heaven. This means they fell there. Thus, at the birth of a man, a star falls in the sky, stays there until he dies, and then falls again."*

The value of such conceptions was unchallenged. Before they became objects for scientific study, meteors represented a source of knowledge about man's destiny, and an opportunity to relish things beyond the rational frontiers of human existence.

Acknowledgment

I wish to thank Alastair McBeath and Andrei Dorian Gheorghe for preparing this English translation for me.

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Fireballs and Meteorites

A Northern Taurid Fireball over Spain

Josep M. Trigo-Rodriguez and Julio Castellano-Roig

In the night of November 16-17, 1999, a −4 fireball (SPMN991101) was photographed by two stations of the *Spanish Photographic Meteor Network*, from which orbital data were obtained. The fireball was of cometary type as suggested by its light curve. The data confirm its close connection with the Northern Taurid stream and Comet 2P/Encke.

The 1999 Leonid campaign was extraordinarily successful for the *Spanish Photographic Meteor Network* (*SPMN*) team and other Dutch and Czech teams who decided to observe from Spain. In the night before the Leonid storm, we observed significant activity from the Taurid complex.

We were able to photograph three bright meteors, which were connected with these streams. Two of them were photographed only from a single station, i.e., without the possibility to determine atmospheric and heliocentric data. A third meteor was photographed from two stations and gave very reliable data. The fireball appeared at $0^h56^m54^s \pm 1^s$ UT on November 17 and was seen visually by the camera operators of both stations, especially during its bright flare. Only two cameras out of seven available at the two stations photographed it. The objectives used were a $f/2.8$, $f = 24$ mm and a $f/2.8$, $f = 35$ mm with TMAX 3200 film, and a rotating shutter with 12 breaks per second was used.

Measuring the Cartesian coordinates of the beginning and end points of the stars and the meteor, we obtained the conversion to equatorial coordinates using a new astrometry software developed by our team. Taking into account the accuracy of our lenses and the distance between stations, the velocity error was of the order of 3%, and the astrometric positional error was less than one arc minute in the two photographs. The captured meteor was too faint to obtain its atmospheric deceleration, but a mean geocentric velocity (corrected for zenith attraction [1]) of 28.8 km/s was obtained from the brighter part of the path. This value is very close to the expected velocity of Northern Taurid members. The fireball astrometry was carried out using digitized images of the negatives. We obtained the trajectory using the method of planes [2].

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Table 1 – Coordinates of the two stations of the *SPMN* in Castelló (Spain) that photographed the Northern Taurid fireball of November 17, 1999, $0^h56^m55^s$ UT.

Location	Longitude	Latitude	Height (m)
Desert de les Palmes	0°02′40″ E	40°04′55″ N	390
Pla d'Arguines	0°23′50″ W	39°45′34″ N	260

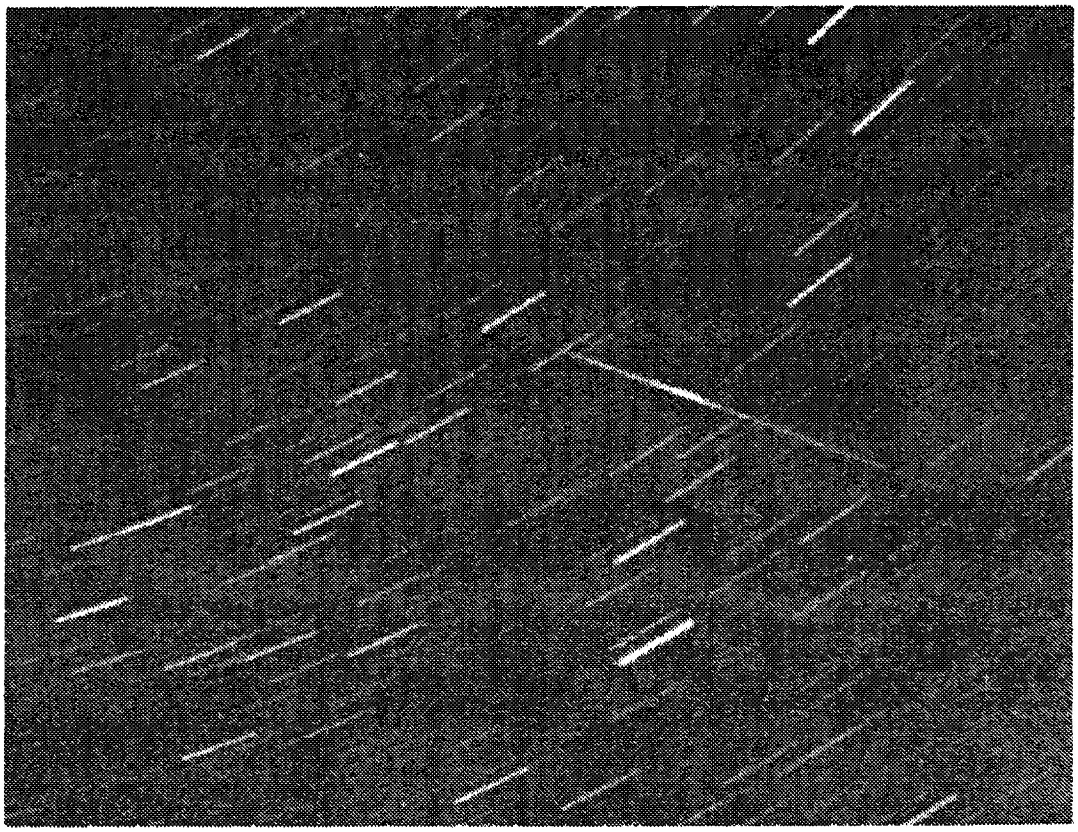

Figure 1 – The −4 Northern Taurid fireball photographed from the Pla d'Arguines station.

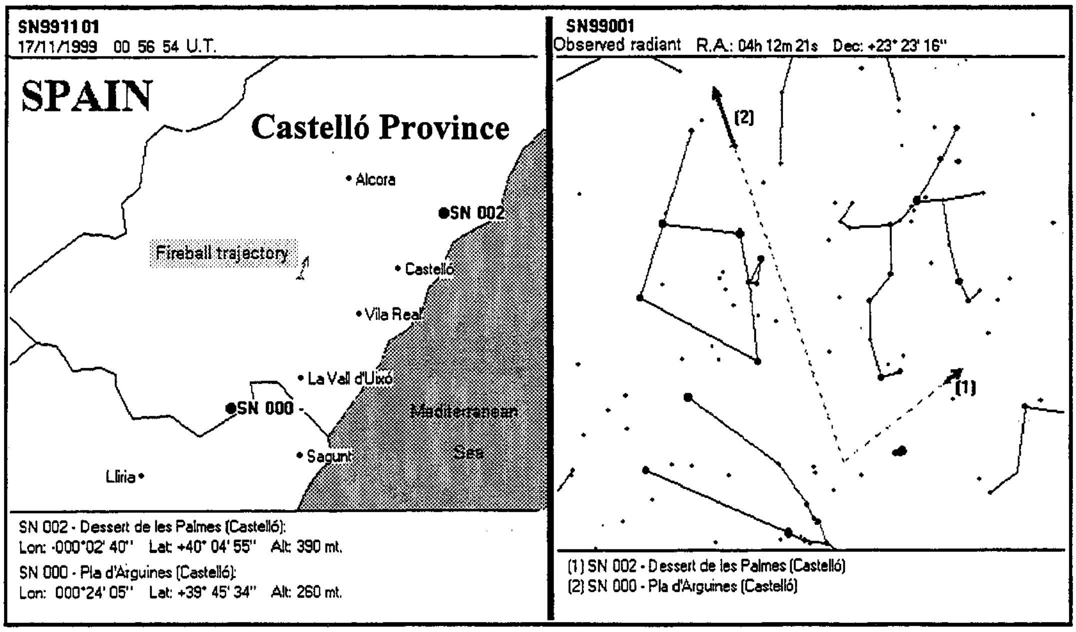

Figure 2 – Fireball trail projected onto the celestial sphere and in a map showing the different stations of our Network in the Castelló province.

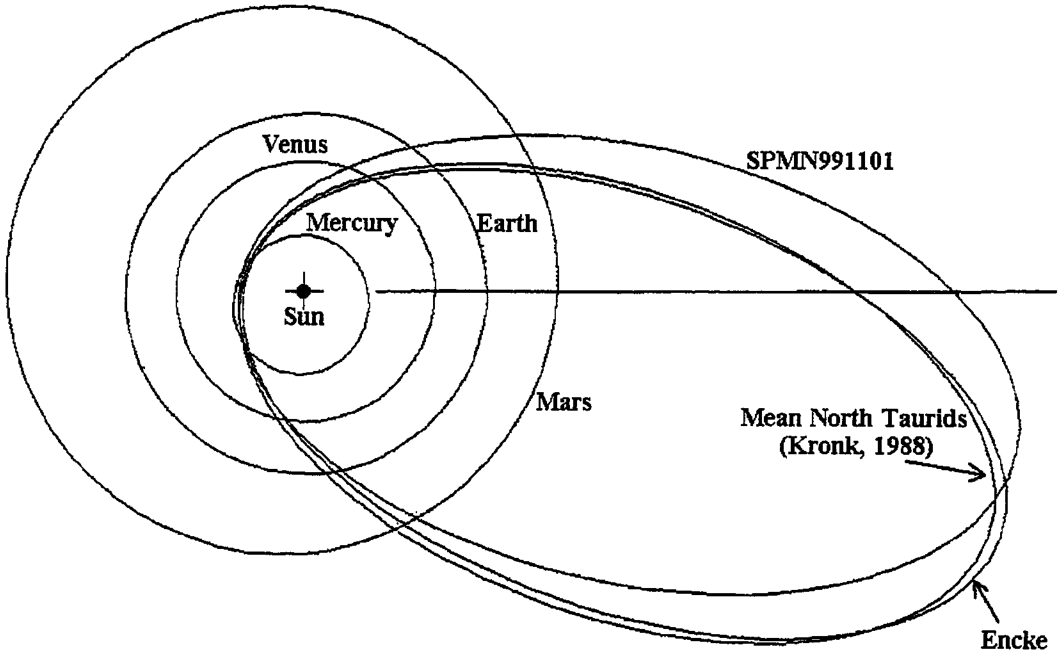

Figure 3 – Northern Taurid SPMN991101 orbit, showing the similarity with the orbit of Comet 2P/Encke. The orbits have been projected on the ecliptic plane taking into account that the meteoroid's orbital inclination was only 1°7.

Table 2 – Trajectory data of SPMN 991101.

Trajectory data	Beginning point	End point
Mean geocentric velocity (km/s)	28.8 ± 0.8	
Trajectory Length (km)	14.0	
Slope	17°65 ± 0°05	
Height (km)	88.69 ± 0.05	75.35 ± 0.05
Longitude	0°15′39″ W	0°14′38″ W
Latitude	39°58′29″ N	40°00′35″ N
Absolute magnitude (Maximum −4)	−1	0
Photometric mass (g) (1.86 g at max.)	0.26	None

Table 3 – Observed and geocentric radiant positions of SPMN 991101.

Radiant (J2000.0)	Observed	Corrected
Right ascension	63°1 ± 0°1	62°9 ± 0°1
Declination	+23°4 ± 0°1	+22°1 ± 0°1

Table 4 – Orbital data (J2000.0) of SPMN 991101.

a	e	q	i	Ω	ω	T (Julian date)	T (Gregorian date)
2.20 AU	0.84	0.3597 AU	1°7	234°2478	293°37	2451541.7718	Dec 29.27175, 1999

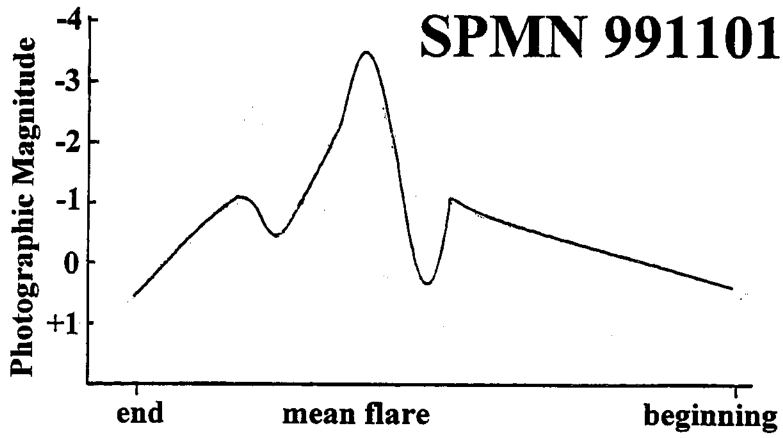

Figure 4 – Trail photometry of the SPMN991101 fireball.

According to its light curve, SPMN991101 belongs to a fragile cometary type of meteoroids. We note that cometary fireballs have a great flare (obvious in Figures 1 and 4) close to the end of the luminous trajectory. From the radiant position and the heliocentric orbit (see Figure 2), it is evident that this meteoroid belonged to the Northern Taurid stream.

From the photometric analysis of the negative, an $M_V = -4$ at maximum light was obtained. With this data and from the mean geocentric velocity obtained, we calculated a meteoroid mass near 2 g using Hughes's formula [3]. This particle followed a heliocentric orbit very similar to that of Comet 2P/Encke.

The way in which our *Spanish Photographic Meteor Network* (*SPMN*) has been set up and is being operated is a nice example illustrating that collaboration between professional and amateur people can be the key to establish other similar projects. Using standard cameras, we obtain very reliable results only with a good coordination and a common methodology. Supported by the new techniques, our procedure consists of sending e-mail information to the participating people about the field centers for adjusting the cameras, in accordance with the Earth's position and the observers' location.

For example, during the Leonid storm night of November 17-18, 1999, we established six stations between the Castelló and València provinces, photographing tens of meteors that we are analyzing at present. Three stations were also working on the island of Mallorca, operated by enthusiastic members of the *Astronomical Observatory of Mallorca* (*OAM*), who also obtained very successful results. We are preparing an article containing detailed information on all Leonid orbits obtained.

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Impressive Shenzhou Re-Entry over the Mediterranean

Josep M. Trigo-Rodriguez, Enric Coll, Julio Castellano-Roig, and Jordi Llorca

On November 27, 1999, the re-entry of the Chinese Shenzhou Long March rocket created an impressive artificial fireball over the Mediterranean Sea. The rocket overflew the Sea passing Andalusia, Valencia, the Balearic Isles, and Sardinia, probably reached the Latium province in Italy.

On Saturday, 27th November 1999, a slow-moving fireball of −10 maximum absolute magnitude with extremely long trajectory was observed to enter the atmosphere in the Southwest of Spain. Initially, the fireball was thought to be the product of a big meteoroid in an ecliptic orbit. However, due to the anomalous visual characteristics of the object as discussed below, this possibility was soon ruled out.

The fireball was really impressive. Because it appeared at 21^h30^m UT on a Saturday night, a lot of people saw it. The phenomenon was described as a silver fireball breaking into several pieces, followed by a reddish wake. It appeared at 200 km altitude, approximately, over Morocco, overflew the Mediterranean Sea, Corsica and the Italian province of Latium, where it was seen, probably before falling into the Adriatic Sea. High-quality visual data were obtained, for example, by Alfonso López-Borgoñoz (Barcelona), Geoffrey Cameron (Castelló), B. Company and T. Vibot (Mallorca), and Damián Arroniz (Alacant). At the Balearic Isles, several members of the *Astronomical Observatory of Mallorca* (*OAM*) coordinated by Enric Coll, Salvador Sánchez, and Miquel Villalonga, took great efforts in collecting eye witness reports from many people. Great efforts to obtain fireball data were also made by Roberto Gorelli (Rome, Italy) and Manuel Montes-Palacio and Francisco Reyes.

At the moment, we know only of the existence of two low-resolution fireball photographs and a videotape obtained by a sailor, without geographic references, showing the evolution of a fragment of the fireball trajectory (Figure 1).

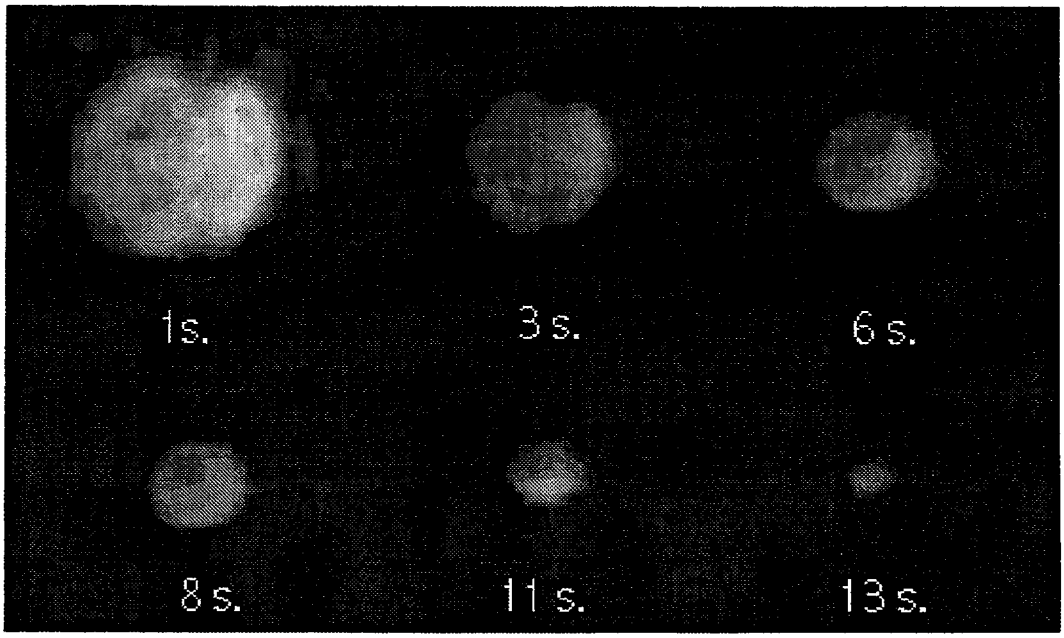

Figure 1 – Selected frames of the 15-seconds fireball videotape sequence obtained casually by a sailor near Mallorca.

Josep Trigo is affiliated to the *Dept. Astronomia* of the *Universitat de València* and Jordi Llorca is affiliated to the *Dept. Química Inorgànica* of the *Universitat de Barcelona*, *Institut d'Estudis Espacials de Catalunya*. The first three authors are members of *SOMYCE*; the third author is also a member of the *Observatori Astronòmic de Mallorca*.

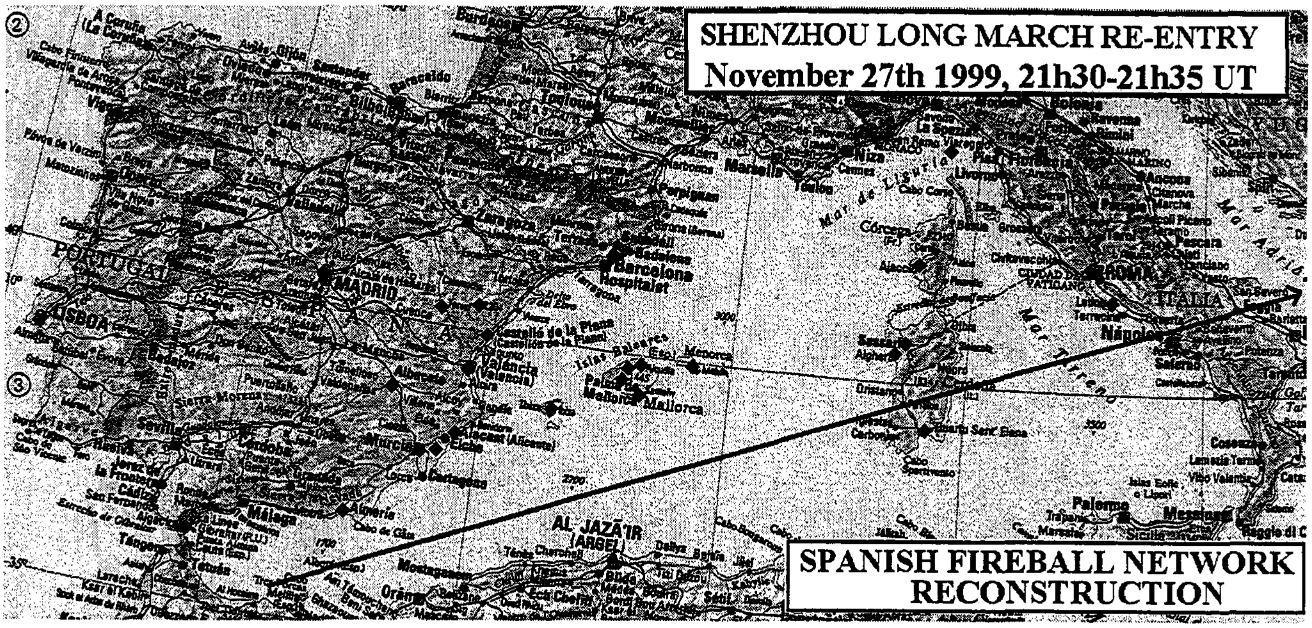

Figure 2 – The November 27 Shenzhou re-entry over the Mediterranean Sea. The fireball was seen from several sites between Spain, France, and Italy noted as diamonds.

Unfortunately, the *Spanish Photographic Meteor Network* (*SPMN*) prepared a double-station watch to for that night in Castelló but it was cancelled due to the presence of low clouds only two hours before the apparition of the fireball! Nevertheless, using visual observations from numerous eyewitnesses in Spain, Sardinia, Corsica, and mainland Italy, it was possible to define an approximate atmospheric path for the fireball, which is shown in figure 2. The begin and end points are uncertain.

Despite the limited quality of the observations, it was possible to resolve the nature of the incident object. The estimated trajectory length was about 1500 km, which can only be produced by an incident object with a low geocentric velocity entering under a narrow angle. Using *SPMN* software, we have calculated a velocity estimate from the visual observations, and obtained a value in the range of 5–10 km/s. All these results taken together point to rocket debris as a source of the observed fireball. Assuming a low orbit for the rocket, we have estimated a velocity of 8 km/s and a duration of about 3 minutes for the rocket's atmospheric flight. Taking into account atmospheric deceleration, the last estimate may have to be increased by one or two minutes.

The rocket origin hypothesis was confirmed by Manuel Montes-Palacio (NASA), who calculated the re-entry time of the Shenzhou Long March Chinese rocket (#25957 = 99-61B) using the SatEvo software, and obtained $20^{h}30^{m}$ UT, approximately. We strongly believe that the November 27 fireball was produced by the re-entry of the Shenzhou rocket.

In this connection, it is interesting to note that a similar artificial fireball event occurred over Mallorca in August 1990. At that time, two persons observed, besides a bright green-red fireball with a low incidence angle and very slow geocentric velocity, the fall of a 2-kg object in the garden of their property.

This object was studied by means of chemical analysis, X-ray diffraction, and electron microscopy (Figure 3). It was composed of a manganese-silicon alloy containing small quantities of iron and titanium. The morphology and chemical composition of the object demonstrated its artificial origin. Similar alloys are used in the construction of rockets and artificial satellites, but there are no natural samples with similar characteristics. The "Mallorca object" is a direct confirmation that great fireballs may actually be caused by the fall of space waste, which in turn may cause serious injuries to human beings.

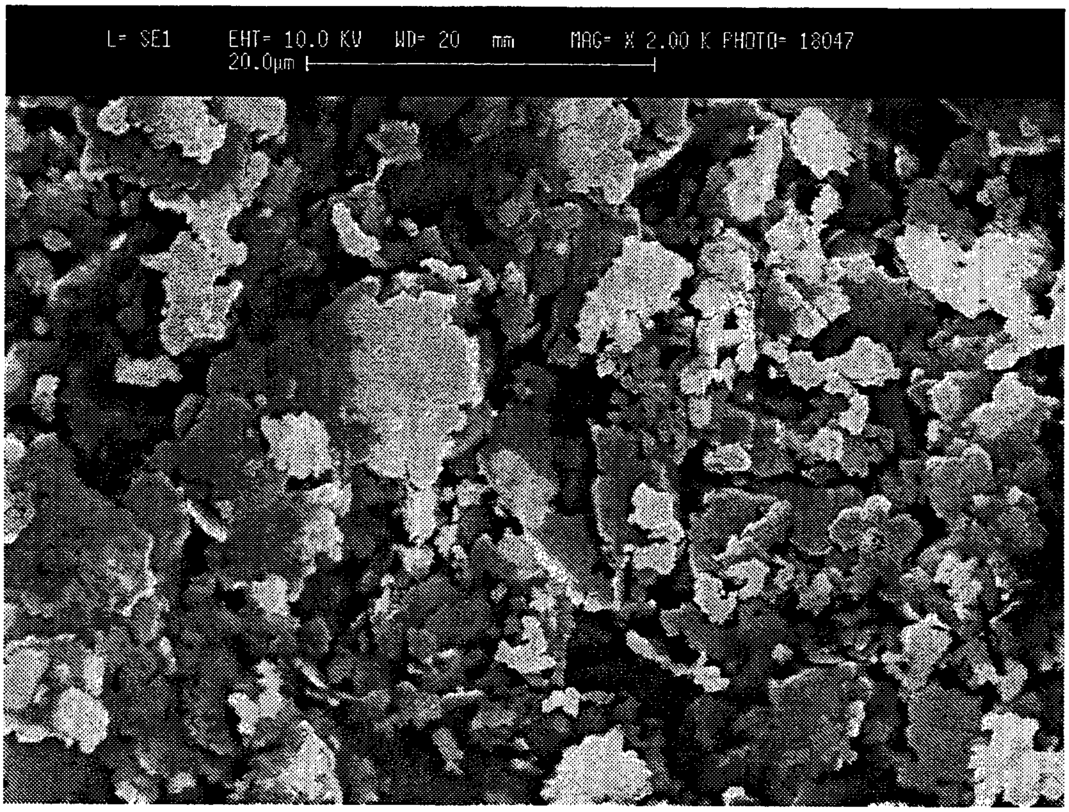

Figure 3 – Microscope image of the object recovered in Mallorca on August 1990 after it was observed as a fireball.

Observational Results

SPA Meteor Section Results: March–April 1999

Alastair McBeath

Observations and other details sent to the *SPA Meteor Section* from March and April, 1999, are presented and discussed. Weak γ-Normid activity was independently reported from Australia and South Africa, suggesting a peak perhaps around March 17. Patchy skies hampered coverage of the Lyrids, though an ill-defined maximum on April 22-23 was found in the radio data. Two possible Virginid radiant areas were noted in each of March and April, though only one of the April radiants coincided well with any of those found in previous *Section* results.

1. Introduction

Conditions improved from January-February for European watchers in March-April, and observers in the southern hemisphere too enjoyed some helpful skies at times. Table 1 has our observing totals.

Table 1 – Visual, photographic, and radio hours' totals, plus visual and photographed meteor numbers, recorded in each month, including a partial breakdown of visual meteor types.

Month	Visual	VIR	LYR	SAG	Meteors	Photo	Radio	Video	Video Met.
March	$85\overset{h}{.}5$	114	–	–	632^{h}	96^{h}	3437^{h}	$36\overset{h}{.}8$	92
April	$64\overset{h}{.}4$	31	97	21	399^{h}	146^{h}	3468^{h}	$23\overset{h}{.}4$	57

Photographic reports were received from *Arbeitskreis Meteore* (*AKM*) members Ina Rendtel (who kindly provided all the *AKM* details, extracted from their journal *Meteoros*, issues 2:4, 2:5 and 2:6 (1999)), Jürgen Rendtel, Roland Winkler, J. Strunk, all in Germany. No trails have yet been found among their all-sky fireball patrol negatives. All the video data were collected by Sirko Molau, another of the active *AKM* observers in Germany.

Radio observations were forwarded to us by Chris Steyaert in the form of *Radio Meteor Observation Bulletins* 68–70 inclusive, April to June 1999. The radio observers included

> Enric Fraile Algeciras (Spain), Michael Boschat (Canada), Maurice de Meyere (Belgium), Ghent University (Belgium), Will Kelsey (California, USA), Werfried Kuneth (Austria), R.B. Minton (New Mexico, USA), Sadao Okamoto (Japan), and Ilkka Yrjölä (Finland).

The raw data were analyzed as normal in these results papers, and two graphs, Figures 1 and 2, showing activity in March and April, are presented as examples here, both from data collected by Werfried Kuneth.

Visual reports came from

> *AKM* members Franziska Böttcher, Frank Enzlein, Christoph Gerber, Mathias Growe, Ralf Kuschnik, Sylvio Lachmann, Hartwig Lüthen, Sven Näther, Jürgen Rendtel (Australia and Germany), Janko Richter, Harald Seifert (Germany and Norway), Manuela Trenn (Australia), Roland Winkler (all in Germany unless stated); Tim Cooper (South Africa), Andrea Csiki (Romania), Shelagh Godwin (England), Chris Hall (England), Ivor Paul (South Africa), Auke Slotegraaf (South Africa), Adrian Şonka (Romania), and Laura Unci (Romania).

These included 72 meteors plotted during the March–April part of our Virginid project this year.

2. March

Low rates of Virginids were recorded throughout the month, without any clear maxima being apparent. Observers in the southern hemisphere naturally saw slightly higher activity, but even so rarely more than 3–4 an hour at best. Tim Cooper submitted a good series of meteor plots from the month, the chief contribution to our Virginid plotting project for March. From these, two weak possible Virginid radiants could be defined, around $\alpha = 169°$ and $\delta = -5°$ in March 8–10 results, and around $\alpha = 177°$ and $\delta = -9°$ on March 18-19. All these positions have an approximate error of $\pm 2°$–$3°$. Unfortunately, only five trails in total defined these two positions, so the evidence for their reality is not strong. Assuming the two positions may represent the same shower radiant however, they do show a daily drift of $\Delta\alpha = +0.^{\circ}8$ and $\Delta\delta = -0.^{\circ}3$, comparable to the expected average daily motion for the overall Virginid radiant as previously reported ($\Delta\alpha = +0.^{\circ}9$ and $\Delta\delta = -0.^{\circ}3$ [1, esp. p. 233]). Naturally, this numerical coincidence could be just by chance, but it perhaps strengthens the chances the radiants found were real.

Neither position coincides with any of the radiants found during Period 1 of the *Section*'s earlier Virginid project [1] ($\lambda_{\odot} = 341°$–$360°$, equivalent to March 2–21, 1999), though both lie only 5°–6° outside the boundaries for Areas 1 and 2, respectively. These 1988–1992 areas were also reported as active just before and just after the equivalent time to Tim's observing in 1999. Some evidence of a weak clustering of radiants can be found near these locations in the recently published Japanese visual radiant study from 1970–1997, too, notably in the double-station corrected results [2, esp. p. 125], though a greater (if still diffuse) clustering of radiants in south-eastern Leo and north-western Virgo as far east as γ Virginis receives better support in the Japanese findings.

Weak γ-Normid activity was independently recorded by four of our southern hemisphere observers between March 11 and 21, two each in South Africa (Ivor Paul and Auke Slotegraaf) and Australia (Jürgen Rendtel and Manuela Trenn). Observed rates were never better than 2–3 per hour, but no real support for the maximum previously noted around March 14 was found. If anything, activity seemed marginally higher on March 17 (when Jürgen and Manuela were appropriately observing from Boxhole Crater in Australia's Northern Territory!), with ZHRs around 5–6 ± 3. This confirms the shower remains observable.

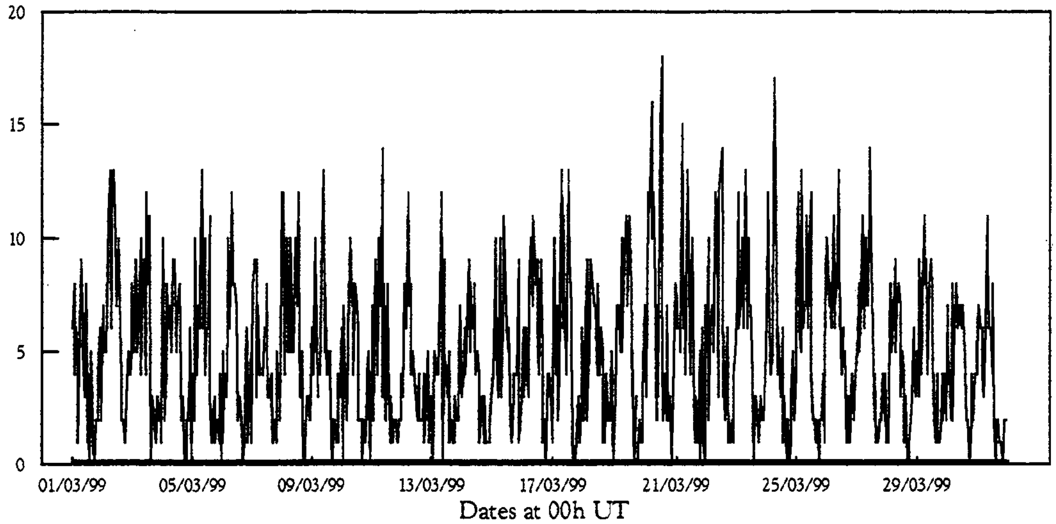

Figure 1 – Raw hourly long-duration radio meteor echo counts ($D > 3.5$ s) from March 1999, in data collected by Werfried Kuneth. Werfried's set-up was operated continuously with only a couple of one-hour breaks. The day-to-day variation during the month was very slight, much as normal.

In the radio data (see Figure 1), no unexpected activity was found compared to past years [3], although three observers had their equipment off-line for modifications or relocation at various times in mid to late March. All the echo-count maxima noted before were seen again, and although none were missed, the peaks around $\lambda_\odot = 346°–347°$ (March 7–8) and $\lambda_\odot \approx 350°$ (March 11) were noted in only 40–50% of the available datasets, while a similar number found stronger activity than at these times around $\lambda_\odot = 348°–349°$ (March 9–10) and $\lambda_\odot \approx 351°$ (March 12) respectively (this latter rather less strongly, however).

3. April

Most of the visual observations were concentrated between April 13 and 24, especially over the quite favorable Lyrid maximum, although weather conditions were generally poor to abysmal for most watchers then. Tim Cooper again put in some sterling work to secure most of the possible Virginid plots, and examination of his data suggests a further two weak and diffuse radiants from a total of six meteor trails between April 13–19. These were centered around $\alpha = 204°$ and $\delta = -4°$, both parameters $\pm 4°$, and around $\alpha = 196°$ and $\delta = 0°$, both parameters $\pm 5°$. The first of these gives an excellent coincidence with Area 10 in [1] ($\alpha = 206°$ and $\delta = -3°$), though this was found active between April 20 and 25 in 1988–1992. The second of Tim's radiants fell almost exactly midway between the centers of Areas 9 and 10 from [1]. The Japanese data [2, p. 126] support several weak radiant clusters around and east of γ Virginis, and just east of the line between γ and α Virginis during early to mid April, which give reasonable near-fits to the *SPAMS* data noted here. Tim later endeavored to observe the π-Puppids on April 24, but saw none in poor, moonlit skies.

Our visual Lyrid coverage was generally disappointing, with only a mean ZHR calculable for April 21-22 (12 ± 3), and no observations from the time closest to the expected peak around 16^{h} UT on April 22. *IMO* data (available in the *IMO News* archive of the Website) suggested a ZHR possibly as high as 32 ± 9 on April 22-23, though this is not well-confirmed.

The radio data, illustrated by Figure 2, give a clear rate-spike around $\lambda_\odot = 31°–32°$ (April 22–23), with the highest echo-counts generally coinciding with the Lyrid radiant's visibility on the local-time night of April 22-23. Unfortunately, there are too few complete datasets from this time to refine the peak's accuracy any better.

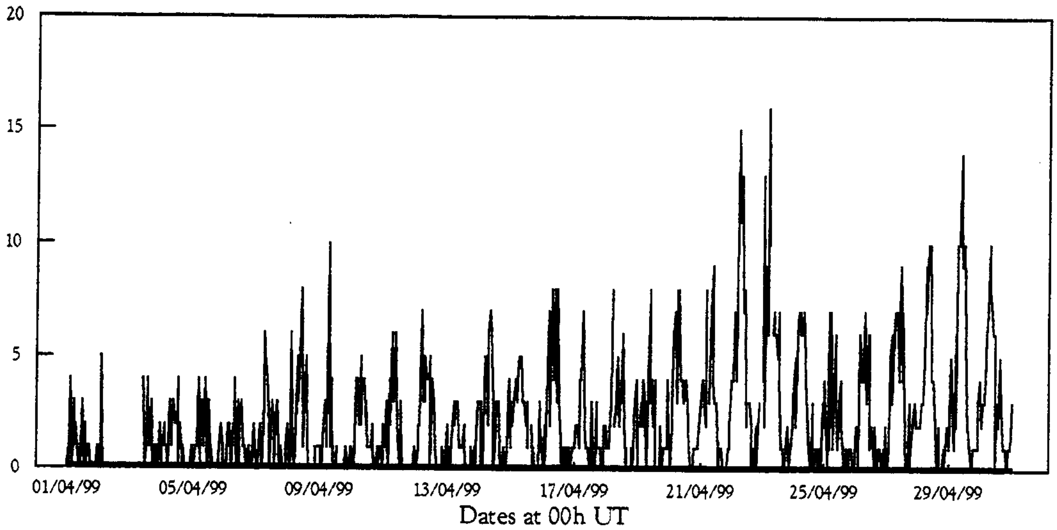

Figure 2 – Raw hourly very-long-duration radio meteor echo counts ($D > 6.5$ s) from April 1999, in data collected by Werfried Kuneth. Werfried again provided continuous monitoring except between 5^h UT on April 2 to 9^h UT on April 3, plus a few other minor breaks when propagation interference was encountered. The Lyrids show up reasonably clearly on April 22-23, and notice the rising rates in the last few days of the month as the η-Aquarids increase towards their early May peak.

April's remaining typical radio echo-peak features were recorded again, as noted in [3], with the weakest confirmation occurring for the $\lambda_\odot = 22°–24°$ (April 12–14) period. Unlike in 1998, the then-missing very minor $\lambda_\odot \approx 20°$ (April 10) peak was detected by 60% of our observers this year.

4. Acknowledgments

Grateful thanks are extended to all the observers and correspondents this report has relied on for their support and encouragement. Clear skies for your observing!

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[1] A. McBeath, "UK Visual Results for the Virginids, 1988–1992", *WGN* 20:6, December 1992, pp. 226–237.

[2] Y. Shigeno, "Visual Meteor Radiant Observations", *WGN* 27:2, 1999, pp. 120–132.

[3] A. McBeath, "SPA Meteor Section Results: September–October 1998", *WGN* 27:3/4, June–August 1999, pp. 209–214.

[4] A. McBeath, "The Forward Scatter Meteor Year", in *Proceedings 1997 IMC*, Petnica, Yugoslavia, A. Knöfel, A. McBeath (eds.), IMO, 1998, pp. 39–54.

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As is often the case, we are short of suitable photographs for the front cover. When you think you have such a photograph, please send it to us! Important properties of such a photograph are that they should contain enough contrast to reproduce in black-and-white, and that the details that matter are not too fine to accommodate for the uninevitable information loss in the printing process.

While the front cover typically contains a meteor photograph, other subjects such as observer groups, equipment, meteorite craters, ... are also acceptable.

Marc Gyssens, Editor-in-Chief

The 1999 Leonid Meteor Shower from NainiTal, India

Nilakshi Dhingra, Karunakar Upadhyay, S.B. Pandey, J.C. Pandey, Sneh Lata,
Uttar Pradesh State Observatory

Observations of the 1999 Leonids as seen from Nainital, India, are described.

It is very encouraging that the IMO *receives more and more meteor observations from "less traditional" locations, improving the geographical distribution of the observations. The present article is therefore as much a presentation of a new observing group as an article on the actual meteor shower observed. Notice that the observations were not carried out according to the* IMO *standard method.*

Marc Gyssens, Editor-in-Chief

1. Introduction

From time immemorial, celestial events have been attracting mankind due to their eye-catching vision. With the progress of science, scientists and general people wait eagerly for such events to quench the thirst of curiosity, to broaden the horizon, and enrich the knowledge of science.

In this perspective, the astronomy of meteor showers is gaining momentum and interest among professional and amateur astronomers, scientists in other fields, and public in general, because of its spectacular perception.

A recent publication of R. McNaught and D. Asher [1], predicted good Leonid showers in 1999 and 2000, and strong storms in 2001 and 2002. There had been a global alert for the Leonid shower on November 18, with a predicted peak time of 2^h08^m UT, which favored observing sites in West Asia, Europe, and Africa. Though India is in the South of Asia, the promise of a bright meteor shower on a dark night had lured our enthusiastic team.

2. Brief introduction of the site

The *Uttar Pradesh State Observatory* (*UPSO*) was established in 1954 [2]. Research and developmental activities at the observatory have increasingly covered selected areas of astronomy and astrophysics. The observatory is well-known for its precise observations in the studies related to comets, ring formation in the solar system, variable stars, star clusters, stellar populations, photometry of galaxies, optical follow-up observations of radio and space-borne astronomical sources, as well as gravitational micro-lensing and milli-magnitude variations in rapidly oscillating peculiar A-type stars. The *UPSO* is located at longitude $\lambda = 79°27.'4$ E and latitude $29°21.'7$ N, at an altitude of 1951 m above sea level and around 9 km away from the city light and pollution.

3. Observations

It is difficult to observe meteors by telescopical techniques because of their very narrow and fast view. By the naked eye, we can easily carry out necessary observations, and it is very enjoyable and fun also to see meteors, especially meteor showers, in particular when in a team. So, our team of 5 research students (working in different fields of astronomy, and to be considered at present as amateur astronomers, because we are still infant in our research career) carried out observations of Leonids on the most promising night of November 17-18, 1999, for 2.5 hours (0^h45^m–3^h15^m Indian Standard Time), from one of the topmost locations of the *Uttar Pradesh State Observatory* (*UPSO*), from where the entire sky was clearly visible, except for a small part in the southern direction. On the night of November 17-18, the sky was very clear, without even a single patch of cloud, and the Moon was in its First Quarter. In fact, we were fortunate to have an adequately dark night for this wonderful event. Now the team was primed with paper, pen, and torch. We envisaged our sitting plan in such a manner that one person was placed in the center, and the other four around this person, facing different directions to cover the entire sky.

The first Leonid was seen at 1^h15^m IST in the eastern part of the sky. We divided brightnesses of meteors in 6 categories by comparing them with stars of known magnitude. Those categories were *extremely bright* (EB, brighter than Venus, i.e., magnitude −4 or brighter); *highly bright* (HB, magnitude around −3); *very bright* (VB, between magnitudes −1 and −2, comparable to Sirius); *bright* (B, between magnitudes 0 and +2, comparable to Vega); *dim* (D, between magnitudes +3 and +4); and *very dim* (VD, between magnitudes +5 and +6).

Figure 1 shows the meteor activity during the observing period.

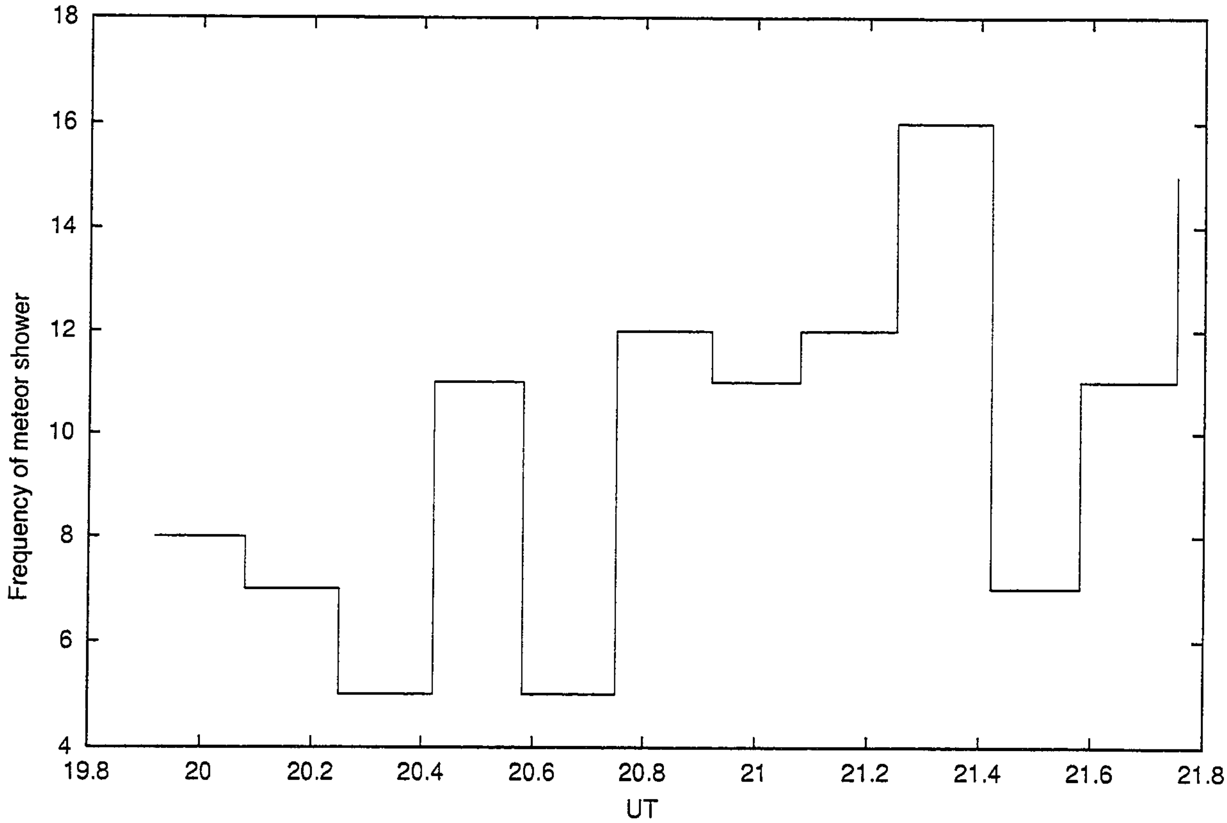

Figure 1 – Raw Leonid counts.

4. Results

In a period of 2 hours, in all, 120 meteors have been seen in all directions in the sky.

According to our visual inspection, we concluded that about 38% of the meteors were dim, 33% were bright, 19% were highly bright, and only one was extremely bright with a brilliant bluish tinge. This meteor appeared in the eastern direction just above the constellation of Leo, whose tail sojourned in the sky for about 2 minutes in vertical position and then turned horizontal towards the north while fading slowly. The rest of the meteors lasted for 1–2 seconds. On average, one meteor was seen per minute.

In comparison to last year's (November 18, 1998) observations, this year's shower was stronger and more prominent, as, due to clouds last year, we could see only 70 meteors in 4 hours (0^h30^m–3^h57^m IST), from the same sight, with an average of 0.3 meteors per minute.

In a nut-shell, it was an awe-inspiring experience to observe the meteor shower on the chilly night of November 17-18. We hope that, in the future, astronomers will generally be able to predict meteor activity more precisely with the help of world-wide data collection, and make the general public more aware of this stimulating subject.

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[1] R.H. McNaught D.J. Asher, *WGN* 27, 1999, pp. 850–102.

[2] Ram Sagar, *Current Science* 77:5, 1999, pp. 643–651.

The International Meteor Organization

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