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The slow-moving fireball EN090397A of −7 maximum absolute magnitude as photographed from Ondřejov on March 9, 1997, at $20^h59^m12^s \pm 4^s$ UT. More details can be found elsewhere in this issue.

In this issue:

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Useful Information

The October Issue *(WGN 25:5)*

The *October issue* will be mailed during the second week of October. Contributions are due on *September 28* at the latest. They should be sent to *Marc Gyssens*.

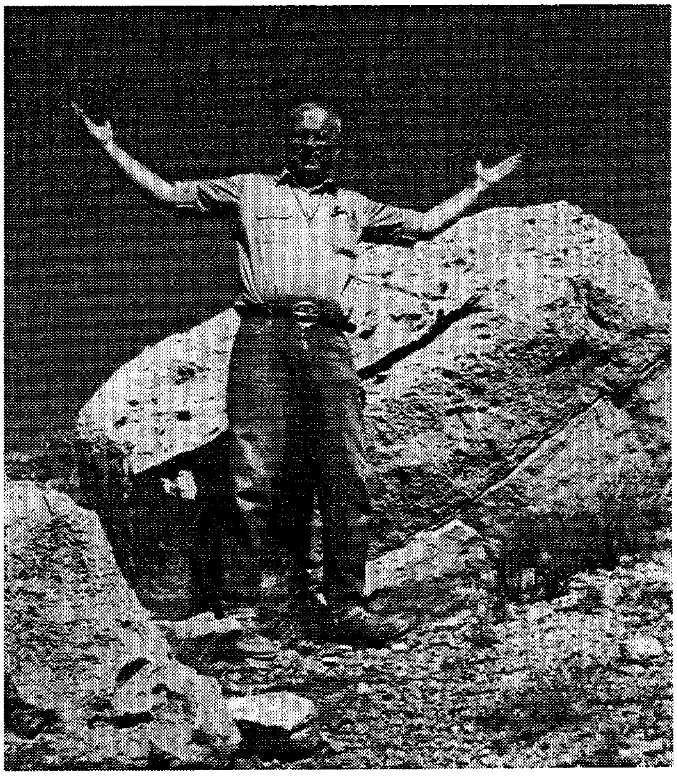
Administrative Correspondence

Ordering *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 *Ina Rendtel*.

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

In Memoriam
Eugene Shoemaker, 1928–1997

Dieter Heinlein



Dr. Eugene Shoemaker at the rim of the Barringer Meteor Crater on October 9, 1995.

With the death of Dr. Eugene ("Gene") Shoemaker at age 69, the world has lost one of its most esteemed and popular planetary scientists. On the afternoon of July 18, 1997, he was fatally injured in an automobile accident in Australia near Tanami (500 km northwest of Alice Springs), and he died shortly after this two-car wreck. His wife Carolyn, who accompanied him on their annual trip Down Under, to search for impact craters in the outback, suffered broken ribs but she survived.

Eugene Shoemaker was born on April 28, 1928, in Los Angeles. When still in his teens, Gene was fascinated by the dream to become an astronaut and to get the chance to walk on the Moon and to bang on it with his own hammer. So he started a university career in geology, but medical problems prevented him from being selected for the Apollo program and personally doing geological field work on the surface the Moon.

Working for the U.S. Geological Survey (USGS) since 1948, Shoemaker organized the Branch of Astrogeology of the USGS in Flagstaff, Arizona in 1961 and acted as its director until 1966. He took part in the Ranger lunar robotic missions, was PI for the television experiment on the Surveyor lunar landers (1963–1968), and performed geological field trainings for the Astronauts of the Apollo lunar landings (1965–1970). Moreover, he gave lectures as Professor at the California Institute of Technology. During the last two decades, Shoemaker chaired NASA working groups on how to survey near-Earth objects and how to prevent dangerous impacts. He recently was active in the Clementine mission that imaged the Moon.

Gene Shoemaker surely was one of the great founders of the field of planetary science. His main interest soon became the investigation of meteorite impact craters and Earth-crossing asteroids. Shoemaker's signature work was the research of the Barringer Meteor Crater near Winslow, Arizona. But he discovered and proved numerous structures on our Earth to be created by asteroid impact, e.g., the Nördlinger Ries in Germany in 1960. His comprehensive work on meteorite impacts and the role that they play(ed) in the evolution of the solar system is a fundamental milestone in the history of space science.

Gene gained worldwide fame in March 1993, when he discovered (together with his wife Carolyn and colleague David Levy) a comet that broke up by the tidal forces of Jupiter and crashed into the largest planet of our solar system 16 months later. The discovery of this famous comet Shoemaker-Levy 9 was only the top of the iceberg: with their telescope of the Palomar Mountain Observatory, California, Eugene and Carolyn Shoemaker have found more than 300 new minor planets, and they became the leading comet discoverer team of this century.

One of Gene Shoemaker's great merits was his ability to explain the wonders of the planets and asteroids not only scientifically correct to his colleagues, but also to the layman and amateur: he did it in a way that it was impossible not to get excited and fascinated in the topic he was talking about. Highly appreciated by amateurs as a good teacher and likewise as a dear friend, Dr. Shoemaker was also bestowed with numerous awards and medals by the scientific community. Since 1980, he was a member of the National Academy of Sciences of the United States.

He never was tired bringing to other scientists' and the public's attention the danger of the impacts of comets and asteroids on the Earth—even if the probability for such an event might be low: this can happen! What is the probability for a head-on car crash "in the middle of nowhere" in the Australian outback? It did happen! With Gene Shoemaker as a victim of such a most unlikely impact event, the world has lost a highly renowned geologist and astronomer, and quite a few of us have lost a good friend.

Gotfred Møbjerg Kristensen, 1945–1997

Jürgen Rendtel

With great sorrow, we received the sad news that our member Gotfred Møbjerg Kristensen of Denmark has passed away on May 24, 1997.

Gotfred was born on May 12, 1945. He had a wide interest in various astronomical topics, but his main interest was into meteor work. He made a lot of visual and photographic meteor observations, but, probably, he was most known for his radio meteor work. Gotfred joined the *IMO* from its very beginning and became one the founding members.

Moreover, Gotfred played an important role in Danish meteor astronomy through his observations and, very importantly, by inspiring other people to become involved in meteor astronomy. Gotfred administered the Danish Fireball Center of the Meteor Section of the Danish Astronomical Society, and he also coordinated visual meteor work in Denmark.

Unfortunately, I did not have the privilege to meet Gotfred personally. We had a few contacts after the appearance of a large fireball which was observed by different methods. While I caught it with a fireball camera, Gotfred recorded an intense radio echo.

It will be very difficult to find one or more persons to continue Gotfred's work. The death of Gotfred Møbjerg Kristensen is a great loss, not only to his two brothers and their families—he was not married, but also to Danish and international meteor astronomy.

From the Editor-in-Chief

Marc Gyssens

Traditionally, the time of writing of the August issue is a period of anticipation. Will the Perseids still show enhanced activity? If so, is it going to happen earlier or later than expected? Will the height and/or the width of the "new peak" have changed since last year? And how will the "regular" Perseid peak perform? Of course we are longing for answers for these questions as we did before, but this year the joy of this anticipation is sadly overshadowed by the tragic deaths of Gene Shoemaker and Gotfred Kristensen. We thank Dieter Heinlein and Jürgen Rendtel for sharing their thoughts with us.

In this issue, you find articles on a wide variety of topics, and we hope you will find this issue pleasing. Clearly video observing of meteors is becoming ever more important!

When the October issue will appear, two important events will have passed: the 1997 Perseids and the 1997 IMC. *First of all, I wish to encourage our readers and their friends to make both events into a big success. For those of you who intend to attend the* IMC, *but have not yet registered, we ran the registration form one last time in this issue. There is no time left for delaying to return it! And secondly, give your journal the necessary feedback! With your help, we intend to give you next time a representative account of both events.*

Meanwhile, I wish you many clear nights for observing!

Letters to WGN

compiled by Marc Gyssens

Stones from heaven: some meteoric fossil folklore

Further to Alastair McBeath's most interesting article (*WGN* 25:3, 1997, p. 128) on the association of fossil corals with fallen stars, I am inspired to respond to his request for further examples of similar linkages.

The comparable example that I am aware of concerns the Menomini Indians of Wisconsin in North America. The following quotation is taken from W.J. Hoffman (*American Bureau of Ethnology* 14, 1893, p. 210):

> *"When a star falls down from the sky it leaves a fiery trail; it does not die, but its shade goes back to the place whence it dropped to shine again. The Indians sometimes find the small stars in the prairie where they have fallen. They are of stone, and are round, with a spot in the center, and four or five points projecting from the surface. I have myself found some of these fallen stars."*

There is an obvious correspondence between the account presented by Hoffman and those given by Robert Plot in his Natural *Histories*. The "stones" that Hoffman describes are commonly called sand-dollars and are fossilized Echinoderms. The Menomini Indians have occupied the same territory for many centuries and were first encountered in what is now North East Wisconsin in 1634. If the ancient origin of the Menomini association is creditable, it would appear that we have an independent convergence of ideas. This, it seems to me, is quite a remarkable circumstance.

The First Nations people of North America were not great astronomers, and they have no written language. Certainly, they watched the heavens and developed an extensive creation mythology and a calendar that was handed down from one generation to the next by a vigorous oral tradition. Numerous examples can be found, however, of native stories in which shooting stars feature. The Tsetsaut Indians of Alaska, for example, have one legend that runs,

> *"A long time ago fire was seen coming through the air from the north. It looked like a huge animal. Its face was fire. Fire came from its mouth and also from its back. Flames shot from its paws. The Thing, moving backwards, thundered through the air. In olden times, these monsters came often. Now they have not been seen for a long time."*

This story, which was tentatively called *The Meteor*, was collected and published by K.B. Judson in 1911 (*Myths and Legends of Alaska*, A.C. McClurg and Co., Chicago).

A number of Indian tribes recorded astronomical events in pictographic form in their annual Winter Counts. Among the significant events recorded on the surviving Counts are the 1833 Leonid storm, a bright, electrophonic fireball witnessed in 1821, and several total lunar and solar eclipses. While these events are fascinating in them selves, it was only upon reading Alastair McBeath's article that I realized something else about the Winter Count pictographs. The artistry of the stars and meteors shown in the Winter Counts was similar to that used in European star charts. Since the early 13th century, European printers have drawn stars as crosses (+) and as asterisks (*). Later, the +s and *s became triangulated to form what we now call a star shape. Typically, the "stars" had between five to eight vertices (see e.g., G.S. Synder's *Maps of the Heavens*, André Deutsch Ltd., London, 1984). Now, we all know that real stars do not look star shaped—they are at best bright dots or circles, and they are drawn this way on modern star charts. This observation was certainly clear to the ancient Chinese observers, who always used circles to represent stars on their celestial maps (see e.g., R. Stephenson, *New Scientist*, January 2, 1993). The interesting point about the Winter Count pictographs is that both stars and fireballs are drawn as five-pointed star shapes, with the fireball having an elongated tail. The Leonid storm meteors, on the other hand, are drawn as crosses (+), some with added tails, some without (see e.g., P. Murdin, *New Scientist*, August 20, 1981). I have no good answer to why real stars have traditionally been drawn as star shapes, but it strikes me as highly interesting that two cultures have developed the same imagery (apparently) independently. I say "apparently" in parenthesis since the American Indians only started drawing Winter Counts in the early 1800s, and consequently their imagery may be a reflection of what European settlers had shown them. At the very least, there is probably room for more research on this topic.

Martin Beech, July 3, 1997

The 1997 International Meteor Conference

Petnica, Yugoslavia, September 25–28, 1997

Vladimir Lukić

Another *International Meteor Conference* in the Balkans takes place in Petnica, Yugoslavia, from September 25 to 28, 1997. For our readers' convenience, we republish the information and registration form provided in an earlier issue of *WGN*. If you still wish to participate, return it at once to Treasurer Ina Rendtel!

International Meteor Conference

Petnica, Valjevo, Yugoslavia, September 25–28, 1997

Registration Form

Each individual participant should fill out a form and return it to *Ina Rendtel, Mehlbeerenweg 5, D-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. 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 1997 *IMC* from September 25 to 28;
- ○ 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 Petnica;
- ○ I wish to stay in Yugoslavia 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 140 DEM or a pre-payment of at least 100 DEM should be sent to the Treasurer, *Ina Rendtel*. Follow the payment instructions below. Participants paying only 100 DEM have to pay the remaining 40 DEM upon arrival in Petnica.

Date and signature: ____

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

- in Europe: pay in DEM to Ina Rendtel, postal giro account number 547234107 at Postbank Berlin, bank code 10010010. No bank checks, please! (Bank checks can only be send 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*

Meteor Shower Calendar: October 1997–March 1998

compiled by Alastair McBeath

1. October to December

Ecliptical minor shower activity reaches what might be regarded as a peak in early to mid November, with the Taurid streams in action, but before then we have the Orionids (whose central peak of several submaxima, October 21, 7^h UT, is badly affected by a waning gibbous Moon, as are the minor ε-Geminids). Around October 9, 17^h UT, any Draconid activity this year might be detected, when the Moon is at first quarter, but it is likely to be 1998, when Comet 21P/Giacobini-Zinner returns to perihelion, that we have the best chance to see any noticeable activity from this source. The Leonids (maximum due November 11, 17^h UT) and the Geminids (peak: December 13, 22^h UT) both lose out to bright moonlight in 1997, along with several of the late-year low-activity showers, such as the α-Monocerotids (those checking for another outburst at the time of 1995's should be alert around November 21, 13^h UT), Monocerotids, σ-Hydrids, and Coma Berenicids. By contrast, the χ-Orionids, Phoenicids, the early part of the weak Puppid-Velid complex, and Ursids during December are all rather better-placed with regard to the Moon.

Southern Taurids

Active: October 1–November 25; Maximum: November 5 ($\lambda_\odot = 223°$); ZHR = 5;
Radiant: $\alpha = 50°$, $\delta = +13°$; Radiant drift: see Table 2; size: $\alpha = 20° \times \delta = 10°$;
$V_\infty = 27$ km/s; $r = 2.3$;
TFC: Choose fields on the ecliptic and $\approx 10°$ E or W of the radiants ($\beta > 40°$ S).

Northern Taurids

Active: October 1–November 25; Maximum: November 12 ($\lambda_\odot = 230°$); ZHR = 5;
Radiant: $\alpha = 58°$, $\delta = +22°$; Radiant drift: see Table 2; size: $\alpha = 20° \times \delta = 10°$;
$V_\infty = 29$ km/s; $r = 2.3$;
TFC: Choose fields on the ecliptic and $\approx 10°$ E or W of the radiants ($\beta > 40°$ S).

These two streams form a complex associated with Comet 2P/Encke. Defining their radiants is best achieved by careful visual or telescopic plotting, photography, or video work, since they are large and diffuse. The brightness and relative slowness of many shower meteors makes them ideal targets for photography, while these factors coupled with low, steady combined Taurid rates makes them excellent targets for newcomers to practice their plotting techniques on. The activity of both streams produces an apparently plateau-like maximum for about ten days in early November, and the shower has a reputation for producing some superbly bright fireballs at times, although seemingly not in every year. The year 1995 produced an impressive crop of brilliant Taurids between late October and mid-November, for instance, and the last few days of October with the opening ones of November seem especially likely to yield Taurid fireballs, from past analyses. New Moon on October 31 means this period, and the Southern Taurid maximum are notably favored with dark skies in 1997.

The near-ecliptic radiants for both shower branches mean all meteoricists can observe the streams, with the northern hemisphere somewhat better-placed, from where suitable radiant zenith distances are obtained for much of the lengthening late autumnal nights. Even in the southern hemisphere, a good 3–5 hours watching around local midnight is possible with Taurus well above the horizon, however.

χ-Orionids

Active: November 26–December 16; Maximum: December 2 ($\lambda_\odot = 250°$); ZHR = 3;
Radiant: $\alpha = 82°$, $\delta = +23°$; Radiant drift: see Table 2; radius: 8°;
$V_\infty = 28$ km/s; $r = 3.0$;
TFC: $\alpha = 83°$, $\delta = +09°$ and $\alpha = 80°$, $\delta = +24°$ ($\beta > 30°$ S).

This weak visual stream is moderately active telescopically, although a number of brighter meteors have been recorded by professional photographic patrols in the past too. The shower has a double radiant (at least), but the southern branch has been rarely detected. The χ-Orionids may be a continuation of the ecliptic complex after the Taurids cease to be active. The radiant used here is a combined one, suitable for visual work, although telescopic or video observations should be better-able to determine the exact radiant structure. November's New Moon favors the shower with dark skies this year, and the radiant, actually in eastern Taurus at the shower's peak, is well on display for all watchers throughout the night.

Phoenicids

Active: November 28–December 9; Maximum: December 6, 8^h UT ($\lambda_\odot = 254.^\circ 25$);
ZHR: variable, usually 3 or less, may reach 100;
Radiant: $\alpha = 18°$, $\delta = -53°$; Radiant drift: see Table 2; radius: 5°;
$V_\infty = 18$ km/s; $r = 2.8$;
TFC: $\alpha = 40°$, $\delta = -39°$ and $\alpha = 65°$, $\delta = -62°$ ($\beta < 10°$ N).

Only one impressive Phoenicid return has so far been reported, that of its discovery in 1956, when the ZHR was about 100. Three other potential bursts of lower activity have been reported, but never by more than one observer, under uncertain circumstances. *IMO* observers noted rates barely at the visual detection limit between 1988 and 1995, making the normal current activity virtually nonexistent. This may be a periodic shower, however, and more observations of it are needed by all methods. Radio workers may find difficulties, as radar echoes from the 1956 event were only 30 per hour, perhaps because these low-velocity meteors produce too little radio-reflecting ionization. Observing conditions this year are reasonable for all southern hemisphere watchers, with a waxing crescent Moon a problem only in the evening hours. This is a little unfortunate, since the radiant, although well on view for most of the night, culminates at dusk, but it should not be regarded as a major deterrent.

Ursids

Active: December 17–26; Maximum: December 22, 11^h UT ($\lambda_\odot = 270.^\circ 7$);
ZHR = 10 (occasionally variable up to 50);
Radiant: $\alpha = 217°$, $\delta = +76°$; Radiant drift: see Table 2; radius: 5°;
$V_\infty = 33$ km/s; $r = 3.0$;
TFC: $\alpha = 348°$, $\delta = +75°$ and $\alpha = 131°$, $\delta = +66°$ ($\beta > 40°$ N);
$\alpha = 63°$, $\delta = +84°$ and $\alpha = 156°$, $\delta = +64°$ ($30° \leq \beta \leq 40°$ N).

A northern hemisphere shower which has been very poorly observed, although at least two major outbursts have occurred in the past half-century or so, in 1945 and 1986, and several other rate enhancements, recently in 1988 and 1994, have been reported too. Other similar events could easily have been missed due to poor weather or too few observers active. All forms of observation can be used for the shower, since many of its meteors are faint, but with so little work carried out on the stream, it is impossible to be precise in making statements about it.

Its radiant is circumpolar from most northern sites (thus fails to rise for most southern ones), though it culminates after daybreak, and is highest in the sky later in the night. The waning Moon, just past last quarter, will be a minor nuisance this year when the radiant is approaching its highest, but with observations at a premium, that should not put off prospective watchers.

2. January to March

The opening quarter of the year brings several low-activity showers, including the first of the year's main diffuse ecliptical stream complexes, the Virginids, active from late January to mid-April. Of the two better showers, only the northern-hemisphere Quadrantids in early January are free from moonlight. The other, the α-Centaurids, a sometimes good southern-hemisphere shower (maximum around February 7, 16^h UT) is too close to Full Moon for non-radio observations. The minor δ-Cancrids in mid-January lose out too to a bright Moon, along with the γ-Normids in mid-March. Daylight radio peaks are due from the Capricornids/Sagittarids around 13^h UT on February 1, and the χ-Capricornids on February 13, probably around 14^h UT. Neither radio shower has been well-observed in recent times, and as both have radiants under 10°–15° west of the Sun at maximum, they cannot be regarded as visual targets even from the southern hemisphere.

Quadrantids

Active: January 1–5; Maximum: January 3, 17^h UT ($\lambda_\odot = 283.^\circ 16$);
ZHR = 120 (can vary $\sim$ 60–200);
Radiant: $\alpha = 230°$, $\delta = +49°$; Radiant drift: see Table 2; radius: $\sim$ 5° at maximum;
$V_\infty = 41$ km/s; $r = 2.1$ at maximum, but variable
TFC: $\alpha = 242°$, $\delta = +75°$ and $\alpha = 198°$, $\delta = +40°$ ($\beta > 40°$ N);
PFC: $\alpha = 150°$, $\delta = +70°$ before 0^h local time;
$\alpha = 180°$, $\delta = +40°$ and $\alpha = 240°$, $\delta = +70°$ after 0^h local time ($\beta > 40°$ N).

The year commences with a good return of the Quadrantids for northern hemisphere observers, as the Moon will be a waxing crescent setting by the local late evening hours of January 3. Since the shower's radiant is in northern Boötes, it is circumpolar for many northern locations, but it attains a useful elevation only after local midnight or so, and gets higher towards morning twilight. The Moon will thus present no problems in 1998.

An interesting challenge is to try spotting the occasional long-pathed shower member from the southern hemisphere around dawn, but sensible Quadrantid watching cannot be carried out from such locations.

The maximum time given above is based on the best-observed return of the shower ever analyzed, from 1992 *IMO* data, confirmed by radio results in 1996 and 1997, and a repeat of which time in 1998 would favor sites from Alaska and the Northern Pacific islands to Far Eastern Siberia, China, and Japan. The peak itself is short-lived, and can be easily missed in just a few hours of poor winter weather in the north, which may be why the ZHR level apparently fluctuates from year to year, but some genuine variability is probably present too. An added level of complexity comes from the fact that mass-sorting of particles across the meteoroid stream may make fainter objects (radio and telescopic meteors) reach maximum up to 14 hours before the brighter (visual and photographic) ones, so observers should be alert throughout the shower!

Past observations have suggested the radiant is very diffuse away from the maximum, contracting notably during the peak itself, although this may be a result of the very low activity normally seen away from the hours near maximum. Photographic and video observations from January 1 to 5 would be particularly welcomed by those investigating this topic, using the PFCs and TFCs given above, along with telescopic and visual plotting results.

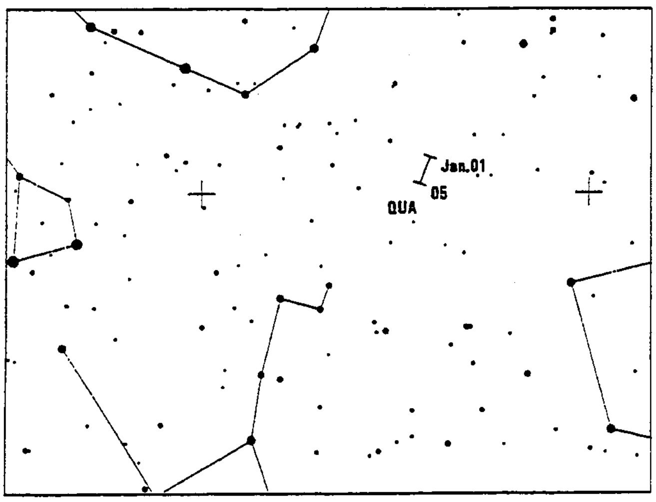


Figure 1 – Radiant position and drift of the Quadrantids in early January.

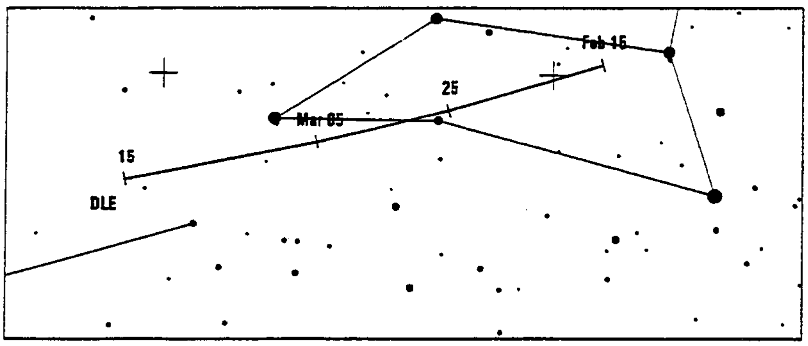


Figure 2 – Radiant position and drift of the δ-Leonids

δ-Leonids

Active: February 15–March 10; Maximum: February 24 ($\lambda_\odot = 336°$); ZHR = 2;
Radiant: $\alpha = 168°$, $\delta = +16°$, Radiant drift: see Table 2; radius: 5°;
$V_\infty = 23$ km/s; $r = 3.0$;
TFC: $\alpha = 140°$, $\delta = +37°$ and $\alpha = 151°$, $\delta = +22°$ ($\beta > 10°$ N);
$\alpha = 140°$, $\delta = -10°$ and $\alpha = 160°$, $\delta = 00°$ ($\beta < 10°$ N).

This minor shower is probably part of the early Virginid activity. Rates are normally low, and its meteors are predominantly faint, so it is a prime candidate for telescopic investigation. Visual observers must make very accurate plots of the meteors to distinguish them from the nearby Virginids and the sporadics. Northern hemisphere sites have a distinct advantage for covering this stream, whose radiant is well on view for most of the night near the peak, close to the "Sickle" or "Head" of Leo, but southern hemisphere watchers should not ignore it, as they are better-placed to note many of the other Virginid radiants. With the Moon just two days before New at the shower's maximum, conditions could scarcely be better for observing it.

3. Working list of meteor showers

Table 1 – Working list of meteor showers for the period October 1997–March 1998. 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 only.

Shower	Activity	Maximum		Radiant			V_∞	r	ZHR
		Date	$\lambda_\odot$	α	δ	Radius	(km/s)		
δ-Aurigids (DAU)	Sep 05–Oct 10	Sep 08	166°	60°	+47°	5°	64	3.0	6
Piscids (SPI)	Sep 01–Sep 30	Sep 19	177°	5°	−01°	5°	26	3.0	3
Draconids* (GIA)	Oct 06–Oct 10	Oct 09	196°5	262°	+54°	2°	20	2.6	
ε-Geminids (EGE)	Oct 14–Oct 27	Oct 18	205°	102°	+27°	5°	70	3.0	2
Orionids (ORI)	Oct 02–Nov 07	Oct 21	208°	95°	+16°	10°	66	2.9	20
Southern Taurids (STA)	Oct 01–Nov 25	Nov 05	223°	52°	+13°	10°/5°	27	2.3	5
Northern Taurids (NTA)	Oct 01–Nov 25	Nov 12	230°	58°	+22°	10°/5°	29	2.3	5
Leonids (LEO)	Nov 14–Nov 21	Nov 17	235°2	153°	+22°	5°	71	2.5	var
α-Monocerotids (AMO)	Nov 15–Nov 25	Nov 21	239°3	110°	+03°	5°	65	2.4	
χ-Orionids (XOR)	Nov 26–Dec 15	Dec 02	250°	82°	+23°	8°	28	3.0	3
Dec Phoenicids (PHO)	Nov 28–Dec 09	Dec 06	254°3	18°	−53°	5°	18	2.8	var
Puppid/Velids (PUP)	Dec 01–Dec 15	Dec 07	255°	123°	−45°	10°	40	2.9	10
Dec Monocerotids (MON)	Nov 27–Dec 17	Dec 08	257°	100°	+08°	5°	42	3.0	3
σ-Hydrids (HYD)	Dec 03–Dec 15	Dec 11	260°	127°	+02°	5°	58	3.0	2
Geminids (GEM)	Dec 07–Dec 17	Dec 13	262°0	112°	+33°	5°	35	2.6	110
Coma Berenicids (COM)	Dec 12–Jan 23	Dec 19	268°	175°	+25°	5°	65	3.0	5
Ursids (URS)	Dec 17–Dec 26	Dec 22	270°7	217°	+76°	5°	33	3.0	10
Quadrantids (QUA)	Jan 01–Jan 05	Jan 03	283°2	230°	+49°	5°	41	2.1	120
δ-Cancrids (DCA)	Jan 01–Jan 24	Jan 17	297°	130°	+20°	10°/5°	28	3.0	4
α-Centaurids (ACE)	Jan 28–Feb 21	Feb 07	318°7	210°	−59°	4°	56	3.0	6
δ-Leonids (DLE)	Feb 15–Mar 10	Feb 24	336°	168°	+16°	5°	23	3.0	2
γ-Normids (GNO)	Feb 25–Mar 22	Mar 13	353°	249°	−51°	5°	56	2.4	8
Virginids (VIR)	Jan 25–Apr 15	Mar 24	4°	195°	−04°	15°/10°	30	3.0	5

Table 2 – Radiant positions for October 1997–March 1998 in α and δ.

	NTA	**STA**	**ORI**	**DAU**				
Oct 5	25o +12°	27° +7°	85° +14°	89° +49°		**GIA**		
Oct 10	29° +14°	31° +8°	88° +15°	95° +49°		262° +54°		
Oct 15	34° +16°	35° +9°	91° +15°		**EGE**			
Oct 20	38° +17°	39° +11°	94° +16°		99° +27°			
Oct 25	43° +18°	43° +12°	98° +16°		104° +27°			
Oct 30	47° +20°	47° +13°	101° +16°		109° +27°			
Nov 5	53° +21°	52° +14°	105° +17°					
Nov10	58° +22°	56° +15°		**LEO**	**AMO**			
Nov15	62° +23°	60° +16°		150° +23°	113° −5°			
Nov20	67° +24°	64° +16°	**XOR**	153° +21°	117° −6°			
Nov25	72° +24°	69° +17°	75° +23°		121° −7°	**MON**	**PUP**	**PHO**
Nov30			80° +23°	**HYD**		91° +8°	120° −45°	14° −52°
Dec 5	**COM**	**GEM**	85° +23°	122° +3°		96° +8°	122° −45°	18° −53°
Dec10	169° +27°	108° +33°	90° +23°	126° +2°		100° +8°	125° −45°	22° −53°
Dec15	173° +26°	113° +33°	94° +23°	130° +1°	**URS**	104° +8°	128° −45°	
Dec20	177° +24°	118° +32°	**DCA**		217° +75°			
Jan 0	186° +20°	**QUA**	112° +22°					
Jan 5	190° +18°	231° +49°	116° +22°					
Jan 10	194° +17°		121° +21°					
Jan 20	202° +13°		130° +19°	**ACE**	**VIR**			
Jan 30				200° −57°	157° +16°	**DLE**		
Feb 10				214° −60°	165° +10°	155° +20°	**GNO**	
Feb 20				225° −63°	172° +6°	164° +18°	225° −53°	
Feb 28					178° +3°	171° +15°	234° −52°	
Mar10					186° 0°	180° +12°	245° −51°	
Mar20					192° −3°		256° −50°	
Mar20					198° −5°			

4. Daytime radio meteor streams

Table 3 – Working list of daytime radio meteor streams. 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.

Shower	Activity	Max	$\lambda_\odot$	Radiant		Best Observed		Rate
		Date	2000.0	α	δ	50° N	35° S	
Sextantids	Sep 09–Oct 09	Sep 27	184°3	152°	00°	06^h–12^h	06^h–13^h	medium
Cap/Sagittarids	Jan 13–Feb 04	Feb 02	312°5	299°	−15°	11^h–14^h	09^h–14^h	medium
χ-Capricornids	Jan 29–Feb 28	Feb 14	324°7	315°	−24°	10^h–13^h	08^h–15^h	low

5. Lunar phases

Table 4 – Lunar phases for October 1997–March 1998.

New Moon	Oct 01	Oct 31	Nov 30	Dec 29	Jan 28	Feb 26	Mar 28
First Quarter	Oct 09	Nov 07	Dec 07	Jan 05	Feb 03	Mar 05	Apr 03
Full Moon	Oct 16	Nov 14	Dec 14	Jan 12	Feb 11	Mar 13	Apr 11
Last Quarter	Sep 23	Oct 23	Nov 21	Dec 21	Jan 20	Feb 19	Mar 21

Ongoing Meteor Work

The η-Aquarid Meteor Shower in 1997

Jürgen Rendtel

From data of the 1997 return of the η-Aquarids, profiles of the population index r and the ZHR have been calculated. The ZHR maximum is located at $\lambda_\odot = 44°5 \pm 0°2$ (May 4, 1997, 22^h UT). This is by 1° earlier than the average derived for the period 1988 to 1995. The minimum value of the population index of $r = 1.95 \pm 0.4$ occurs about 1° after the ZHR maximum. Also this value is considerably lower than the standard figure of $r = 2.7$. This difference is also the reason for the lower maximum ZHR of 54 ± 3 as compared to the average of 69 ± 4. Analyses of the number densities for different particle populations indicate a mass segregation in the meteoroid stream, with the larger particles appearing later than the smaller meteoroids.

1. Introduction

The η-Aquarid meteor shower with its maximum in early May is the most active shower visible for observers in the southern hemisphere, while it is practically invisible to observers north of about 45° N. The radiant rises only in the morning hours, but the observing window for optical observations remains short for almost all regions. This fact as well as the uneven distribution of meteor observers in the hemispheres causes a number of specific problems for the analysis of data.

The η-Aquarids are caused by the passage of the Earth through the meteoroid stream of comet 1P/Halley, as is the appearance of the Orionids in October. Since the minimum distance to the comet's orbit and the stream's core region is smaller in early May, the rates of the η-Aquarids are higher than those of the Orionids.

While the *IMO*'s *VMDB* contains a quite large number of η-Aquarid data over the years, the 1997 return was certainly the best observed for a long time. The ZHR curve shown in the *Visual Handbook* [1] is a composite profile derived from data obtained between 1988 and 1995. Seen the number of reports available for the 1997 return, it seemed worthwhile to do an analysis of this independent data set.

2. 1997 observations

The η-Aquarid return was one of the very few major meteor shower maxima which was observable without interference of moonlight in 1997. A note was sent via `imo-news` to alert as many observers as possible. The η-Aquarids were also chosen for the joint meteor observation in Jordan [2]. In total, 37 observers sent in their data of the η-Aquarids:

Sanaa Abdo (Jordan), Khalid Al-Tal (Jordan), John Assmus (USA), Mohammad Awadallah (Jordan), Eva Bojurova (Bulgaria), Michael Buhagiar (Australia), Tim Cooper (South Africa), Hani Dalee (Jordan), Tomasz Fajfer (Poland), Pete Gural (USA), Cathy Hall (Canada), Ibrahim Jamil (Jordan), Khalil Konsul (Jordan), Marco Langbroek (the Netherlands), Robert Lunsford (USA), Adam Marsh (Australia), Norman McLeod (USA), Iris Miljački (Yugoslavia), Nikola Milutinovic (Yugoslavia), Sirko Molau (Germany), Saša Nedjković (Yugoslavia), Mirko Nitschke (Germany), Mohammad Odeh (Jordan), Dragana Okolić (Yugoslavia), Lyna Rashkova (Bulgaria), Luís A. Reck de Araujo (Brazil), Jürgen Rendtel (Germany), Petra Rendtel (Germany), Elena Sarbinska (Bulgaria), Branislav Savic (Yugoslavia), Richard Taibi (USA), Valentin Velkov (Bulgaria), Koos Van Zyl (South Africa), Marija Vucelja (Yugoslavia), Graham Wolf (New Zealand), George Zay (USA), Irena Zivkovic (Yugoslavia).

The total 1997 sample comprises 140 hours of net observing time. More than 160 count intervals have been reported during which more than 1100 η-Aquarid meteors were seen. In contrast, the already quoted composite ZHR curve [1] included 523 intervals collected over a period of eight years.

3. Analysis of the data

As usual, we first analyze the population index r from the available magnitude data. As in many other meteor showers, the value of r is somewhat lower around the rate maximum. The profile shown in Figure 1 is based on 870 η-Aquarid magnitudes. The values far off the maximum were set to the standard value of $r = 2.7$. The minimum of the population index reached $r = 1.95$ at $\lambda_\odot = 45\overset{\circ}{.}8 \pm 0\overset{\circ}{.}1$, which is significantly lower than the reference value of $r = 2.7$, but there was no r-profile calculated by now. The minimum value of $r = 1.95$ corresponds to a mass index of $s = 1.72$. Hughes [3] comes to $s = 1.71$ for the mass range $10^{-13} < m < 10^{-1}$ g, which covers the particle sizes included in our sample. He listed data from other references, which are between 1.72 and 1.95 for the visual range. Chebotarev et al. [4] derive a mass index s in the range between 1.4 and 2.5 from radar data obtained in the period 1981–1986.

The minimum in the population index r found from the 1997 visual data occurred significantly *later* than the ZHR maximum, indicating a mass sorting in the stream as discussed later.

As to be expected, the minimum figure of r is also smaller than the lowest r reported from the detailed analysis of the 1990 Orionid data [5], indicating that the particle set-up is slightly different along the trajectories of the Earth through the 1P/Halley meteoroid stream with a larger portion of larger meteoroids present closer to the core region of the stream. Nevertheless, both passages are distant from the comet's orbit (0.065 AU for the η-Aquarids and 0.18 AU for the Orionids [3]).

The short observing window of 1 to 3 hours duration towards the morning twilight—depending on the geographic latitude—and the distribution of the observers around the globe yields a data set which differs from that obtained for other showers in a very important point. There is no temporal overlapping between observations of different regions. The observers cover just three regions: Australia/New Zealand, South Africa/Middle East/Europe, and South/North America. This separation means that there is no period which can be used for calibration of the shower rates. So, we have to trust the reliability of the standard method as found from several other analyses of global data.

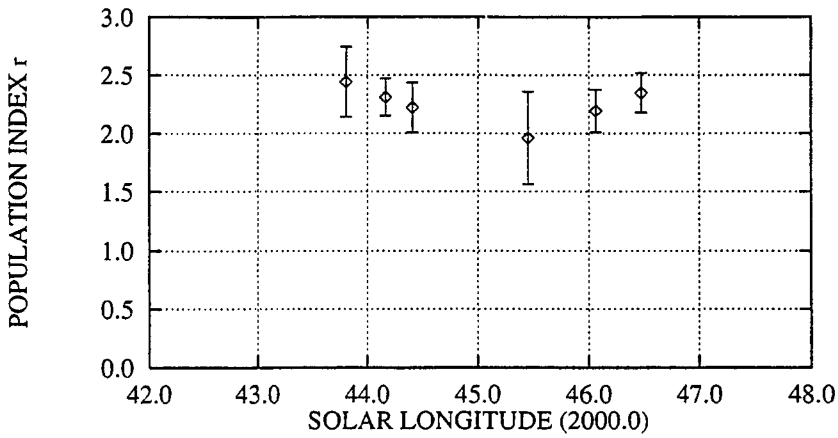


Figure 1 – Profile of the population index r obtained from the magnitude data of the 1997 return. The sampling interval was chosen as 1° in length, shifted by 0°5 for the period $\lambda_\odot = 43°–46°$. Further off the maximum, the number of shower meteors remained too low for a determination of an r-profile.

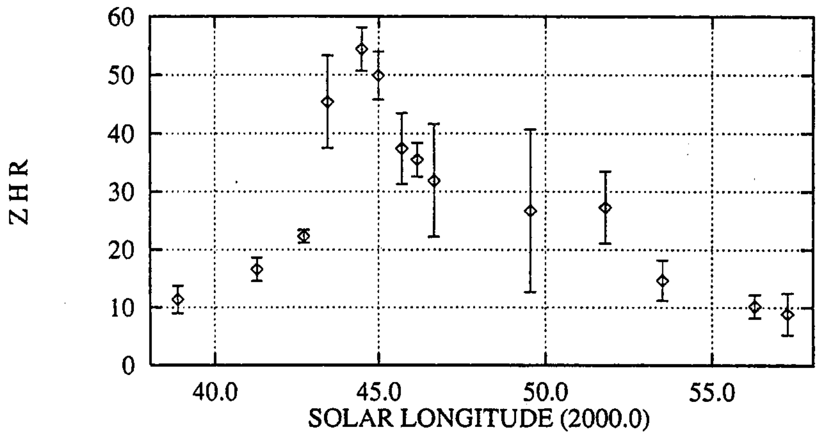


Figure 2 – ZHR profile of the 1997 η-Aquarids, based on 1050 shower meteors reported in 165 count intervals and the r-profile shown in Figure 1.

Another problem to be kept in mind is the low position of the radiant, particularly in the first interval for each data set. Hence, the correction factors for calculating the ZHR are large, and, combined with the small sample of shower meteors which can effectively be seen, the error margins for the individual ZHRs are large. Despite all these limitations, there are no obvious "jumps" or steps in the resulting ZHR curve (Figure 2).

The maximum ZHR of 54 ± 3 is somewhat lower than that of the combined data (69 ± 4) shown in [1]. This is not too much surprising and should be mainly an effect of the different value of r. For a rough estimate, we may assume an average limiting magnitude of 6.0 for all observations. With $r = 2.0$ the ZHR would be just 0.9 of the ZHR determined with the standard $r = 2.7$. The maximum ZHR occurred at $\lambda_\odot = 44°5 \pm 0°2$ (May 4, 1997, $22^{\rm h}$ UT). This is one day earlier than derived from the combined data set ($\lambda_\odot = 45°5$). Although no reduction of the various forward scatter data summarized in [6] has been made, the raw data support the maximum at this position rather than a day later.

The ZHR profile is relatively wide with a full width at half maximum (FWHM) of about 5°. Like in the reference profile, there seems to be a slight skewness of the 1997 ZHR profile with a steeper ascending branch as compared to the descending branch. Analyses of radar data [4] hint on a double maximum, with the first one close to the position found here, and another maximum near a solar longitude of 48°. However, the radar data include a somewhat different particle population, and the structure varied considerably from one return to the next. Also, the visual rate profile quoted by Hughes [3] shows some variations with higher rates around $\lambda_\odot = 49°$. The scatter of the averages determined from the current data set, particularly after the maximum is considerable, and hence it is difficult to make conclusions from the profile shown in Figure 2.

As already noted, the maximum in ZHR occurs about 1° (about 1 day) *before* the minimum of the population index r, i.e., the observers recorded a larger portion of brighter meteors in the night after the ZHR maximum (May 5-6) than at the actual ZHR maximum. This implies a kind of mass sorting within the meteoroid stream as it is known from other streams as well. Details can be seen from the figures listed in Table 1.

Table 1 – Number density maxima positions and strengths of the 1997 η-Aquarids for different meteoroid masses. The values of the number density S are given in particles per 10^9 km^3.

Magnitude range	Mass range	Number density S	Position $\lambda_\odot$
≤ 6.5	$\geq$ 0.3 mg	74	$44.^\circ 0 \pm 0.^\circ 5$
≤ 3.0	$\geq$ 1 mg	4.7	$44.^\circ 5 \pm 0.^\circ 3$
≤ 0.7	$\geq$ 10 mg	0.74	$44.^\circ 7 \pm 0.^\circ 3$

4. Conclusions

The 1997 return of the η-Aquarids allowed the determination of profiles of the population index r and the ZHR. The position of the ZHR maximum is located at $\lambda_\odot = 44.^\circ 5 \pm 0.^\circ 2$. This is by 1° earlier than the average derived for the returns from 1988 to 1995. Further analyses will be necessary to find whether the position is subject to variations and whether the shape (FWHM) of the profile varies at different returns, as indicated from radar data [4].

The value of the population index is $r = 2.2$ at the rate maximum, and reaches a minimum of $r = 1.95$ near $\lambda_\odot = 45.^\circ 5$. During the entire period between $\lambda_\odot = 43.^\circ 8$ and $\lambda_\odot = 46.^\circ 5$, the population index is considerably lower than the standard figure of $r = 2.7$. This difference is also the reason for the lower maximum ZHR of 54 ± 3 as compared to the average of 69 ± 4 shown in [1].

Indications for a mass sorting in the meteoroid stream are found from the positions of the maxima in number density for different masses, with the larger portion of bright meteors occurring about $0.^\circ 7$ later than the faint-meteor peak.

References

[1] J. Rendtel J., R. Arlt, R. Koschack, A. McBeath, P. Roggemans, J. Wood, "Meteor Shower Descriptions", in *Handbook for Visual Meteor Observers*, J. Rendtel, R. Arlt, A. McBeath, eds., IMO, Potsdam, 1995, pp. 126–279.

[2] J. Rendtel, "Observing the η-Aquarids from the Desert", *WGN* 25:3, June 1997, pp. 121–122.

[3] D.W. Hughes, "P/Halley Dust Characteristics: a Comparison Between Orionid and Eta Aquarid Meteor Observations and those from the Flyby Spacecraft", *Astron. Astrophys.* 187, 1987, pp. 879–888.

[4] R.P. Chebotarev, S.O. Isamutdinov, A. Hajduk, "Radar Observations of Eta Aquarids in 1981–1986 at Dushanbe and Ondřejov", *Bull. Astron. Inst. Czechosl.* 39, 1988, pp. 82–85.

[5] R. Koschack, P. Roggemans, "The 1990 Orionids", *WGN* 19:4, August 1991, pp.115–130.

[6] C. Steyaert, *Radio Meteor Observation Bulletin* 46, June 1997.

The Makings of Meteor Astronomy: Part XIV

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August is Perseid month and this not only gives us the opportunity to get out and observe meteors, it also gives us an excuse to look at some Perseid folklore.

1. Introduction

If we exclude the transitory outburst of activity that presently occurs around August 12.4 UT, the main peak of the Perseids is actually realized on August 12.75 UT [1]. The Perseid stream delivers a consistent rain of meteors each year, and this indicates that the shower is old and well established, with material being smoothly distributed around the stream orbit. Having a high orbital inclination of 113° to the ecliptic, the Perseid stream does not suffer significantly from planetary perturbations and its nodal progression rate is very small.

The time interval between successive Perseid maxima is essentially that of the sidereal year (365.25637 days). Because the sidereal year is some 0.0139 days longer than the Gregorian calendar year, the date on which the Perseids reach their maximum advances by 1 day in every 72 years (the Gregorian calendar year is 365.2425 days long). The result of this effect is that, if we go back in time, the date of Perseid maximum shifts to early August. All this would be fine from a historical point of view except for a slight complication which occurred in October 1582, when the Julian calendar was abandoned (at least by most European countries) for the modern-day Gregorian calendar. The change in calendars introduced a jump of 10 days in the daily reckoning. Also, the Julian calendar attributed 254.25 days to the year, and, consequently, in the Julian calendar the date of the Perseid maximum will change by one day in 151.5 years. Hasegawa [2] suggests that the Perseids may have been observed as long ago as 36 AD, but Hughes [3] has questioned this, and it would appear that the earliest bonafide observation of the Perseid shower dates to 830 AD. We shall return to the calendar issue shortly, but first we have to consider some history.

2. The tears of Saint Lawrence

Human beings are the greatest architects of hyperbole. Sometimes, just the slightest anecdote of a story is blown out of all proportion, taking-on as it does a life of its own. The association of the Perseid meteors with the burning tears of Saint Lawrence (also spelt "Laurance" and "Laurence") is, I would contend, one such example of admittedly harmless human excess. We have all heard of the association of the Perseids with St. Lawrence, and every newspaper and every science magazine quotes the story verbatim—indeed, ad nauseam. What I want to consider here is the actual evidence for the folkloric association. If one is to believe the popular press, it would seem that virtually all our European ancestors knew of the burning tears that could be seen on August 10—the designated feast day of St. Lawrence.

Let us first consider the story of St. Lawrence. Taking our lead from the *Penguin Dictionary of Saints* [4], Lawrence was one of the seven deacons of Rome and was martyred three days after Pope Sixtus II, on August 10, 258 AD. He was buried in the cemetery on the road to Tivoli, where the church of St. Lawrence-outside-the-Walls now stands. According to tradition, when ordered by the city prefect to hand over the church's riches, Lawrence assembled the poor and sick and presented them to the prefect saying "here is the church's treasure." There upon he was put to death by being roasted on a gridiron. The story is a powerful one full of allegory, but it is the case that the description of Lawrence's death is almost certainly untrue. *The Catholic Encyclopedia* notes, for example, that it was much more likely that Lawrence was beheaded—as Pope Sixtus was [5]. The story of the gridiron is due solely to the poet Prudentius who wrote a hymn in honor of St. Lawrence circa 405 AD, some 150 years after Lawrence's death [6].

The key lines that Prudentius wrote concern the words of the city prefect,

> *Get up on the pyre they have laid for you, lie down on the bed you deserve; and then, if you like, argue that my god of fire is nothing.*

So, here we encounter out first problem with the legend of St. Lawrence. Essentially, it would appear that the story of St. Lawrence being roasted on a gridiron was poetic license. Strangely, while St. Lawrence is understandably the patron saint of the poor, he is also, in somewhat bad taste, the patron saint of cooks, and restaurateurs [7].

3. What Mr. T. Forster actually wrote

The association of the Perseid meteors with the tears of St. Lawrence can be traced to essentially a single source. In 1839, Edward C. Herrick [8] re-produced a quote from Quetelet, who in turn explained,

> *"According to Mr. T. Forster, a superstition has 'for ages' existed among the Catholics of some parts of England and Germany, that the burning tears of St. Lawrence are seen in the sky on the night of August 10th; this being the anniversary of his martyrdom."*

And this is it! Not one single manuscript note or reference is given to how or where Forster acquired his information. Certainly, Forster did not mention any connection between the August meteors and St. Lawrence in his text, *The Pocket Encyclopaedia*, published in 1827 [9]. Forster did note that *"falling stars or small meteors are seen all the year, but are most common in August, as are all meteors."* The term *meteor* in the context used by Forster accounted for many diverse phenomena, ranging from wind squalls, lightning, rain storms, and shooting stars. Forster's views on meteors were, in fact, decidedly out-dated and basically Aristotelian [10]. In the Rustic Calendar appended to his Encyclopaedia, Forster writes,

> *"August 10th—St. Lawrence, M.—sunflower Helianthus annus, flowers abundantly; falling stars and meteors most abound about this time of year."*

The reference to St. Lawrence is purely an acknowledgment that August the 10th is his designated feast day. In Supplement to Part IV of the Rustic Calendar, however, Forster makes reference to a *"curious"* manuscript named *Ephemerides Rerum Naturalium*, in which the days of the year are named according to the *"phenomena which happen on the average of years on each day."* For August 10, the manuscript provides the simple description, *"meteorides."* This entry sounds very compelling, but there are, once again, a few problems. Firstly, as was pointed out by Alexander von Humboldt in 1849 [11], the reference that Forster gave for the preservation site of the manuscript was incorrect. Forster claimed that the manuscript was held in the library of Christ's College, Cambridge, England. They have no such manuscript, and it would appear that the manuscript is lost. Not only this, Forster suggested that the manuscript was written by a monk in the 10th century. The key point here is that, if the manuscript was actually written in the 10th century, then we know for a certainty that it could not possibly have referred to the Perseids. In the 10th century, the Perseids would have peaked around July 23! The *New Catholic Encyclopedia* [12] comments that *"the feast of St. Lawrence is noted in martyrologies as early as the beginning of the 4th century."* In the 4th century, the Perseids would have peaked around July 19.

So, there we are, no reference to burning tears, and a lost manuscript that presumably would not support the link between St. Lawrence's feast day and the Perseids anyway. Not only this, support for the "popular" idea that shooting stars could be seen on August 10 is not exactly easy to come by. Indeed, I have not been able to find a single reference to such an association in any of the well-known sources on proverbs, folklore, and superstitions. In *Inwards Weather Lore* [12], however, the entry for August 10 reads,

> *St. Lawrence—Germany—if on St. Lawrence's day the weather be fine, fair autumn and good wine may be hoped for.*

In Lean's *Collectanea* [14], the only reference to St. Lawrence is the English aphorism,

> *"Lawrence bids wages—A proverbial saying for the lazy, because of St. Lawrence's Day (August 10) being in the dog-days, the weather is usually hot and faint.*

In *The Book of Days* [15] (a miscellany of popular antiquities in connection with the Calendar—published in 1862), no mention of meteors is made on any of the five pages relating to August 10. In Brewer's *Dictionary of Phrase and Fable* (published 1870), the only reference to St. Lawrence is the phrase *"lazy as Lawrence."* The phrase being associated with Christian fortitude and made with reference to the detail that Lawrence did not squirm before his tortures [16]—the "detail" being related to Prudentius's account of Lawrence's martyrdom [6]. In an anonymous article on Worcestershire folklore, published in the *Folk-Lore Journal* [17], there is mention of the ancient tradition of roasting an ox on August 10. Tilley [18] makes reference to the following proverbs for August:

(1573) *"dry August and warm does harvest no harm;"*
(1732) *"a wet August never brings dearth."*

Tilley also collected the saying *"more like the Devil than St. Lawrence."* This proverb has parallels with that given in Brewer's *Dictionary*. I make no claim to exhaustion in this study, but do contend that the association of the August meteors with the tears of St. Lawrence was never a popular one.

The Perseids would have peaked on the night of August 10 in the mid-1750s. It seems, therefore, that any truly ancient linkage between the Perseids and the tears of St. Lawrence cannot be believed. It is also curious that, if the linkage was established during the late 1700s to early 1800s, so little mention of it can be found in the literature. I am sure someone, somewhere, can find an original source describing an aphorism between the Perseids and the fiery tears of St. Lawrence—and when he or she does, I would be pleased to learn.

In summing up, it would appear that the whole story of St. Lawrence and the Perseids is mostly one of fabrication—it is a fine story nonetheless. Church historians believe that St. Lawrence was beheaded rather than roasted on a gridiron, and the idea that ancient European peoples associated August 10 with Perseid meteors can not be true. Likewise, the suggestion that contemporary (i.e., within the last several hundred years) European peasantry linked August 10 with the Perseids and the tears of St. Lawrence, while possibly true, has no actual documentation.

4. Saved by Gozo

There is, I am pleased to say, one apparently well-attested custom that links the feast day of St. Lawrence with the August meteors. I am grateful to Adrian Galea for sending me an article by Sandro Lanfranco, which appeared in the magazine *Sirius* [19]. The article concerns the collection of a supposed Perseid meteorite from the village of St. Lawrence on the island of Gozo—Gozo is one of the islands in the Maltese Archipelago.

Each year, the inhabitants of the village of St. Lawrence scour the surrounding land for small black rocks, which are supposed to be coals from the fire that consumed St. Lawrence. The coals are supposed by the villagers to fall from the sky. Lanfranco goes on to reveal in his article that the black rocks collected by the villagers are indeed samples of coal—probably relics from the islands' once thriving lime manufacturing industry. No indication is given in Lanfranco's article on how long the Gozo tradition has been enacted; that the tradition has *"solid foothold"* is the only indication of age. The Gozo tradition is truly wonderful and has a number of parallels with the topic raised by Alastair McBeath [20] where fossils are identified as fallen stars—see also [21].

5. Other saintly tears

Since every day of the year is the feast day of at least one saint, it is not too surprising that many naturally recurring events have been attributed to one saint or another.

Forster writes in his *Perennial Calendar* [22], for example, *"the sunflower is referred to as 'St. Bartholemow's star',"* since it flowers around August 24, the feast day of St. Bartholomew. Likewise, the glow worm (Lampyris noctiluca) is called "St. John's worm," since it is first seen at about the time of the feast of St. John the Baptist. While the linkage between meteors and "fiery tears" does appear to be a very natural, although not actually proven one to make, there are other accounts of saints crying. Forster [22], for example, gives the following proverb for July 15:

"All the tears that St. Swithin can cry, St. Bartlemy's dust mantle wipes dry."

July 15 is the feast day for St. Swithin. Inwards [13] also noted the St. Swithin proverb and adds another:

"In this month is St. Swithin's day,
On which if that it rain they say,
Full forty days it will,
Or more or less some rain distil."

In St. Swithin's case, the saintly tears clearly refer to rain.

References

[1] R. Arlt, S. Molau, M. de Lignie, *WGN* 25:3, June 1997, p. 123.

[2] I. Hasegawa, in *Meteoroids and Their Parent Bodies*, J. Štohl and I.P. Williams, eds., Astronomical Institute, Slovak Academy of Sciences, Bratislava, 1993, pp. 209–226.

[3] D.W. Hughes, *Earth, Moon and Planets* 68:1–3, 1995, pp. 31-70.

[4] "Penguin Dictionary of Saints", Penguin Books, London, 1965.

[5] "The Catholic Encyclopedia", Robert Appleton Company, New York, 1910.

[6] H.J. Thomson, "The Poems of Prudentius", Vol. II, William Heinmann Ltd., London, 1953.

[7] A. Sandoval, "The Directory of Saints", Dutton, New York, 1996.

[8] E.C. Herrick, *American Journal of Science* 38, 1839, p. 325.

[9] T. Forster, "The Pocket Encyclopaedia of Natural Phenomena", John Nichols and Son, London, 1827.

[10] M. Beech, "WGN 21:1", February 1993, p. 36.

[11] A. Von Humboldt, in *Cosmos*, Vol. 1, 1849, p. 111.

[12] "The New Catholic Encyclopedia", Catholic University of America, Washington, DC, 1967.

[13] R. Inwards, "Weather Lore: Taken from the World's Literature and the Age-Old Wisdom of Farmers, Mariners, Bird Watchers, etc.", Rider and Company, London, 1950.

[14] V.S. Lean, "Lean's Collectanea: Proverbs, Folk Lore and Superstitions", Vol. 1, W. Arrowsmith, London, 1902.

[15] "The Book of Days: A Miscellany of Popular Antiquities in Connection with the Calendar", W. and R. Chambers Ltd., London, 1862.

[16] "Brewer's Dictionary of Phrase and Fable", Harper and Row Publishers, New York, 1968.

[17] *Journal of the Folk-Lore Society* 26, 1915, p. 96.

[18] M.P. Tilley, "A Dictionary of the Proverbs in England in the 16th and 17th Century", The University of Michigan Press, Ann Arbor, 1950.

[19] S. Lanfranco, *Sirius*, no. 14, 1988, p. 29.

[20] A. McBeath, *WGN* 25:3, June 1997, p. 128.

[21] M. Beech, "in Letters to WGN", *WGN* 25:4, August 1997, p. 147.

[22] T. Forster, "The Perennial Calendar", Harding, Mavor and Lepard, London, 1824.

Double-Station TV Meteor Observations in 1996

Yoshihiko Shigeno, Hiroyuki Shioi, and Shoichi Tanaka

During TV double-station meteor observations started in December 1992, 688 double-station meteors were observed [1,2]. In 1996, these observations yielded 308 double-station meteors within 9 nights. From these meteors, averages and their standard deviations of radiants, atmospheric entry velocities and orbital elements were obtained for 6 major streams of which we observed more than 3 meteors in one night.

1. Instrument description

The instrument used for our TV observations is shown in Figure 1. The light coming from the left side of the figure is focused on the photoelectric plate of the image intensifier (Hamamatsu Photonics V3287P) by an objective lens. The electrons emitted from the photoelectric plate are amplified by the MCP (Micro Channel Plate) and transformed into light on the fluorescent plate. The image on the fluorescent plate is led to the CCD (Hitachi KPM1) by using a macro photo lens (Nikon $f/2.8$, $f = 55$ mm).

A photograph of the observation instrument is shown in Figure 2. Twenty-five of these instruments were built and distributed to Japanese observers. One of these was delivered to the National Astronomical Observatory.

When an objective lens of $f/1.2$, $f = 50$ mm (Nikon) is used, the area of the image is $13° \times 17°$. The limiting magnitude for meteors is 7.5 and the average measuring error is $126''$. Most of the observations were conducted by using this lens.

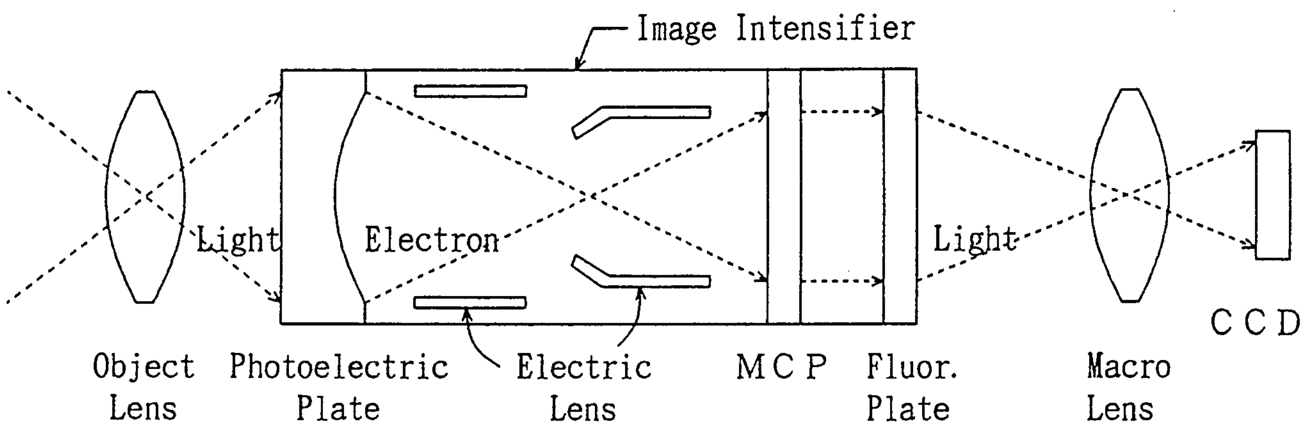

Figure 1 – Sketch showing the construction of the TV meteor camera used for our observations.

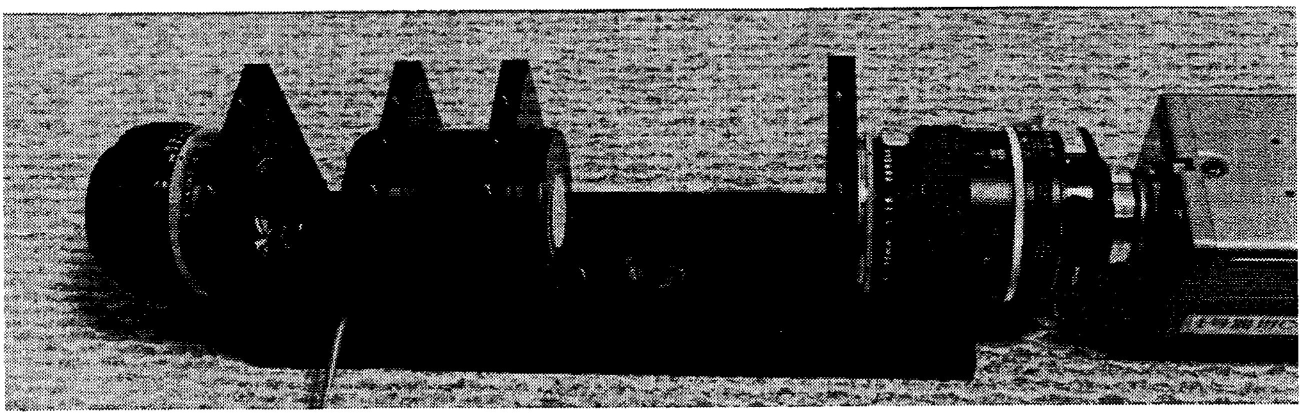

Figure 2 – TV meteor camera (SAE type).

When an objective lens of $f/1.4$, $f = 85$ mm (Nikon) is used, the area of the image is $7.5^\circ \times 9.5^\circ$. In this case, the meteor limiting magnitude is 8.5 and the average measuring error is $86''$. The latter lens was used for the observations on August 11 and 12, 1996.

2. Results of observations

Table 1 shows the observational results for 6 meteoroid streams in 1996. For comparison, the result of photographic observation by Lindblad [3] is shown. The results include the date of observation, the corrected radiant (eq. 2000.0), standard deviation of the corrected radiant, geocentric velocity, standard deviation of geocentric velocity, orbital elements (equinox 2000.0), the observed magnitude, beginning and end heights, and number of meteors (TV observations unless otherwise mentioned). The averages are given in the upper line, and the standard deviation is shown in the lower line for each result.

As a reference, corrected radiants for all double station meteors obtained during the observation days of Quadrantids, Perseids, and Orionids are shown in the star charts shown as Figures 3, 4, and 5, respectively, using $\times$ and $+$ for the different observations.

Table 1 – Orbital elements of the streams.

Str	Date (UT) (yyyymmdd.ddd)	α (2000.0)	δ (2000.0)	SD	V_G (km/s)	SD (km/s)	a (AU)	e
QUA_0	Lindblad	$230\overset{\circ}{.}1$	$+48\overset{\circ}{.}5$	-	41	-	3.04	0.677
QUA_1	19960103.835	$230\overset{\circ}{.}1$	$+48\overset{\circ}{.}8$	$0\overset{\circ}{.}3$	40.6	1.4	2.51	0.611
	SD ± 0.029	$1\overset{\circ}{.}7$	$0\overset{\circ}{.}9$	$0\overset{\circ}{.}3$	1.7	0.6	-	0.067
QUA_2	19970103.678	$230\overset{\circ}{.}3$	$+49\overset{\circ}{.}5$	$0\overset{\circ}{.}6$	40.9	0.9	2.89	0.661
	SD ± 0.044	$2\overset{\circ}{.}2$	$1\overset{\circ}{.}1$	$0\overset{\circ}{.}3$	1.3	0.4	-	0.066
LYR_0	Lindblad	$271\overset{\circ}{.}4$	$+33\overset{\circ}{.}6$	-	49	-	28	0.968
LYR_1	19960422.741	$272\overset{\circ}{.}0$	$+32\overset{\circ}{.}7$	$0\overset{\circ}{.}6$	43.6	2.2	3.58	0.750
	SD ± 0.039	$2\overset{\circ}{.}2$	$0\overset{\circ}{.}4$	$0\overset{\circ}{.}1$	2.5	0.7	-	0.152
PER_0	Lindblad	$46\overset{\circ}{.}2$	$+57\overset{\circ}{.}4$	-	59	-	81	0.996
PER_1	19960811.728	$47\overset{\circ}{.}1$	$+57\overset{\circ}{.}8$	$0\overset{\circ}{.}2$	59.0	1.3	19.6	0.952
	SD ± 0.061	$0\overset{\circ}{.}9$	$0\overset{\circ}{.}6$	$0\overset{\circ}{.}1$	1.1	0.6	-	0.076
PER_2	19960812.670	$48\overset{\circ}{.}0$	$+57\overset{\circ}{.}9$	$0\overset{\circ}{.}3$	58.9	1.4	13.7	0.930
	SD ± 0.067	$1\overset{\circ}{.}1$	$0\overset{\circ}{.}6$	$0\overset{\circ}{.}2$	1.1	0.7	-	0.063
PER_3	19940812.700	$46\overset{\circ}{.}7$	$+58\overset{\circ}{.}1$	$0\overset{\circ}{.}2$	59.5	0.9	110	0.991
	SD ± 0.034	$0\overset{\circ}{.}9$	$0\overset{\circ}{.}4$	$0\overset{\circ}{.}2$	1.7	0.6	-	0.068
ORI_0	Lindblad	95°	+16°	-	66	-	11.5	0.951
ORI_1	19961021.736	$95\overset{\circ}{.}9$	$+15\overset{\circ}{.}8$	$1\overset{\circ}{.}3$	65.7	1.9	7.94	0.928
	SD ± 0.056	$1\overset{\circ}{.}1$	$0\overset{\circ}{.}7$	$1\overset{\circ}{.}0$	2.6	0.7	-	0.122
ORI_2	19931024.729	$97\overset{\circ}{.}9$	$+15\overset{\circ}{.}8$	$0\overset{\circ}{.}6$	65.4	2.2	5.97	0.908
	SD ± 0.035	$1\overset{\circ}{.}0$	$0\overset{\circ}{.}9$	$0\overset{\circ}{.}3$	1.9	1.5	-	0.078
NTA_0	Lindblad	64°	+23°	-	29	-	2.3	0.83
NTA_1	19961116.675	$58\overset{\circ}{.}7$	$+24\overset{\circ}{.}3$	$0\overset{\circ}{.}5$	23.0	1.0	1.81	0.732
	SD ± 0.025	$2\overset{\circ}{.}5$	$1\overset{\circ}{.}2$	$0\overset{\circ}{.}2$	1.9	0.5	-	0.040
STA_0	Lindblad	61°	+16°	-	27	-	2.2	0.82
STA_1	19961116.663	$61\overset{\circ}{.}6$	$+15\overset{\circ}{.}8$	$0\overset{\circ}{.}7$	24.4	1.4	1.89	0.756
	SD ± 0.019	$2\overset{\circ}{.}1$	$1\overset{\circ}{.}8$	$0\overset{\circ}{.}3$	3.7	0.0	-	0.085

Generally, good results were obtained for the Quadrantids, the Perseids, and the Orionids. This is especially the case for the Perseids, because we used an objective lens of $f/1.4$, $f = 85$ mm. Hence, the accuracy of the data is better, as mentioned above.

However, compared with the result of photographic observation (35 mm small camera, $f/1.4$, $f = 50$ mm lens) shown in the entry PER_3 in Table 1, the error of the velocity calculation was larger.

Concerning Lyrids, Northern and Southern Taurids, the velocity determined from our observations was lower as compared to the result of Lindblad. The available observations gave no hint whether this phenomenon was caused by an error or whether we found a true difference.

3. Conclusion

Compared to photographic observations, the error of measurement of positions by our TV observation is 5 to 10 times larger. Therefore, we could not judge if the observation was effective or not for obtaining orbital elements.

Table 1 – continued.

Str	Date (yyyymmdd.ddd)	q (AU)	ω	Ω	i	Obs Mag	H_b (km)	H_e (km)	N
QUA_0	Lindblad	0.981	171.°1	282.°4	71.°9	–	103	91	Phot
QUA_1	19960103.835	0.976	169.°1	282.°8	71.°6	4.7	102.2	88.1	16
	SD ± 0.029	0.004	3.°2	0.°0	2.°5	1.8	2.1	3.2	
QUA_2	19970103.678	0.978	171.°3	283.°4	71.°3	4.4	105.8	90.3	17
	SD ± 0.044	0.005	3.°9	0.°1	1.°7	2.1	2.9	8.7	
LYR_0	Lindblad	0.919	214.°3	31.°7	79.°0	–	107	88	Phot
LYR_1	19960422.741	0.894	222.°4	32.°9	76.°2	4.1	108.7	93.0	4
	SD ± 0.039	0.018	3.°4	0.°0	2.°0	0.6	1.5	0.7	
PER_0	Lindblad	0.948	150.°5	139.°6	113.°3	–	114	94	Phot
PER_1	19960811.728	0.950	150.°7	139.°4	113.°5	4.8	116.0	97.6	10
	SD ± 0.061	0.008	2.°6	0.°0	1.°0	2.1	6.6	2.6	
PER_2	19960812.670	0.952	151.°0	140.°3	113.°3	5.3	113.8	98.0	19
	SD ± 0.067	0.008	2.°1	0.°1	1.°0	2.0	5.4	4.3	
PER_3	19940812.700	0.958	152.°9	139.°8	113.°2	0.7	111.5	91.1	11
	SD ± 0.034	0.008	2.°3	0.°1	1.°1	0.9	4.7	5.1	Phot
ORI_0	Lindblad	0.575	82.°7	28.°2	164.°3	–	117	99	Phot
ORI_1	19961021.736	0.574	83.°8	28.°7	163.°8	4.4	115.8	99.5	21
	SD ± 0.056	0.043	8.°8	0.°1	2.°3	0.9	1.3	4.5	
ORI_2	19931024.729	0.547	87.°1	31.°4	163.°2	5.1	117.0	97.3	19
	SD ± 0.035	0.036	6.°0	0.°0	2.°0	1.1	3.3	2.3	
NTA_0	Lindblad	0.38	293.°4	228.°1	3.°3	–	103	80	Phot
NTA_1	19961116.675	0.486	281.°6	234.°7	3.°6	5.8	99.4	89.6	3
	SD ± 0.025	0.047	4.°2	0.°0	0.°9	0.4	2.3	1.0	
STA_0	Lindblad	0.40	113.°2	33.°4	5.°8	–	101	82	Phot
STA_1	19961116.663	0.460	104.°2	54.°6	4.°5	5.8	95.5	87.1	3
	SD ± 0.019	0.063	4.°0	0.°0	2.°3	0.8	6.5	5.4	

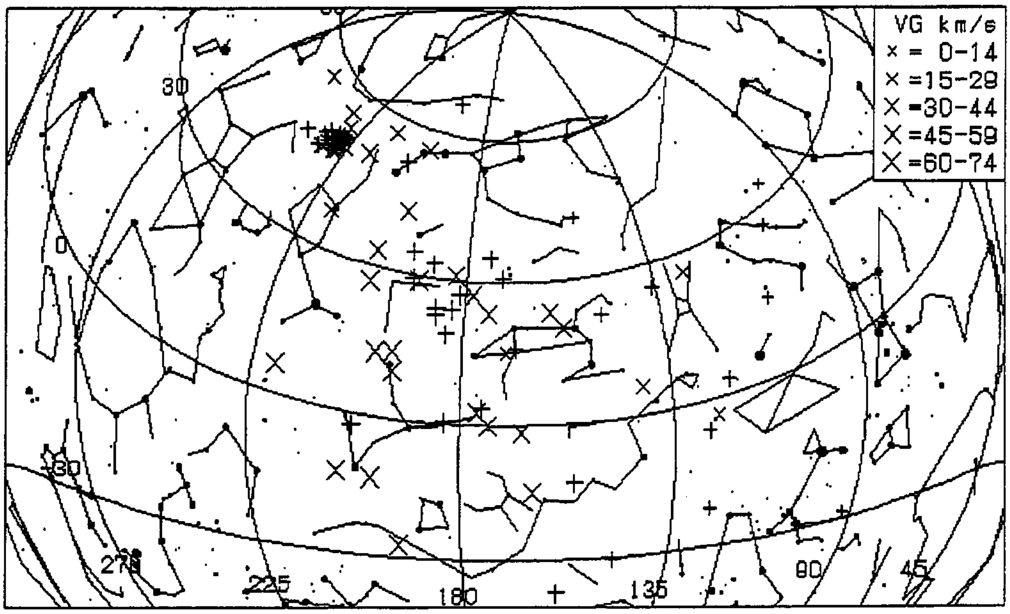

Figure 3 – Chart showing the corrected radiants for the Quadrantid period (×: January 3, 1996; +: January 3, 1997).

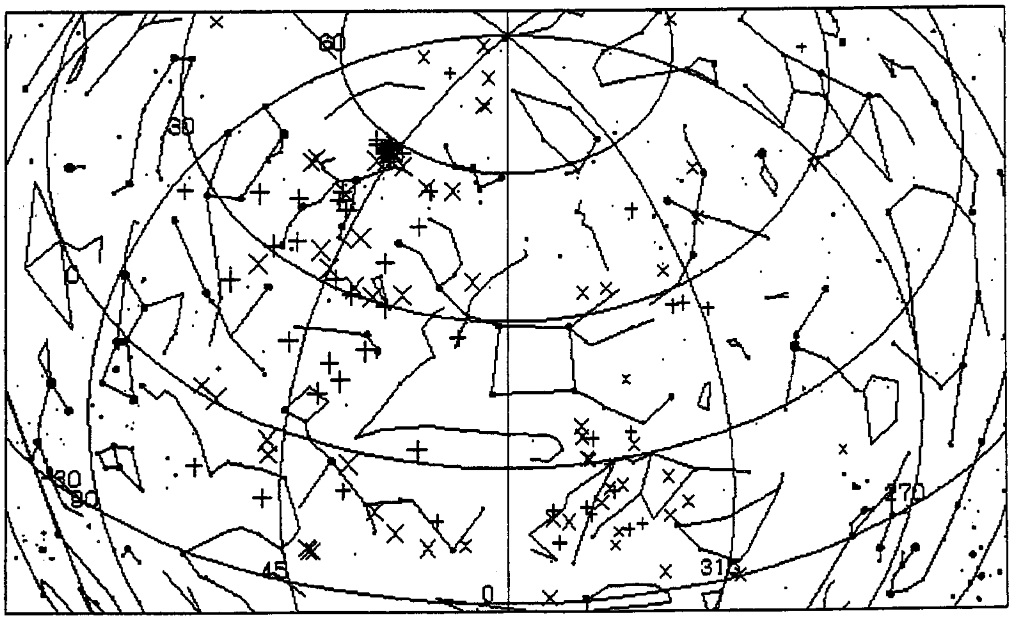

Figure 4 – Chart showing the corrected radiants for the Perseid period (×: August 11, 1996; +: August 12, 1996).

During our double-station TV meteor observations in 1996, more than 10 double-station meteors of 3 meteoroid streams were obtained. From these results, we judged that the observations were useful for obtaining the orbits.

We will continue the double-station TV meteor observations and try to increase the accuracy in the future.

We are opening all observed meteor data to the public.

If you would like to receive these data, please send a letter to Yoshihiko Shigeno, e-mail: `cyg@nikon.co.jp`.

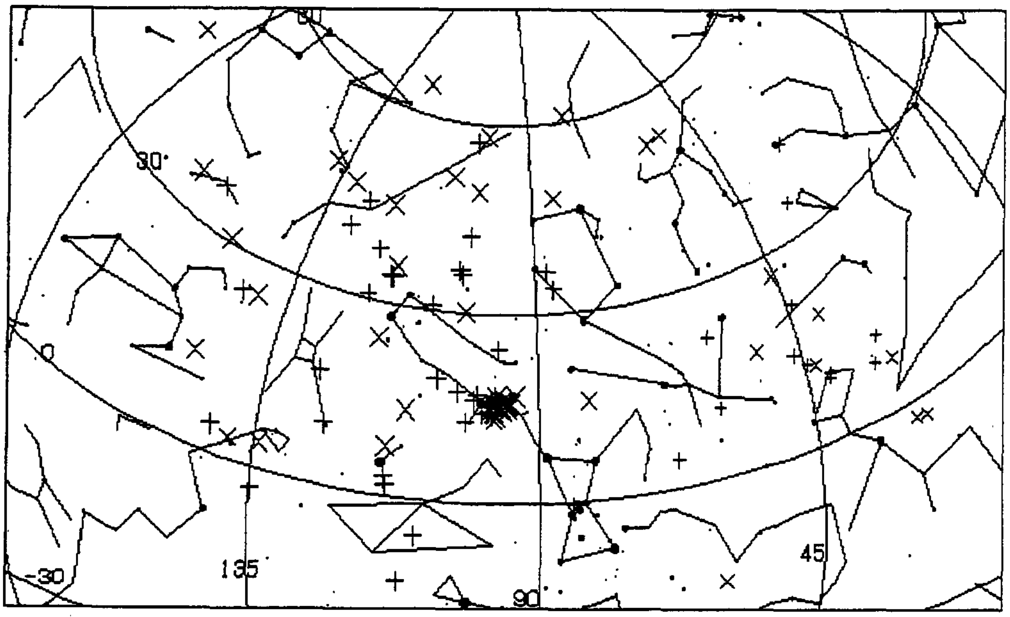

Figure 5 – Chart showing the corrected radiants for the Orionid period (×: October 21, 1996; +: October 24, 1993).

References

[1] Y. Shigeno, H. Shioi, "Double-Station TV Meteor Observations", *WGN* 24:1-2, 1996, pp. 37–42.

[2] Y. Shigeno, H. Shioi, S. Tanaka, "Double-Station TV Meteor Observations (Part II)", *WGN* 24:5, 1996, pp. 161–170.

[3] B.A. Lindblad, "Physics and orbits of meteoroids", in *The Evolution of the Small Bodies of the Solar System*, Soc. Italiana di Fisica, Bologna, 1987.

Detection of Three Meteor Streams by Double-Station TV Observations in 1994

Masayoshi Ueda, Takuji Nakamura, Masatoshi Sugimoto, and Masaki Tsutsumi

We have carried out double-station TV meteor observations in 1994. The orbits of 217 meteors have been determined from doubly observed meteors.

The authors carried out double-station meteor observations using a television (TV) system for five nights in 1994, and 273 double-station meteors were obtained through 19.4 hours of observing.

Our TV systems consisted of an image intensifier, a video camera and a lens with focal lengths of 24–85 mm. Distances between stations were 35–60 km (Table 1).

Out of 273 double-station meteors, 217 meteors were subjected to the calculation of orbital elements (Tables 2 and 3). From these data, the following 3 meteor streams were detected: the η-Aquarids, southern δ-Aquarids, and ε-Aurigids (Table 4).

Table 1 – Outline of the double-station observations using a TV system in 1994. The table gives the observing period, the data of stations 1 and 2, the distance D (in km) between these stations, and the number of meteors N. In the station data, "Obs" gives the observer, "Foc" is the focal length in mm, E is the average of the measurement errors, and "Loc" lists the location: (a) Habikino Osaka, Japan, 135°.64 E, 34°.53 N; (b) Miyama Osaka, Japan, 135°.37 E, 35°.03 N; (c) Muroh Nara, Japan, 136°.01 E, 34°.57 N; (d): Shigaraki Shiga, Japan, 136°.11 E, 34°.85 N.

Date (UT 1994)	Station 1				Station 2				D	N
	Obs	Foc	E	Loc	Obs	Foc	E	Loc		
May 6, 17^h00^m–19^h00^m	Ueda	58	5′	(a)	Sugimoto	24	7′	(b)	60	26
Jul 30, 14^h00^m–17^h30^m	Ueda	58	4′	(a)	Sugimoto	50	4′	(c)	35	36
Sep 10, 13^h20^m–18^h40^m	Ueda	58	2′	(a)	Sugimoto	50	4′	(c)	35	101
Sep 13, 13^h30^m–18^h50^m	Ueda	85	2′	(a)	Nakamura Tsutsumi	85	2′	(d)	56	47
Oct 1, 15^h15^m–18^h30^m	Ueda	58	4′	(a)	Sugimoto	50	4′	(b)	60	63
Total: 5 nights, 19.4 h.										

The weighted average of the velocities, radiant points, and orbital elements for these streams are listed in Table 4. The brightness of observed meteors, mostly around magnitude 4 and 5, was fainter than that obtained in visual or photographic observations.

The distribution of radiant points for 12 double-station meteors belonging to the η-Aquarids are described in Figure 1, with the ellipses representing the scale of estimate error. Radiant points were dispersed by 4°.8 and 0°.9 in northwest and northeast direction, respectively. This uneven distribution is presumably due to the estimate error.

The distribution of radiant points for 9 double-station meteors belonging to the southern δ-Aquarids is described in Figure 2. Radiant points were distributed in an area of 5°.0 × 1°.9.

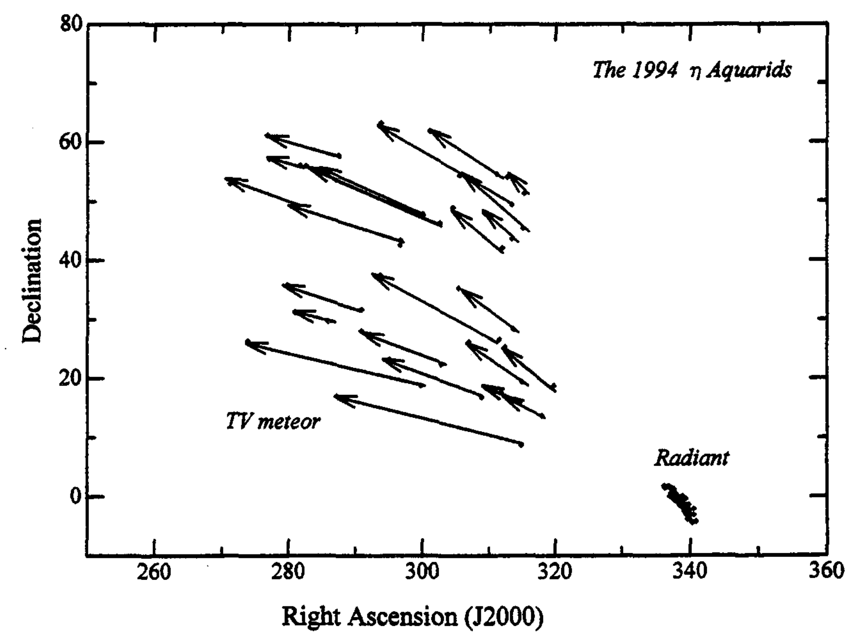

Figure 1 – Distribution of radiant points for 12 double-station TV meteors selected as the η-Aquarids. Ellipses indicate the scale of expected errors in determining radiant points.

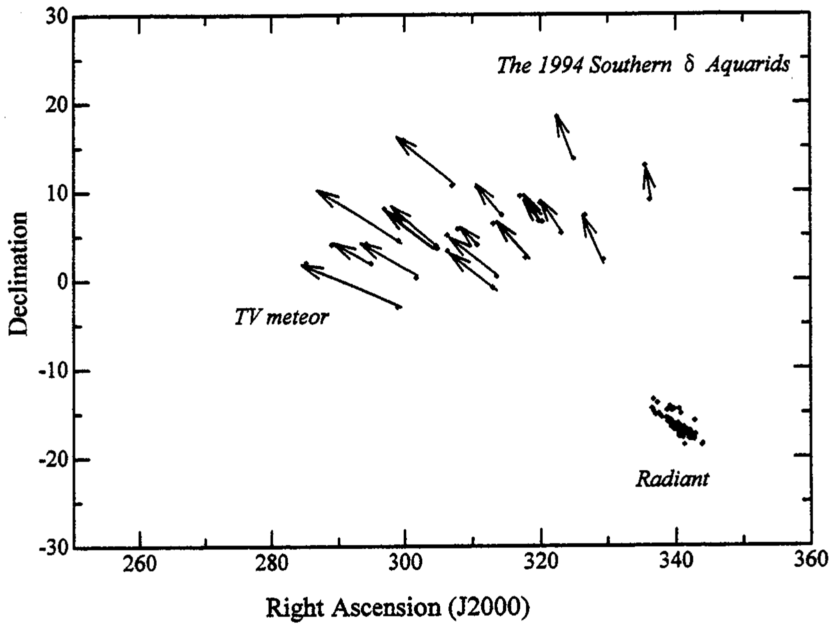

Figure 2 – Distribution of radiant points for 9 double-station TV meteors selected as the Southern δ-Aquarids. Ellipses indicate the scale of expected errors in determining radiant points.

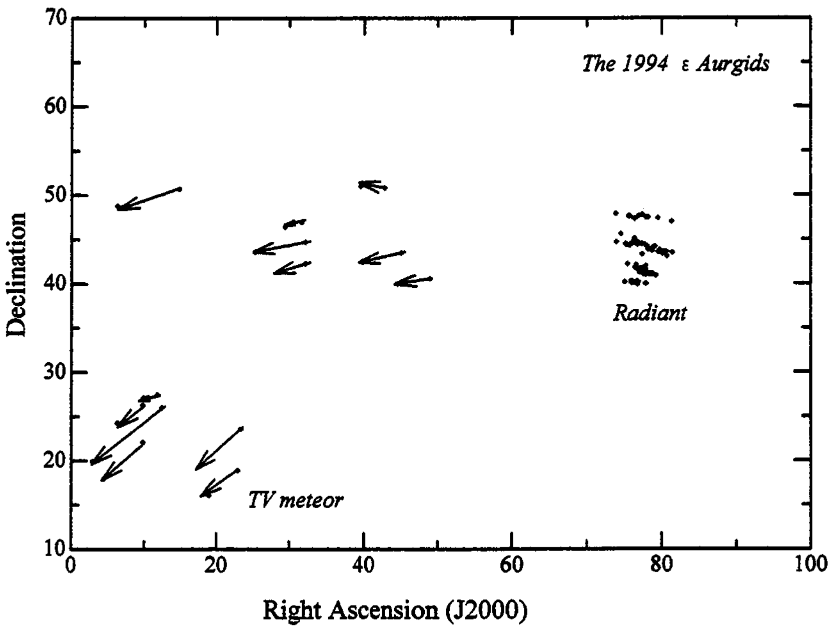

Figure 3 – Distribution of radiant points for 7 double-station meteors selected as the ε-Aurigids. Ellipses indicate the scale of expected errors in determining radiant points.

The ε-Aurigids is a newly detected stream. The distribution of the radiant points for 7 double-station meteors belonging to this stream is described in Figure 3.

Radiant points, distributed in an area of $2\overset{\circ}{.}9 \times 7\overset{\circ}{.}5$, were dispersed compared with the other two streams.

Acknowledgment

We are grateful to Dr. Ito for his assistance in preparing this paper.

Table 2 – The radiant position (2000.0), velocity, and height of the 217 TV meteors. α and δ are the right ascension and declination of the radiant position, corrected for both zenithal attraction and diurnal aberration; $\Delta\alpha$ and $\Delta\delta$ are the errors. V_{obs} is the observed velocity and V_g is the velocity corrected for both zenithal attraction and the diurnal aberration.

No.	Date yyyymmdd	UT hhmmss	α (°)	$\Delta\alpha$ (°)	δ (°)	$\Delta\delta$ (°)	V_{obs} (km/s)	V_g (km/s)
UF94001	19940506	171443	304.1	0.86	−11.8	4.86	72.9	71.8
UF94002	19940506	171636	256.2	1.11	+27.3	1.26	37.5	35.8
UF94003	19940506	172029	337.4	1.28	+00.2	1.61	67.7	66.4
UF94004	19940506	172257	338.4	0.46	−00.8	0.41	68.1	66.8
UF94005	19940506	172749	252.4	1.26	+27.6	1.09	34.5	32.7
UF94006	19940506	172857	338.6	0.52	−00.8	0.57	65.9	64.5
UF94007	19940506	173044	338.0	0.47	−00.5	0.26	67.0	65.7
UF94008	19940506	173419	349.3	0.69	+09.5	0.39	59.8	58.4
UF94009	19940506	173807	243.6	2.05	+13.9	0.95	31.9	30.0
UF94010	19940506	174217	338.9	1.64	−00.4	1.72	69.9	68.6
UF94011	19940506	174729	245.7	2.53	−11.9	3.15	26.2	23.9
UF94012	19940506	175204	243.4	1.39	−11.7	1.56	34.5	32.9
UF94013	19940506	175648	271.2	1.17	−23.6	2.76	39.0	37.3
UF94014	19940506	180237	337.5	0.33	+00.1	0.57	69.3	68.0
UF94015	19940506	180625	339.3	0.59	−01.6	0.69	67.7	66.4
UF94016	19940506	181108	339.7	1.12	−02.6	1.60	60.3	65.6
UF94017	19940506	182656	339.7	0.60	−03.4	1.00	64.6	63.3
UF94018	19940506	183133	338.8	0.87	−01.3	1.05	65.6	64.3
UF94019	19940506	183227	258.3	1.56	+20.3	1.43	38.1	36.6
UF94020	19940506	183715	337.6	1.03	+00.9	1.03	69.1	67.9
UF94021	19940506	183844	244.3	1.10	−17.1	1.51	33.8	32.1
UF94022	19940506	184659	338.1	1.35	−00.5	1.35	67.4	66.1
UF94023	19940506	185957	305.2	1.22	+06.6	2.76	56.1	54.8
UF94024	19940730	141802	322.2	1.10	+55.2	1.04	43.4	41.9
UF94025	19940730	142452	308.1	0.33	−20.8	0.88	24.7	22.0
UF94026	19940730	143608	339.5	3.28	−14.7	1.27	44.3	42.7
UF94027	19940730	144108	341.0	1.81	−16.8	0.97	40.1	38.3
UF94028	19940730	144350	334.3	4.71	−10.8	3.27	42.6	40.9
UF94029	19940730	144839	340.0	1.25	−16.4	0.42	44.4	42.8
UF94030	19940730	144906	337.8	1.50	−15.4	0.98	44.0	42.4
UF94031	19940730	152019	342.3	1.57	−17.9	0.79	41.2	39.5
UF94032	19940730	152627	339.6	0.80	−16.6	0.88	42.8	41.2
UF94033	19940730	153458	306.8	1.31	−16.9	3.99	22.1	19.2
UF94034	19940730	153624	17.6	6.06	+26.0	0.52	75.9	74.7
UF94035	19940730	154054	31.6	4.87	+38.4	0.29	71.2	70.1
UF94036	19940730	154238	342.5	1.47	−17.5	1.00	41.6	39.9
UF94037	19940730	155105	37.2	7.67	+24.9	0.81	79.5	78.4
UF94038	19940730	155240	359.5	1.07	+51.7	3.73	60.5	59.4
UF94039	19940730	155336	342.4	1.64	+01.2	0.90	37.9	36.1
UF94040	19940730	155355	307.3	0.28	−08.3	0.31	31.6	29.7
UF94041	19940730	155702	339.8	0.56	−16.7	0.56	42.9	41.3
UF94042	19940730	155756	306.6	0.67	−06.7	1.11	26.1	23.8
UF94043	19940730	160614	351.1	3.42	−27.6	2.99	34.9	32.9
UF94044	19940730	162458	245.0	18.05	+50.2	2.64	14.5	9.7
UF94045	19940730	163546	16.3	5.00	+25.3	0.86	67.8	66.6
UF94046	19940730	163823	303.2	0.98	−22.0	1.26	24.6	22.1
UF94047	19940730	165349	319.3	0.54	+21.7	1.12	38.1	36.6
UF94048	19940730	165512	340.8	0.57	−17.4	1.23	40.3	38.7
UF94049	19940730	165632	29.5	1.88	+34.8	0.36	76.0	74.9
UF94050	19940730	170937	0.2	0.21	+21.5	0.57	65.9	61.3

Table 2 – continued. Q is the angle between the meteor trajectories as seen from the two stations, "Obs Mag" and "Abs Mag" are the observed and absolute magnitude of the meteor, and h_b and h_e are the heights on which the meteor was first observed and at which it vanished. Meteors which begun or ended out of the camera field are designated with an asterisk.

No.	Q (°)	Obs Mag	Abs Mag	h_b (km)	h_m (km)	h_e (km)
UF94001	6.5	4.4	4.0	107	100*	100
UF94002	70.5	4.0	3.8	102	97	92
UF94003	24.0	4.7	4.2	117	114*	114
UF94004	26.6	3.2	2.8*	121	115*	112
UF94005	63.9	3.2	3.3	90	90	81
UF94006	28.6	4.7	4.3	114	105	102
UF94007	32.7	1.2	0.5	123	103	94
UF94008	34.5	4.5	4.5	102	98*	98
UF94009	36.1	2.9	2.8	98	93	86
UF94010	24.6	3.3	3.0	117	112*	111
UF94011	37.2	4.5	4.6	91	90	86
UF94012	32.9	4.9	4.8	93	92	88
UF94013	22.9	5.1	5.2	96	92	89
UF94014	22.8	3.3	2.6	120	115	98
UF94015	24.4	1.4	1.2	121	108*	106
UF94016	23.8	3.6	2.9	116	109	103
UF94017	23.6	4.7	4.3	114	107	104
UF94018	29.8	2.6	1.9	113	108	99
UF94019	38.8	2.7	2.5	96	95*	86
UF94020	30.1	4.7	4.2	116	112	102
UF94021	29.2	5.0	4.8	102	97	93
UF94022	19.3	3.8	3.3	115	113	100
UF94023	23.1	3.1	2.7	100	97	91
UF94024	25.1	2.7	2.6	107	98	89
UF94025	43.0	3.4	3.2	97	90	87
UF94026	14.1	5.0	4.8	102	95	93
UF94027	17.0	4.3	4.1	105	98	89
UF94028	15.4	3.7	3.7	103	96*	96
UF94029	13.1	2.5	2.1	106	95	86
UF94030	22.8	3.2	3.0	102	96	89
UF94031	17.0	3.3	3.1	100	95	88
UF94032	25.8	3.2	3.2	100	95*	88
UF94033	35.8	4.7	4.7	99	95	93
UF94034	6.9	4.9	4.6	111	104	101
UF94035	9.1	3.0	2.7*	111	107	99
UF94036	20.8	3.9	3.6	102	97	88
UF94037	4.7	3.7	3.3	115	111	106
UF94038	13.2	5.9	5.3	113	106	104
UF94039	39.2	2.6	2.6	92	90	83
UF94040	42.7	2.6	2.3	108	90	74
UF94041	29.7	2.5	2.3	104	93	85
UF94042	51.0	2.3	2.5	98	87	80
UF94043	20.1	2.2	2.0	104	98*	98
UF94044	19.3	5.5	5.4	82	80	79
UF94045	9.0	4.3	4.2	101	95	90
UF94046	21.6	3.3	3.2	103	97	91
UF94047	41.7	3.6	3.4	97	89	83
UF94048	33.3	3.1	3.0	103	96	93
UF94049	9.7	0.6	0.3	125	106	93
UF94050	36.5	1.9	1.4	117	109	96

Table 2 – continued.

No.	Date yyyymmdd	UT hhmmss	α (°)	$\Delta\alpha$ (°)	δ (°)	$\Delta\delta$ (°)	V_{obs} (km/s)	V_g (km/s)
UF94051	19940730	172248	341.4	0.14	−18.9	0.82	37.4	35.7
UF94052	19940910	132024	298.5	1.81	+58.0	0.90	19.1	15.6
UF94053	19940910	133959	294.5	2.41	−13.4	3.10	15.8	11.4
UF94054	19940910	134246	8.7	1.67	−18.9	2.88	32.1	29.9
UF94055	19940910	140053	31.6	3.37	+51.2	0.53	57.6	56.3
UF94056	19940910	140611	32.1	2.75	+07.7	2.04	27.9	25.3
UF94057	19940910	140714	55.8	2.94	+53.0	0.46	60.7	59.4
UF94058	19940910	141945	332.6	0.56	−22.1	3.68	18.1	14.3
UF94059	19940910	141955	289.0	4.79	+28.7	1.12	22.3	19.7
UF94060	19940910	144347	331.9	0.60	+04.2	1.65	20.9	17.8
UF94061	19940910	145406	10.0	0.59	+11.0	0.93	42.9	41.3
UF94062	19940910	145458	348.9	0.52	−03.4	1.93	25.8	23.3
UF94063	19940910	145509	38.6	5.38	+15.6	3.13	65.5	64.3
UF94064	19940910	150149	83.8	1.73	+54.6	0.60	65.6	64.5
UF94065	19940910	150903	334.3	0.73	+03.7	1.09	21.4	18.4
UF94066	19940910	151150	76.7	2.93	+53.3	0.60	63.7	62.5
UF94067	19940910	152957	88.6	1.95	+40.7	0.86	61.3	60.0
UF94068	19940910	153302	14.2	0.13	+08.6	0.40	44.0	42.4
UF94069	19940910	153527	328.5	3.41	+38.4	0.44	29.2	27.1
UF94070	19940910	153537	73.0	1.34	−10.7	0.99	60.0	58.6
UF94071	19940910	153700	322.9	1.21	+54.1	0.53	18.8	15.3
UF94072	19940910	154303	5.4	0.40	−03.5	1.98	27.0	24.6
UF94073	19940910	154431	63.1	2.39	+57.6	0.18	58.8	57.5
UF94074	19940910	154605	215.8	0.98	+65.8	0.70	32.7	30.9
UF94075	19940910	154822	26.6	1.30	−17.7	2.01	45.5	44.0
UF94076	19940910	155325	339.1	0.82	+68.0	0.54	35.8	34.1
UF94077	19940910	160607	13.8	0.17	−01.0	0.76	24.2	21.4
UF94078	19940910	160703	359.9	0.18	+06.9	1.09	26.7	24.3
UF94079	19940910	160903	167.4	2.24	+76.2	1.34	41.6	40.0
UF94080	19940910	161513	12.3	0.20	−02.1	0.66	37.8	36.1
UF94081	19940910	161641	311.9	9.52	+60.8	1.83	31.2	29.3
UF94082	19940910	161804	43.1	2.14	+39.4	0.22	63.9	62.8
UF94083	19940910	161839	344.5	0.89	+20.6	1.21	26.4	24.1
UF94084	19940910	162018	5.0	0.12	+06.9	0.55	31.6	29.6
UF94085	19940910	162020	79.0	1.49	−14.9	1.56	58.7	57.3
UF94086	19940910	162106	81.1	2.86	−13.4	1.89	65.3	64.0
UF94087	19940910	162333	73.1	3.80	+64.2	0.50	58.3	57.1
UF94088	19940910	162521	66.7	1.09	+03.6	1.09	72.9	71.7
UF94089	19940910	162548	339.6	1.14	+23.0	1.02	30.5	28.6
UF94090	19940910	163050	51.8	3.07	+39.6	0.35	61.7	60.5
UF94091	19940910	163207	54.5	2.26	+13.1	2.11	60.7	59.5
UF94092	19940910	163446	106.6	2.00	+47.0	0.87	61.5	60.3
UF94093	19940910	163802	46.5	0.65	+45.8	0.26	58.1	56.8
UF94094	19940910	163959	75.3	6.13	+53.8	0.74	49.2	47.7
UF94095	19940910	165855	64.8	2.83	+49.4	1.02	52.6	51.3
UF94096	19940910	165914	19.9	0.16	−13.6	0.93	40.3	38.8
UF94097	19940910	165921	70.9	2.08	+54.0	0.41	56.4	55.1
UF94098	19940910	170218	77.8	3.93	+12.8	3.18	68.6	67.4
UF94099	19940910	170756	41.1	0.99	+26.3	0.90	42.4	40.8
UF94100	19940910	171039	59.9	2.43	−04.8	2.90	58.8	57.5
UF94101	19940910	171405	10.0	0.86	+18.3	2.41	24.9	22.4
UF94102	19940910	171641	77.8	2.48	−05.2	2.41	68.0	66.8
UF94103	19940910	171956	47.1	0.25	+30.4	0.33	69.1	68.1

Table 2 – continued.

No.	Q (°)	Obs Mag	Abs Mag	h_b (km)	h_m (km)	h_e (km)
UF94051	37.6	2.2	2.2	101	88	85
UF94052	52.7	4.6	4.8	96	93	88
UF94053	23.6	3.8	4.2	81	79	76
UF94054	19.0	3.7	3.8	100	93*	93
UF94055	19.4	1.5	1.4	105	99	97
UF94056	10.3	3.9	4.1	98	90	88
UF94057	12.3	2.1	1.9	122	111*	104
UF94058	27.6	2.5	2.8	88	87*	86
UF94059	13.4	4.5	4.8	86	82	77
UF94060	38.2	3.9	4.2	94	89	83
UF94061	27.4	4.3	4.3	101	97	87
UF94062	40.8	4.3	4.6	96	89	85
UF94063	8.2	4.3	4.1*	106	104	99
UF94064	13.2	3.2	2.9	118	109	101
UF94065	32.7	4.1	4.3	96	89	86
UF94066	13.4	4.3	4.1	116	110	103
UF94067	9.9	3.4	3.2	110	106	100
UF94068	50.6	3.2	3.4	99	91	85
UF94069	23.4	4.7	4.8	97	92	87
UF94070	7.9	5.4	5.2*	110	107	105
UF94071	50.8	4.5	4.6	96	90	84
UF94072	30.7	5.9	5.9	96	94	92
UF94073	14.9	3.3	3.2	112	104	96
UF94074	20.0	4.1	4.1	104	100*	97
UF94075	20.4	4.7	4.6	106	104	101
UF94076	42.5	2.6	2.8	92	90	82
UF94077	37.4	3.3	3.5	99	91	86
UF94078	39.8	5.0	5.1	98	94	90
UF94079	22.5	5.2	5.3*	100	94	90
UF94080	32.6	2.6	2.8	101	93	86
UF94081	23.7	5.7	5.8	97	94*	93
UF94082	14.6	5.8	5.6	111	105	97
UF94083	25.2	5.0	5.2	96	90	83
UF94084	40.9	3.9	4.1	97	94	82
UF94085	11.1	3.1	3.2*	97	97	93
UF94086	8.8	4.9	4.7	113	110	107
UF94087	21.6	5.4	5.3	109	104	101
UF94088	10.0	5.3	4.9	115	113	99
UF94089	20.2	4.1	4.4	88	88	78
UF94090	12.3	2.7	2.5	113	105	99
UF94091	12.9	5.1	4.9	111	105	100
UF94092	11.4	3.0	2.9*	111	106	100
UF94093	43.8	2.8	2.7	108	102	91
UF94094	22.3	2.8	2.7*	106	104	100
UF94095	22.1	5.4	5.3	108	103	101
UF94096	26.2	4.5	4.4	106	100	96
UF94097	23.1	5.2	5.1	110	105	98
UF94098	6.6	5.6	5.4	111	109	105
UF94099	32.1	5.0	4.9	100	99	89
UF94100	22.0	3.1	3.1*	99	99	95
UF94101	51.5	5.5	5.7	88	87	84
UF94102	10.9	4.8	4.5	112	109*	105
UF94103	48.6	3.2	3.1	113	100	93

Table 2 – continued.

No.	Date yyyymmdd	UT hhmmss	α (°)	$\Delta\alpha$ (°)	δ (°)	$\Delta\delta$ (°)	V_{obs} (km/s)	V_g (km/s)
UF94104	19940910	172913	59.6	0.82	+58.7	0.56	48.6	47.2
UF94105	19940910	173355	82.7	3.32	+13.8	2.59	66.8	65.6
UF94106	19940910	173520	83.6	3.33	−03.8	4.31	67.0	65.8
UF94107	19940910	173928	69.7	5.63	+57.4	1.51	67.2	66.2
UF94108	19940910	174413	7.5	0.24	−01.7	1.04	30.3	28.4
UF94109	19940910	174501	77.9	4.03	+19.1	1.82	70.8	69.6
UF94110	19940910	174534	55.9	1.16	+50.0	1.34	61.4	60.3
UF94111	19940910	174651	0.5	0.77	−00.5	4.02	28.2	26.1
UF94112	19940910	175103	65.9	0.68	+06.8	0.77	66.3	65.1
UF94113	19940910	175206	8.9	2.61	+75.5	1.09	33.5	31.7
UF94114	19940910	175315	18.5	0.21	−08.4	0.78	27.0	24.7
UF94115	19940910	175325	3.5	0.90	+06.4	1.57	27.5	25.3
UF94116	19940910	175956	3.6	1.17	+05.2	1.73	28.2	26.1
UF94117	19940910	180551	335.0	5.20	+61.8	0.45	30.7	28.8
UF94118	19940910	180603	90.4	4.06	−04.4	2.80	59.3	57.9
UF94119	19940910	180604	76.4	1.37	+01.9	0.94	68.7	67.5
UF94120	19940910	180730	355.8	1.85	−32.6	1.89	28.7	26.7
UF94121	19940910	180953	42.1	0.49	+26.4	0.26	60.2	59.2
UF94122	19940910	181056	322.0	5.24	+47.1	1.32	11.5	3.5
UF94123	19940910	181131	67.3	3.36	+46.0	1.47	56.9	55.7
UF94124	19940910	181830	76.5	0.46	+11.9	0.41	71.8	70.8
UF94125	19940910	183336	92.4	2.27	+42.5	0.33	73.9	72.8
UF94126	19940910	184015	70.7	1.94	+45.9	0.48	58.6	57.4
UF94127	19940913	135206	321.0	0.47	+17.2	0.60	15.0	10.1
UF94128	19940913	142401	5.6	1.25	−34.5	1.12	21.9	18.7
UF94129	19940913	143001	8.4	0.30	+03.1	0.35	31.9	29.8
UF94130	19940913	145000	10.2	0.37	+08.3	0.38	36.4	34.6
UF94131	19940913	151045	7.2	0.57	−00.7	0.73	35.7	33.8
UF94132	19940913	151937	63.8	1.13	+32.7	0.62	71.5	70.4
UF94133	19940913	154708	17.5	0.26	+01.3	0.27	39.5	37.8
UF94134	19940913	160633	77.3	3.38	+44.5	1.40	65.4	64.2
UF94135	19940913	160921	4.2	0.46	+15.6	0.24	35.4	33.7
UF91136	19940913	161912	11.4	0.16	+04.0	0.31	34.9	33.1
UF94137	19940913	162653	49.6	0.85	+33.7	0.31	54.7	53.4
UF94138	19940913	162736	0.6	0.16	+01.5	0.45	27.4	25.2
UF94139	19940913	163522	81.2	0.57	+01.9	0.36	71.5	70.3
UF94140	19940913	164429	292.4	5.13	+68.6	0.31	11.4	3.0
UF94141	19940913	164736	315.4	3.89	−06.5	3.53	19.6	16.5
UF94142	19940913	164751	69.1	0.52	+00.7	0.26	70.2	69.0
UF94143	19940913	165609	26.1	0.91	+19.6	0.19	68.7	67.8
UF94144	19940913	165612	67.6	0.59	+05.6	0.44	70.4	69.3
UF94145	19940913	165819	74.7	0.61	+11.9	0.37	70.7	69.5
UF94146	19940913	170038	1.7	0.20	+01.8	0.71	28.8	26.7
UF94147	19940913	173011	83.9	3.52	+38.1	0.80	49.3	47.8
UF94148	19940913	173403	15.0	1.34	+29.6	1.37	18.6	15.1
UF94149	19940913	173812	76.0	3.09	+44.5	0.26	62.2	61.0
UF94150	19940913	173853	343.5	0.55	+57.4	0.19	40.4	39.0
UF94151	19940913	173944	28.1	0.30	+34.1	0.21	58.5	57.4
UF94152	19940913	175056	78.0	1.25	+41.1	0.23	70.3	69.2
UF94153	19940913	175217	76.9	4.43	+47.6	0.56	64.0	62.8
UF94154	19940913	175557	59.4	0.82	+39.0	0.25	63.1	62.0
UF94155	19940913	175741	77.2	1.67	+41.7	0.59	63.2	62.1
UF94156	19940913	175950	60.2	0.92	+36.8	0.21	57.9	56.7

Table 2 – continued.

No.	Q (°)	Obs Mag	Abs Mag	h_b (km)	h_m (km)	h_e (km)
UF94104	46.7	6.0	6.2	98	90	87
UF94105	8.1	6.0	5.8	112	110	104
UF94106	11.5	3.7	3.5	116	110*	110
UF94107	24.0	5.9	5.7	108	105	103
UF94108	28.1	2.5	2.5	100	92	88
UF94109	5.1	5.3	5.3	103	98	93
UF94110	34.1	5.0	5.0	100	99*	93
UF94111	18.6	4.5	4.7	96	93	92
UF94112	22.3	3.2	2.9	113	109	98
UF94113	34.2	3.9	3.9	103	99	93
UF94114	32.6	3.8	4.1	92	87	79
UF94115	27.2	5.5	5.7	98	94	92
UF94116	23.2	5.4	5.4	100	93	91
UF94117	25.5	4.7	4.6*	105	102	96
UF94118	10.8	4.7	4.5*	103	102	98
UF94119	12.0	3.9	3.6	117	109	102
UF94120	14.8	5.5	5.5	103	99	98
UF94121	49.9	5.2	5.1	103	103	88
UF94122	47.0	4.1	4.8	79	73	69
UF94123	22.3	4.8	4.8	102	100	95
UF94124	14.9	1.8	1.7	126	104	96
UF94125	15.0	5.0	4.7	117	111	102
UF94126	21.6	3.2	3.1	109	104	97
UF94127	69.5	4.7	4.8	84	81	77
UF94128	30.4	5.4	5.2	99	95	91
UF94129	43.8	4.0	4.0*	101	90	86
UF94130	45.1	5.4	5.5	102	96	91
UF94131	40.5	5.3	5.4	100	95*	94
UF94132	14.2	4.8	4.5	118	112	104
UF94133	49.9	5.9	6.0	96	96	86
UF94134	9.0	5.2	5.0*	114	109	103
UF94135	87.7	6.9	6.8	97	92	85
UF91136	50.3	4.2	4.1	97	92	82
UF94137	32.2	5.8	5.8	98	97	91
UF94138	63.2	5.6	5.8	93	91	84
UF94139	21.2	6.3	5.8*	119	116*	108
UF94140	50.6	5.2	5.4	84	76	74
UF94141	11.9	5.9	5.9	087	84	81
UF94142	24.0	4.4	3.9*	119	110*	101
UF94143	59.0	6.0	5.8	100	89	87
UF94144	30.2	5.0	4.8*	108	108	98
UF94145	23.4	5.7	5.3*	117	109	102
UF94146	39.5	5.5	5.6	101	95	92
UF94147	13.9	6.1	6.1	102	102	99
UF94148	21.5	4.0	4.3	86	86	78
UF94149	11.5	6.1	6.1	102	98	94
UF94150	52.8	3.3	3.1	109	99	92
UF94151	86.5	5.5	5.6	98	90	85
UF94152	15.8	4.7	4.2*	119	113	98
UF94153	12.6	6.3	6.0	116	112	111
UF94154	40.9	5.7	5.8	100	93	90
UF94155	26.2	5.4	5.5*	99	93	92
UF94156	48.3	4.7	4.6	100	95	89

Table 2 – continued.

No.	Date yyyymmdd	UT hhmmss	α (°)	$\Delta\alpha$ (°)	δ (°)	$\Delta\delta$ (°)	V_{obs} (km/s)	V_g (km/s)
UF94157	19940913	180551	65.3	1.11	+24.6	0.50	74.3	73.3
UF94158	19940913	180628	99.3	0.85	+21.7	0.42	69.9	68.7
UF94159	19940913	181722	53.1	0.52	+10.3	0.37	62.7	61.6
UF94160	19940913	182606	58.6	0.34	+27.3	0.20	67.6	66.6
UF94161	19940913	182637	79.8	0.96	+30.7	0.25	69.9	68.8
UF94162	19940913	182828	76.4	1.50	+40.1	0.19	66.9	65.9
UF94163	19940913	182923	270.5	3.68	+72.5	0.82	17.5	13.6
UF94164	19940913	184156	84.8	1.11	+35.9	0.22	69.9	68.9
UF94165	19940913	184233	79.9	1.53	+43.6	0.17	64.6	63.5
UF94166	19941001	152526	76.8	0.76	+28.1	0.39	69.8	68.6
UF94167	19941001	153757	69.6	1.54	+46.9	0.56	68.9	67.8
UF94168	19941001	153909	101.8	2.24	+36.6	1.19	71.6	70.4
UF94169	19941001	154303	10.0	4.32	+08.2	1.22	22.4	19.5
UF94170	19941001	154548	8.0	0.63	+21.0	0.56	28.5	26.3
UF94171	19941001	155236	78.1	0.93	+29.1	0.35	65.8	64.6
UF94172	19941001	155448	85.2	1.03	+36.0	0.51	72.1	71.0
UF94173	19941001	160527	41.4	3.09	+72.3	1.48	48.1	46.8
UF94174	19941001	161018	56.6	5.76	+69.6	2.47	53.9	52.7
UF94175	19941001	161119	70.5	1.04	+03.8	0.68	62.2	61.0
UF94176	19941001	161355	80.7	1.14	+35.9	0.41	56.0	54.6
UF94177	19941001	162346	25.2	0.26	+05.2	0.64	30.9	28.8
UF94178	19941001	162848	4.1	1.00	+20.1	0.67	29.1	27.1
UF94179	19941001	163018	6.9	0.39	+23.9	0.65	28.7	26.6
UF94180	19941001	164602	24.4	0.44	+02.6	0.65	30.9	28.9
UF94181	19941001	164640	78.2	0.97	+23.8	0.43	65.2	64.0
UF94182	19941001	165256	65.4	1.35	+03.0	0.88	63.5	62.3
UF94183	19941001	165949	348.1	1.00	+15.9	0.70	24.6	22.2
UF94184	19941001	170906	78.4	1.76	+46.6	0.77	54.3	53.0
UF94185	19941001	170951	25.7	0.38	+06.6	0.89	32.4	30.5
UF94186	19941001	171156	95.8	2.30	+52.9	0.56	61.0	59.8
UF94187	19941001	171157	123.2	11.23	+78.6	0.40	41.7	40.1
UF94188	19941001	171552	80.1	3.71	+59.6	0.59	57.3	56.1
UF94189	19941001	172214	23.6	0.40	+05.6	0.39	30.1	28.1
UF94190	19941001	172449	67.2	0.55	+33.9	0.36	64.2	63.1
UF94191	19941001	172743	104.0	0.42	+20.0	0.29	67.1	65.9
UF94192	19941001	173434	22.2	0.65	+04.3	0.78	28.5	26.4
UF94193	19941001	173655	86.7	0.75	+40.4	0.38	69.1	68.0
UF94194	19941001	173710	21.3	0.40	+04.6	0.43	27.7	25.6
UF94195	19941001	173753	17.8	0.98	+12.3	0.62	30.2	28.3
UF94196	19941001	173855	117.7	0.72	+31.4	0.33	62.2	60.9
UF94197	19941001	173855	91.6	2.25	−12.1	2.07	58.6	57.2
UF94198	19941001	174558	160.0	4.79	+71.4	0.61	48.6	47.2
UF94199	19941001	174728	15.9	1.22	−36.9	1.45	23.7	21.2
UF94200	19941001	175016	94.9	1.22	+06.4	0.73	70.2	69.1
UF94201	19941001	175019	102.9	1.81	+53.2	0.62	63.7	62.6
UF94202	19941001	175239	84.2	0.63	+22.8	0.29	74.8	73.8
UF94203	19941001	175819	73.1	1.02	+34.2	0.52	66.0	64.9
UF94204	19941001	175830	12.6	0.91	−02.8	0.77	24.9	22.5
UF94205	19941001	180257	85.4	0.54	+19.5	0.53	70.3	69.2
UF94206	19941001	181134	29.7	0.52	+16.0	0.41	35.5	33.9
UF94207	19941001	181651	85.4	0.74	+13.3	0.27	70.0	68.9
UF94208	19941001	181711	104.8	1.50	+26.8	0.51	76.4	75.4
UF94209	19941001	182457	27.3	0.99	+18.7	0.60	40.9	39.6

Table 2 – continued.

No.	Q (°)	Obs Mag	Abs Mag	h_b (km)	h_m (km)	h_e (km)
UF94157	33.8	7.1	6.6	116	113	107
UF94158	20.3	6.0	6.0*	102	101	92
UF94159	46.0	4.9	4.5	105	100	94
UF94160	60.0	5.6	5.7	100	94	90
UF94161	24.6	7.6	7.4	105	92	90
UF94162	18.8	5.9	6.0	101	95	89
UF94163	34.7	4.7	4.9*	88	88	86
UF94164	20.1	6.3	5.9	115	109	100
UF94165	16.4	3.4	3.2	116	109	100
UF94166	38.5	2.5	2.2	115	112	100
UF94167	58.6	3.8	3.7	103	100	94
UF94168	31.4	5.0	4.6	115	110	109
UF94169	84.1	4.5	4.6	95	92	89
UF94170	78.1	4.5	4.5	100	95	90
UF94171	39.2	3.0	2.8	116	105	101
UF94172	36.1	2.1	1.9	120	108*	106
UF94173	31.0	3.6	3.4	111	105	98
UF94174	26.6	5.6	5.3	107	104	101
UF94175	26.6	4.4	4.2	113	106	97
UF94176	46.7	3.0	2.8	111	102	97
UF94177	39.1	2.8	2.7	113	101	91
UF94178	60.3	4.4	4.4	101	97	92
UF94179	79.6	4.6	4.7	98	92	87
UF94180	67.9	3.6	3.6	99	93	87
UF94181	50.8	4.3	4.2	107	98	94
UF94182	30.4	2.5	2.5	99	95	86
UF94183	45.7	2.4	2.6	104	93	90
UF94184	69.1	3.5	3.4	101	99	93
UF94185	49.2	4.0	4.0	107	98	93
UF94186	45.6	4.6	4.4	109	106	99
UF94187	23.2	4.6	4.4	107	102	98
UF94188	43.7	3.3	2.8	119	112*	108
UF94189	57.9	2.5	2.7	102	91	85
UF94190	77.7	3.8	3.5	114	106	104
UF94191	39.7	2.4	2.5*	108	93	91
UF94192	66.2	5.2	5.2	101	95	92
UF94193	71.4	2.2	2.0	111	106	99
UF94194	52.4	4.2	4.4	93	88	79
UF94195	65.4	4.6	4.6	97	96	90
UF94196	41.2	2.0	1.8*	111	108	98
UF94197	16.1	4.0	3.8	109	106	101
UF94198	24.9	4.3	4.1*	109	107	101
UF94199	30.7	4.6	4.7	97	95	92
UF94200	28.0	4.6	4.4	113	106	102
UF94201	44.2	3.2	3.1	115	105	97
UF94202	60.2	4.3	4.0	114	111	98
UF94203	64.6	4.4	4.2	111	106*	98
UF94204	44.4	3.5	3.6	98	94	90
UF94205	42.3	2.5	2.4	104	102	88
UF94206	74.8	2.8	2.7	100	95	82
UF94207	40.7	1.9	1.7	112	104	94
UF94208	44.7	3.6	3.4	102	99*	92
UF94209	50.6	4.1	4.2	96	95	89

Table 2 – continued.

No.	Date yyyymmdd	UT hhmmss	α (°)	$\Delta\alpha$ (°)	δ (°)	$\Delta\delta$ (°)	V_{obs} (km/s)	V_g (km/s)
UF94210	19941001	182759	102.2	0.75	−14.7	0.73	67.0	65.8
UF94211	19941001	182835	128.2	0.64	+29.1	0.27	49.3	47.7
UF94212	19941001	182904	99.1	0.90	+38.9	0.39	76.3	75.3
UF94213	19941001	182921	121.6	0.89	+28.6	0.30	66.5	65.3
UF94214	19941001	182949	115.2	2.29	+48.3	0.64	63.7	62.5
UF94215	19941001	183001	92.4	1.46	+22.4	0.84	86.6	85.7
UF94216	19941001	183018	112.7	0.90	+32.0	0.34	66.9	65.7
UF94217	19941001	183055	90.2	1.26	+04.5	2.28	66.0	64.9

Table 3 – The orbital elements of the 217 TV meteors (eq. 2000.0).

No.	Date yyyymmdd	UT hhmmss	a AU	e	q AU	Ω (°)	i (°)	ω (°)	P (yr)
UF94001	19940506	171443	−5.9	1.15	0.90	46.0	166.4	217.0	
UF94002	19940506	171636	4.6	0.85	0.71	46.0	54.1	249.3	9.8
UF94003	19940506	172029	46.8	0.99	0.61	46.0	161.4	101.6	320.2
UF94004	19940506	172257	−44.7	1.01	0.60	46.0	164.0	101.1	
UF94005	19940506	172749	3.5	0.80	0.72	46.0	48.1	249.7	6.6
UF94006	19940506	172857	5.8	0.91	0.55	46.0	163.6	92.4	13.9
UF94007	19940506	173044	11.7	0.95	0.58	46.0	163.0	97.9	40.2
UF94008	19940506	173419	9.0	0.97	0.24	46.0	139.6	56.5	27.1
UF94009	19940506	173807	2.8	0.80	0.56	46.0	35.1	270.4	4.6
UF94010	19940506	174217	−4.7	1.13	0.62	46.0	163.8	105.4	
UF94011	19940506	174729	1.1	0.71	0.32	46.0	10.4	310.2	1.2
UF94012	19940506	175204	2.2	0.88	0.25	46.0	15.2	306.6	3.2
UF94013	19940506	175648	0.8	0.99	0.01	226.1	2.3	174.8	0.7
UF94014	19940506	180237	−7.7	1.08	0.63	46.1	162.1	106.6	
UF94015	19940506	180625	164.7	1.00	0.57	46.1	166.1	97.9	2114
UF94016	19940506	181108	11.9	0.95	0.55	46.1	168.1	94.5	40.9
UF94017	19940506	182656	3.4	0.85	0.51	46.1	169.5	85.7	6.2
UF94018	19940506	183133	5.1	0.89	0.55	46.1	164.7	91.5	11.6
UF94019	19940506	183227	2.6	0.78	0.58	46.1	56.8	268.6	4.2
UF94020	19940506	183715	−7.3	1.09	0.63	46.1	160.6	106.0	
UF94021	19940506	183844	1.8	0.87	0.22	46.1	7.1	312.3	2.3
UF94022	19940506	184659	25.5	0.98	0.59	46.1	163.0	99.5	128.6
UF94023	19940506	185957	1.1	0.20	0.90	46.1	130.0	250.6	1.2
UF94024	19940730	141802	48.2	0.98	0.94	127.3	69.3	212.4	334.8
UF94025	19940730	142452	2.6	0.77	0.60	307.3	1.4	87.0	4.1
UF94026	19940730	143608	3.8	0.98	0.06	307.3	24.5	153.8	7.5
UF94027	19940730	144108	1.9	0.95	0.09	307.3	26.1	150.2	2.5
UF94028	19940730	144350	4.2	0.98	0.09	307.3	0.5	148.3	8.6
UF94029	19940730	144839	4.2	0.98	0.07	307.3	30.6	151.5	8.7
UF94030	19940730	144906	5.1	0.99	0.08	307.3	21.8	150.0	11.4
UF94031	19940730	152019	2.0	0.96	0.09	307.3	33.1	150.6	2.9
UF94032	19940730	152627	3.1	0.97	0.08	307.3	27.2	150.1	5.5
UF94033	19940730	153458	1.9	0.67	0.63	127.3	1.4	266.7	2.6
UF94034	19940730	153624	−1.5	1.63	0.95	127.3	151.7	206.9	
UF94035	19940730	154054	−3.1	1.32	1.00	127.3	140.3	166.2	
UF94036	19940730	154238	2.1	0.96	0.08	307.3	33.8	151.4	3.0
UF94037	19940730	155105	−1.2	1.83	1.00	127.3	164.5	167.0	

Table 2 – continued.

No.	Q (°)	Obs Mag	Abs Mag	h_b (km)	h_m (km)	h_e (km)
UF94210	15.5	2.4	2.2	115	103*	92
UF94211	47.9	4.0	4.1*	96	92	87
UF94212	60.1	5.0	4.7	120	106	105
UF94213	40.4	3.3	3.1	115	109	105
UF94214	47.1	4.1	3.9	112	108	104
UF94215	36.1	4.7	4.4	115	107	97
UF94216	41.1	3.9	3.5	115	108	100
UF94217	16.9	3.7	3.6	109	106	93

Table 3 – continued.

No.	Date yyyymmdd	UT hhmmss	a AU	e	q AU	Ω (°)	i (°)	ω (°)	P (yr)
UF94038	19940730	155240	−3.2	1.31	0.99	127.3	104.3	198.1	
UF94039	19940730	155336	1.1	0.95	0.05	127.3	32.7	341.2	1.1
UF94040	19940730	155355	−3228.0	1.00	0.51	127.3	10.4	269.4	
UF94041	19940730	155702	3.1	0.97	0.08	307.3	28.2	150.2	5.6
UF94042	19940730	155756	2.9	0.80	0.57	127.3	9.6	269.0	4.8
UF94043	19940730	160614	1.1	0.83	0.20	307.3	44.0	141.2	1.2
UF94044	19940730	162458	1.5	0.32	1.01	127.3	15.4	182.6	1.8
UF94045	19940730	163546	9.3	0.90	0.89	127.4	149.6	222.4	28.3
UF94046	19940730	163823	3.8	0.83	0.65	307.4	1.4	78.1	7.5
UF94047	19940730	165349	4.3	0.89	0.48	127.4	49.8	277.4	9.1
UF94048	19940730	165512	2.0	0.95	0.09	307.4	27.3	149.2	2.9
UF94049	19940730	165632	−1.4	1.72	1.01	127.4	146.0	174.6	
UF94050	19940730	170937	8.7	0.94	0.53	127.4	136.3	269.4	25.5
UF94051	19940730	172248	1.5	0.92	0.12	307.4	26.5	146.7	1.97
UF94052	19940910	132024	1.5	0.34	0.97	167.7	26.5	211.6	1.8
UF94053	19940910	133959	4.2	0.77	0.97	167.7	2.3	204.1	8.7
UF94054	19940910	134246	2.7	0.85	0.41	347.7	24.2	106.5	4.6
UF94055	19940910	140053	14.2	0.95	0.70	167.7	107.6	248.0	53.8
UF94056	19940910	140611	0.7	0.87	0.09	347.7	10.6	163.4	0.6
UF94057	19940910	140714	3.4	0.73	0.92	167.7	121.8	216.9	6.2
UF94058	19940910	141945	2.4	0.65	0.83	347.7	4.2	55.4	3.7
UF94059	19940910	141955	−10.5	1.09	0.97	167.7	21.0	201.4	
UF94060	19940910	144347	2.6	0.71	0.75	167.7	7.7	247.1	4.2
UF94061	19940910	145406	4.4	0.98	0.09	167.7	20.5	327.0	9.4
UF94062	19940910	145458	2.6	0.79	0.55	167.7	1.0	271.9	4.2
UF94063	19940910	145509	−4.0	1.07	0.27	167.8	178.8	294.8	
UF94064	19940910	150149	−28.4	1.03	0.98	167.8	126.8	160.6	
UF94065	19940910	150903	2.6	0.72	0.73	167.8	7.4	250.7	4.2
UF94066	19940910	151150	5.2	0.81	1.00	167.8	127.7	172.1	11.8
UF94067	19940910	152957	1.4	0.42	0.83	167.8	146.3	113.0	1.7
UF94068	19940910	153302	3.5	0.99	0.05	167.8	10.6	335.8	6.5
UF94069	19940910	153527	5.6	0.86	0.76	167.8	34.2	241.4	13.2
UF94070	19940910	153537	2.7	0.65	0.96	347.8	120.9	27.8	4.5
UF94071	19940910	153700	1.2	0.28	0.87	167.8	25.7	248.5	1.3
UF94072	19940910	154303	1.4	0.74	0.35	347.8	5.8	122.3	1.6
UF94073	19940910	154431	2.7	0.64	0.99	167.8	116.6	198.1	4.5
UF94074	19940910	154605	12.7	0.93	0.94	167.8	46.3	149.2	45.1

Table 3 – continued.

No.	Date yyyymmdd	UT hhmmss	a AU	e	q AU	Ω (°)	i (°)	ω (°)	P (yr)
UF94075	19940910	154822	11.6	0.98	0.28	347.8	63.0	117.0	39.5
UF94076	19940910	155325	2.5	0.64	0.91	167.8	58.4	221.5	4.0
UF94077	19940910	160607	1.0	0.69	0.29	347.8	6.6	137.1	0.9
UF94078	19940910	160703	1.4	0.74	0.37	167.8	6.5	300.2	1.6
UF94079	19940910	160903	4.8	0.81	0.90	167.8	67.3	139.4	10.4
UF94080	19940910	161513	2.4	0.93	0.16	347.8	15.2	138.3	3.6
UF94081	19940910	161641	5.5	0.83	0.94	167.8	45.5	211.1	12.7
UF94082	19940910	161804	21.3	0.97	0.63	167.8	134.7	256.5	98.1
UF94083	19940910	161839	2.0	0.73	0.55	167.8	20.6	273.9	2.9
UF94084	19940910	162018	1.6	0.84	0.24	167.8	6.5	311.0	2.0
UF94085	19940910	162020	3.2	0.69	1.00	347.8	114.0	5.5	5.7
UF94086	19940910	162106	−5.4	1.18	1.01	347.8	119.8	358.0	
UF94087	19940910	162333	5.4	0.81	1.01	167.8	109.3	175.5	12.6
UF94088	19940910	162521	−2.7	1.33	0.91	347.8	149.3	33.5	
UF94089	19940910	162548	7.3	0.92	0.59	167.8	26.2	262.0	19.8
UF94090	19940910	163050	2.2	0.69	0.70	167.8	139.5	256.0	3.3
UF94091	19940910	163207	1.6	0.72	0.44	347.8	165.7	109.7	2.0
UF94092	19940910	163446	3.8	0.83	0.64	167.8	129.5	101.5	7.3
UF94093	19940910	163802	2.0	0.66	0.68	167.8	124.5	259.3	2.8
UF94094	19940910	163959	0.9	0.18	0.70	167.8	114.9	10.3	0.8
UF94095	19940910	165855	1.0	0.19	0.77	167.8	123.5	297.2	0.9
UF94096	19940910	165914	3.3	0.93	0.23	347.8	43.6	127.4	6.1
UF94097	19940910	165921	1.4	0.28	1.00	167.8	121.3	188.8	1.7
UF94098	19940910	170218	3.3	0.69	1.01	347.8	162.2	1.2	5.9
UF94099	19940910	170756	0.7	0.94	0.04	167.8	124.3	347.4	0.6
UF94100	19940910	171039	2.0	0.68	0.64	347.8	128.3	84.0	2.8
UF94101	19940910	171405	0.9	0.71	0.26	167.8	14.6	321.6	0.9
UF94102	19940910	171641	−10.1	1.10	1.00	347.8	133.0	5.5	
UF94103	19940910	171956	−4.4	1.14	0.62	167.8	154.8	253.8	
UF94104	19940910	172913	1.0	0.17	0.85	167.9	105.0	272.3	1.0
UF94105	19940910	173355	2.2	0.55	0.98	347.9	162.9	337.5	3.3
UF94106	19940910	173520	56.0	0.98	0.99	347.9	133.9	347.1	419.3
UF94107	19940910	173928	−3.2	1.32	1.01	167.9	123.1	183.1	
UF94108	19940910	174413	1.5	0.82	0.27	347.9	6.2	128.2	1.9
UF94109	19940910	174501	5.9	0.83	1.01	347.9	173.3	358.9	14.3
UF94110	19940910	174534	3.2	0.72	0.90	167.9	126.3	222.6	5.7
UF94111	19940910	174651	1.7	0.79	0.37	347.9	0.8	116.2	2.3
UF94112	19940910	175103	3.3	0.74	0.85	347.9	152.7	51.4	5.9
UF94113	19940910	175206	1.2	0.22	0.92	167.9	61.6	237.8	1.3
UF94114	19940910	175315	1.0	0.74	0.27	347.9	18.6	136.8	1.0
UF94115	19940910	175325	1.3	0.76	0.31	167.9	5.2	306.8	1.5
UF94116	19940910	175956	1.4	0.78	0.31	167.9	4.0	306.3	1.6
UF94117	19940910	180551	1.8	0.54	0.85	167.9	48.9	235.4	2.5
UF94118	19940910	180603	1.8	0.51	0.87	347.9	127.0	306.4	2.4
UF94119	19940910	180604	15.8	0.94	1.00	347.9	144.3	9.1	62.9
UF94120	19940910	180730	65.6	0.99	0.68	347.9	21.4	70.1	531.0
UF94121	19940910	180953	2.6	0.88	0.32	167.9	154.4	297.0	4.2
UF94122	19940910	181056	1.0	0.08	0.93	167.9	5.6	271.1	1.0
UF94123	19940910	181131	1.1	0.19	0.92	167.9	133.2	244.3	1.2
UF94124	19940910	181830	−80.6	1.01	1.00	347.9	161.4	5.7	
UF94125	19940910	183336	−2.0	1.46	0.91	167.9	147.3	146.2	

Table 3 – continued.

No.	Date yyyymmdd	UT hhmmss	a AU	e	q AU	Ω (°)	i (°)	ω (°)	P (yr)
UF94126	19940910	184015	1.3	0.22	0.99	167.9	135.3	206.9	1.4
UF94127	19940913	135206	1.5	0.41	0.89	170.6	8.9	232.8	1.8
UF94128	19940913	142401	1.8	0.59	0.72	350.6	19.1	76.7	2.3
UF94129	19940913	143001	1.7	0.85	0.25	350.7	0.8	128.9	2.2
UF94130	19940913	144960	2.1	0.92	0.17	170.7	7.3	317.5	3.0
UF94131	19940913	151045	3.5	0.93	0.25	350.7	5.7	123.9	6.6
UF94132	19940913	151937	−9.3	1.09	0.87	170.7	160.0	221.5	
UF94133	19940913	154708	2.2	0.95	0.11	350.7	15.9	146.1	3.3
UF94134	19940913	160633	2.9	0.65	1.01	170.7	142.0	183.2	4.9
UF94135	19940913	160921	2.4	0.90	0.24	170.7	21.5	307.2	3.7
UF91136	19940913	161912	1.9	0.90	0.19	350.7	1.6	136.2	2.5
UF94137	19940913	162653	1.1	0.71	0.32	170.7	141.6	309.2	1.2
UF94138	19940913	162736	1.8	0.77	0.40	170.7	1.1	291.9	2.4
UF94139	19940913	163522	−5.2	1.19	1.01	350.7	144.6	1.7	
UF94140	19940913	164429	1.0	0.03	0.96	170.7	5.8	292.8	1.0
UF94141	19940913	164736	16.6	0.95	0.89	170.7	4.2	220.1	67.7
UF94142	19940913	164751	−5.1	1.18	0.90	350.7	143.0	37.2	
UF94143	19940913	165609	−0.8	1.20	0.15	170.7	145.2	304.3	
UF94144	19940913	165612	−8.8	1.10	0.86	350.7	151.3	43.1	
UF94145	19940913	165819	12.4	0.92	0.97	350.7	161.2	22.0	43.7
UF94146	19940913	170038	1.9	0.80	0.37	170.7	1.0	294.4	2.6
UF94147	19940913	173011	0.7	0.53	0.31	170.8	143.5	7.5	0.5
UF94148	19940913	173403	0.8	0.53	0.37	170.8	14.2	325.4	0.7
UF94149	19940913	173812	1.7	0.41	1.00	170.8	140.4	190.9	2.2
UF94150	19940913	173853	−57.6	1.01	0.80	170.8	59.8	233.6	
UF94151	19940913	173944	−9.4	1.03	0.30	170.8	116.0	293.0	
UF94152	19940913	175056	−129.7	1.01	1.01	170.8	149.3	182.2	
UF94153	19940913	175217	2.7	0.63	1.01	170.8	136.5	183.7	4.5
UF94154	19940913	175557	2.3	0.66	0.76	170.8	144.6	246.6	3.4
UF94155	19940913	175741	1.7	0.42	1.00	170.8	145.8	187.5	2.3
UF94156	19940913	175950	1.1	0.48	0.59	170.8	146.0	285.5	1.2
UF94157	19940913	180551	−3.1	1.28	0.88	170.8	174.6	219.4	
UF94158	19940913	180628	14.2	0.95	0.75	350.8	177.3	298.5	53.6
UF94159	19940913	181722	3.3	0.88	0.41	350.8	159.4	105.1	6.1
UF94160	19940913	182606	6.2	0.89	0.70	170.8	166.5	249.4	15.4
UF94161	19940913	182637	4.6	0.78	1.01	170.8	166.8	180.0	9.8
UF94162	19940913	182828	3.3	0.69	1.00	170.8	149.7	188.3	5.9
UF94163	19940913	182923	1.1	0.11	1.01	170.8	25.7	185.0	1.2
UF94164	19940913	184156	7.6	0.87	0.99	170.8	158.2	164.1	21.0
UF94165	19940913	184233	2.4	0.57	1.01	170.8	143.5	175.9	3.6
UF94166	19941001	152526	−39.5	1.02	0.69	188.3	169.9	247.9	
UF94167	19941001	153757	−2.4	1.31	0.74	188.3	133.6	237.3	
UF94168	19941001	153909	160.2	0.99	1.00	188.3	156.9	176.6	2026.9
UF94169	19941001	154303	1.6	0.64	0.55	188.3	2.4	278.1	1.9
UF94170	19941001	154548	2.4	0.81	0.47	188.3	15.4	280.8	3.8
UF94171	19941001	155236	2.8	0.77	0.64	188.3	167.7	259.6	4.7
UF94172	19941001	155448	−6.6	1.13	0.89	188.3	157.8	218.3	
UF94173	19941001	160527	6.0	0.86	0.85	188.3	82.0	227.1	14.9
UF94174	19941001	161018	−138.3	1.01	0.87	188.3	93.1	222.7	
UF94175	19941001	161119	5.5	0.91	0.47	8.3	137.6	96.0	13.0
UF94176	19941001	161355	0.9	0.53	0.45	188.3	150.7	307.0	0.9

Table 3 – continued.

No.	Date yyyymmdd	UT hhmmss	a AU	e	q AU	Ω (°)	i (°)	ω (°)	P (yr)
UF94177	19941001	162346	1.7	0.83	0.29	8.3	6.5	125.0	2.2
UF94178	19941001	162848	3.9	0.87	0.51	188.3	15.5	272.6	7.7
UF94179	19941001	163018	2.5	0.81	0.48	188.3	18.2	279.2	3.9
UF94180	19941001	164602	1.9	0.83	0.31	8.3	9.1	120.9	2.6
UF94181	19941001	164640	2.4	0.75	0.61	188.3	178.4	264.9	3.8
UF94182	19941001	165256	−7.2	1.06	0.41	8.4	134.4	98.5	
UF94183	19941001	165949	9.1	0.92	0.73	188.4	12.0	244.5	27.4
UF94184	19941001	170906	1.1	0.48	0.55	188.4	128.3	292.0	1.1
UF94185	19941001	170951	1.8	0.86	0.26	8.4	5.7	127.6	2.5
UF94186	19941001	171156	2.2	0.56	0.98	188.4	126.8	199.3	3.4
UF94187	19941001	171157	1.5	0.33	1.00	188.4	77.1	175.7	1.8
UF94188	19941001	171552	2.7	0.67	0.88	188.4	112.8	255.7	4.4
UF94189	19941001	172214	1.7	0.82	0.31	8.4	5.1	122.2	2.2
UF94190	19941001	172449	6.7	0.93	0.47	188.4	152.4	276.3	17.3
UF94191	19941001	172743	2.0	0.50	0.97	8.4	174.8	336.0	2.7
UF94192	19941001	173434	1.7	0.79	0.35	8.4	5.3	118.2	2.1
UF94193	19941001	173655	17.1	0.95	0.90	188.4	149.8	217.4	71.0
UF94194	19941001	173710	1.6	0.77	0.37	8.4	4.3	116.6	2.0
UF94195	19941001	173753	2.1	0.83	0.34	188.4	5.2	296.3	3.0
UF94196	19941001	173855	1.4	0.52	0.67	188.4	158.9	91.7	1.6
UF94197	19941001	173855	2.5	0.61	0.97	8.4	116.4	23.4	3.9

Table 4 is based on the following meteors:

- *η-Aquarids*: UF94003, UF94004, UF94006, UF94007, UF94010, UF94014, UF94015, UF94016, UF94017, UF94018, UF94020, UF094022;
- *δ-Aquarids S*: UF94026, UF94027, UF94029, UF94030, UF94031, UF94032, UF94036, UF94041, UF94048; and
- *ε-Aurigids*: UF94134, UF94152, UF94153, UF94155, UF94162, UF94165.

Table 4 – Radiant points and orbital elements for 3 streams obtained by the double-station TV observations. The solar longitude (eq. 2000.0) is given by $\lambda_\odot$, α and δ are the corrected radiant position (right ascension and declination), and V_g is the geocentric velocity.

Stream	Date and time (UT 1994)	$\lambda_\odot$ (2000.0)	α	δ	V_g (km/s)
η-Aquarids	May 6, 18^h04^m	$46.^\circ06 \pm 0.^\circ029$	$338.^\circ3$	$-\ 0.^\circ8$	66.15
δ-Aquarids S	Jul 30, 15^h46^m	$127.^\circ32 \pm 0.^\circ046$	$340.^\circ2$	$-16.^\circ8$	40.9
ε-Aurigids	Sep 13, 17^h25^m	$170.^\circ77 \pm 0.^\circ027$	$77.^\circ9$	$+42.^\circ0$	65.6

Table 3 – Continued.

No.	Date yyyymmdd	UT hhmmss	a AU	e	q AU	Ω (°)	i (°)	ω (°)	P (yr)
UF94198	19941001	174558	7.5	0.88	0.93	188.4	82.1	148.7	20.5
UF94199	19941001	174728	3.8	0.79	0.80	8.4	22.3	56.9	7.5
UF94200	19941001	175016	26.1	0.96	0.99	8.4	150.8	12.2	133.3
UF94201	19941001	175019	4.6	0.78	1.00	188.4	127.8	180.1	9.7
UF94202	19941001	175239	−2.9	1.30	0.86	8.4	179.0	41.0	
UF94203	19941001	175819	6.2	0.90	0.60	188.4	155.8	261.3	15.5
UF94204	19941001	175830	2.2	0.75	0.55	8.4	5.9	93.4	3.2
UF94205	19941001	180257	9.8	0.91	0.85	8.4	173.0	47.4	30.7
UF94206	19941001	181134	1.6	0.91	0.15	188.4	7.8	322.5	2.0
UF94207	19941001	181651	15.6	0.95	0.85	8.4	161.7	45.9	61.3
UF94208	19941001	181711	−2.7	1.37	0.99	188.4	173.3	167.4	
UF94209	19941001	182457	4.0	0.97	0.13	188.4	18.7	320.9	8.1
UF94210	19941001	182759	−2.5	1.40	0.99	8.4	118.9	348.5	
UF94211	19941001	182835	0.8	0.81	0.15	188.4	147.4	24.3	0.7
UF94212	19941001	182904	−1.9	1.53	1.00	188.4	154.5	183.8	
UF94213	19941001	182921	3.2	0.79	0.67	188.4	163.5	104.5	5.8
UF94214	19941001	182949	3.3	0.72	0.93	188.4	132.4	146.8	5.9
UF94215	19941001	183001	−0.6	2.55	0.98	8.4	178.4	13.9	
UF94216	19941001	183018	2.5	0.64	0.87	188.4	161.3	132.1	3.8
UF94217	19941001	183055	3.1	0.70	0.93	8.4	145.8	33.8	5.5

Table 4 – continued. Together with the usual orbital elements, the number of meteors N is listed.

Stream	a (AU)	e	q (AU)	Ω	i	ω	P (years)	N
η-Aquarids	25.2	0.98	0.59	46°1	163°8	99°0	126.2	12
δ-Aquarids S	2.8	0.97	0.08	307°3	28°5	150°3	4.7	9
ε-Aurigids	3.4	0.71	1.01	170°8	146°7	182°6	6.4	7

Fireballs and Meteorites

Fireballs over Central Europe in February–March 1997

Pavel Spurný and Jiří Borovicka

An overview is given of the data regarding five recent fireballs photographed by stations of the European Fireball Network.

1. Czech Republic, February 10, 1997, $4^h04^m01^s \pm 2^s$ UT

A bright fireball of −7 maximum absolute magnitude was photographed by two Czech stations of the European Fireball Network. The three fish-eye records were obtained at the EN stations #4 Churáňov (fixed and guided picture) and #11 Přimda. The fireball traveled a 83.31-km luminous trajectory in 2.75 seconds and terminated its light at a relatively great altitude of 46.35 km in the vicinity of the Czech town of Klatovy. Time of the fireball passage was determined from the combination of the records from the Churáňov fixed and guided cameras.

Thanks to favorable geometry, the following results based on all available records have a very good precision. According to the dynamic fragmentation model, it is a typical case with more than one sudden fragmentation point.

Table 1 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	33.65 ± 0.02	32.8	13.6 ± 0.4
Height (km)	95.71 ± 0.02	67.8	46.35 ± 0.02
Latitude (° N)	49.1912 ± 0.0002	49.305	49.3931 ± 0.0002
Longitude (° E)	12.3092 ± 0.0002	12.790	13.1678 ± 0.0002
Abs. magnitude	− 3.8 ± 0.3	− 6.7 ± 0.2	− 3.1 ± 0.3
Photomet. mass (kg)	0.35	0.3	*none*
Z R (°)	53.36 ± 0.02		53.96 ± 0.02

Fireball type: I; Ablation coefficient: (0.0081 ± 0.0002) s^2/km^2; PE coefficient: −4.25.

Table 2 – Radiant data (eq. 2000.0).

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	162.09 ± 0.02	160.65 ± 0.02	
δ (°)	+ 15.74 ± 0.02	+ 14.35 ± 0.02	
λ (°)			105.85 ± 0.03
β (°)			+ 04.88 ± 0.02
Initial velocity (km/s)	33.65 ± 0.02	32.01 ± 0.02	37.58 ± 0.02

Table 3 – Orbital data (eq. 2000.0).

Orbit (2000.0)	
a	2.300 ± 0.007 AU
e	0.8762 ± 0.0004
q	0.2847 ± 0.0004 AU
Q	4.316 ± 0.014 AU
ω	301°57 ± 0°05
Ω	321°5095 ± 0°0001
i	8°32 ± 0°03

2. Czech Republic, March 1, 1997, $17^h52^m37^s \pm 10^s$ UT

A bright fireball of −9 maximum absolute magnitude was photographed by one Czech and one Slovak station of the European Fireball Network. The only two fish-eye records were obtained at the EN stations #14 Červená hora and #21 Modra, because the fireball flew before regular exposure time for most of Czech stations, which would be much more better located with respect to the fireball trajectory. In spite of the presence of only two very distant records, the resulting data have a good accuracy. The fireball traveled a 69.58-km luminous trajectory in 3.66 seconds and terminated its light at a relatively great altitude of 40.08 km near the Czech town of Poděbrady. This fireball was observed by many casual witnesses in the Czech republic, and, therefore, the time of the fireball passage is reliably known from these visual observations.

Table 4 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	22.25 ± 0.14	20.0	12 ± 2
Height (km)	71.80 ± 0.06	51.5	40.08 ± 0.06
Latitude (° N)	50.6504 ± 0.0003	50.37	50.2147 ± 0.0003
Longitude (° E)	14.6132 ± 0.0006	14.95	15.1435 ± 0.0006
Abs. magnitude	− 6.9 ± 0.4	− 9.3 ± 0.4	− 7.8 ± 0.4
Photomet. mass (kg)	11.7	3.4	none
Z R (°)	62.6 ± 0.2		63.2 ± 0.2

Fireball type: II; Ablation coefficient: (0.034 ± 0.010) s^2/km^2; PE coefficient: −4.69.

Table 5 – Radiant data (eq. 2000.0).

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	327.94 ± 0.10	323.57 ± 0.12	
δ (°)	+ 53.05 ± 0.06	+ 48.60 ± 0.08	
λ (°)			52.98 ± 0.10
β (°)			+ 25.85 ± 0.15
Initial velocity (km/s)	22.27 ± 0.14	19.5 ± 0.2	37.72 ± 0.12

Table 6 – Orbital data (eq. 2000.0).

Orbit (2000.0)	
a	2.42 ± 0.06 AU
e	0.632 ± 0.009
q	0.8885 ± 0.0004 AU
Q	3.94 ± 0.12 AU
ω	137°1 ± 0°2
Ω	341°2357 ± 0°0001
i	27°0 ± 0°2

3. Czech Republic, March 9, 1997, $20^h59^m12^s \pm 4^s$ UT

A slow-moving fireball of −7 maximum absolute magnitude was photographed by four Czech stations of the European Fireball Network. The five fish-eye records were obtained at the EN stations #4 Churáňov (fixed and guided picture), #11 Přimda, #20 Ondřejov, and #15 Telč. The fireball traveled a 50.83-km luminous trajectory in 3.31 seconds and terminated its light at an altitude of 34 km. The slope of the trajectory was quite steep—the zenith distance of the radiant was only 20°.

A great advantage was the fact that this fireball flew practically over the station #4 Churáňov (near the Czech-German border over the Sumava Mountains), and, therefore, time marks on the luminous trajectory are very well defined. This situation enables us to determine especially dynamic data with a very high accuracy. According to the dynamic fragmentation model it is a typical case with more than one sudden fragmentation point. The time of the fireball passage was determined from the combination of the records from Churáňov fixed and guided cameras and it is in a good agreement with several visual observations. The following results based on all available records have a very good precision.

Table 7 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	17.66 ± 0.03	15.8	7.0 ± 0.9
Height (km)	81.70 ± 0.03	45.6	33.98 ± 0.02
Latitude (° N)	49.1912 ± 0.0002	49.305	49.3931 ± 0.0002
Longitude (° E)	48.9698 ± 0.0006	49.07	49.0976 ± 0.0005
Abs. magnitude	− 0.2 ± 0.5	−7.0 ± 0.4	+0.8 ± 0.5
Photomet. mass (kg)	20.05 ± 0.03	0.6	a few grams
Z R (°)	20.05 ± 0.03		20.20 ± 0.03

Fireball type: I; Ablation coefficient: (0.023 ± 0.002) s^2/km^2; PE coefficient: −4.37.

Table 8 – Radiant data (eq. 2000.0).

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	149.41 ± 0.03	149.42 ± 0.04	
δ (°)	+ 31.59 ± 0.03	+ 29.43 ± 0.04	
λ (°)			96.43 ± 0.04
β (°)			+ 05.65 ± 0.02
Initial velocity (km/s)	17.66 ± 0.03	13.62 ± 0.04	38.02 ± 0.03

Table 9 – Orbital data (eq. 2000.0).

Orbit (2000.0)	
a	2.60 ± 0.02 AU
e	0.660 ± 0.002
q	0.8861 ± 0.0003 AU
Q	4.32 ± 0.04 AU
ω	223°21 ± 0°04
Ω	349°3784 ± 0°0001
i	5°90 ± 0°02

4. Austria, March 9, 1997, $21^h36^m35^s \pm 4^s$ UT

A very slow-moving fireball of −9 maximum absolute magnitude was photographed by one Czech and one Slovak station of the European Fireball Network. The three fish-eye records were obtained at our only southern EN stations #4 Churáňov (fixed and guided picture) and #21 Modra, because the fireball flew over southern Austria and was very far from any of our other stations. In spite of the presence of only two very distant records, the resulting data have a good accuracy. The fireball traveled a 48.12-km luminous trajectory in 4.06 seconds and terminated its light at a relatively low altitude of 31 km. The time of the fireball passage was determined from the combination of the records from the Churáňov fixed and guided cameras.

Table 10 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	13.15 ± 0.04	12.8	8 ± 2
Height (km)	67.22 ± 0.06	40.5	31.21 ± 0.07
Latitude (° N)	47.1788 ± 0.0008	47.11	47.0793 ± 0.0009
Longitude (° E)	13.8808 ± 0.0010	14.17	14.2720 ± 0.0011
Abs. magnitude	− 5.5 ± 0.4	−9.5 ± 0.4	−9.0 ± 0.4
Photomet. mass (kg)	29	12	a few grams
Z R (°)	41.4 ± 0.2		41.7 ± 0.2

Fireball type: II or IIIA; Ablation coefficient: (0.10 ± 0.03) s^2/km^2; PE coefficient: −4.87.

Table 11 – Radiant data (eq. 2000.0).

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	84.5 ± 0.2	69.3 ± 0.3	
δ (°)	+ 44.9 ± 0.2	+ 37.4 ± 0.2	
λ (°)			77.49 ± 0.04
β (°)			+ 03.01 ± 0.05
Initial velocity (km/s)	13.21 ± 0.03	7.46 ± 0.05	37.23 ± 0.05

Table 12 – Orbital data (eq. 2000.0).

Orbit (2000.0)	
a	2.22 ± 0.02 AU
e	0.552 ± 0.004
q	0.9916 ± 0.0001 AU
Q	3.44 ± 0.04 AU
ω	174°61 ± 0°13
Ω	349°4046 ± 0°0001
i	3°01 ± 0°05

5. Czech Republic, March 12, 1997, $19^h30^m11^s \pm 4^s$ UT

A very slow-moving fireball of −5 maximum absolute magnitude was photographed by three Czech stations of the European Fireball Network. The four fish-eye records were obtained at the EN stations #20 Ondřejov (fixed and guided picture), #9 Svratouch, and #15 Telč. The fireball traveled a 23.42-km luminous trajectory in 1.89 seconds and terminated its light at an altitude of 47 km. The slope of the trajectory was quite steep—the zenith distance of the radiant was only 21°. According to the dynamic fragmentation model it is a no-fragmentation case. The time of the fireball passage was determined from the combination of the records from the Ondřejov fixed and guided cameras. The heliocentric orbit of this fireball is quite similar to the orbit of the previous fireball. The following results based on all available records have a very good precision.

Table 13 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	13.308 ± 0.013	12.4	8.5 ± 0.5
Height (km)	68.459 ± 0.013	52.8	46.582 ± 0.004
Latitude (° N)	49.8201 ± 0.0003	49.87	49.8888 ± 0.0001
Longitude (° E)	15.3717 ± 0.0005	15.40	15.4161 ± 0.0002
Abs. magnitude	+ 0.3 ± 0.5	−4.8 ± 0.2	+0.5 ± 0.5
Photomet. mass (kg)	0.17	0.09	none
Z R (°)	20.87 ± 0.04		20.95 ± 0.04

Fireball type: IIIA; Ablation coefficient: (0.158 ± 0.005) s^2/km^2; PE coefficient: -5.00.

Table 14 – Radiant data (eq. 2000.0).

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	109.31 $\pm$ 0.05	105.61 $\pm$ 0.07	
δ (°)	+ 30.11 $\pm$ 0.04	+ 24.28 $\pm$ 0.06	
λ (°)			85.95 $\pm$ 0.02
β (°)			+ 00.326 $\pm$ 0.012
Initial velocity (km/s)	13.402 $\pm$ 0.014	7.53 $\pm$ 0.03	37.04 $\pm$ 0.02

Table 15 – Orbital data (eq. 2000.0).

Orbit (2000.0)	
a	2.154 $\pm$ 0.009 AU
e	0.539 $\pm$ 0.002
q	0.9882 $\pm$ 0.0001 AU
Q	3.30 $\pm$ 0.02 AU
ω	190°39 $\pm$ 0°04
Ω	352°3153 $\pm$ 0°0001
i	0°327 $\pm$ 0°012

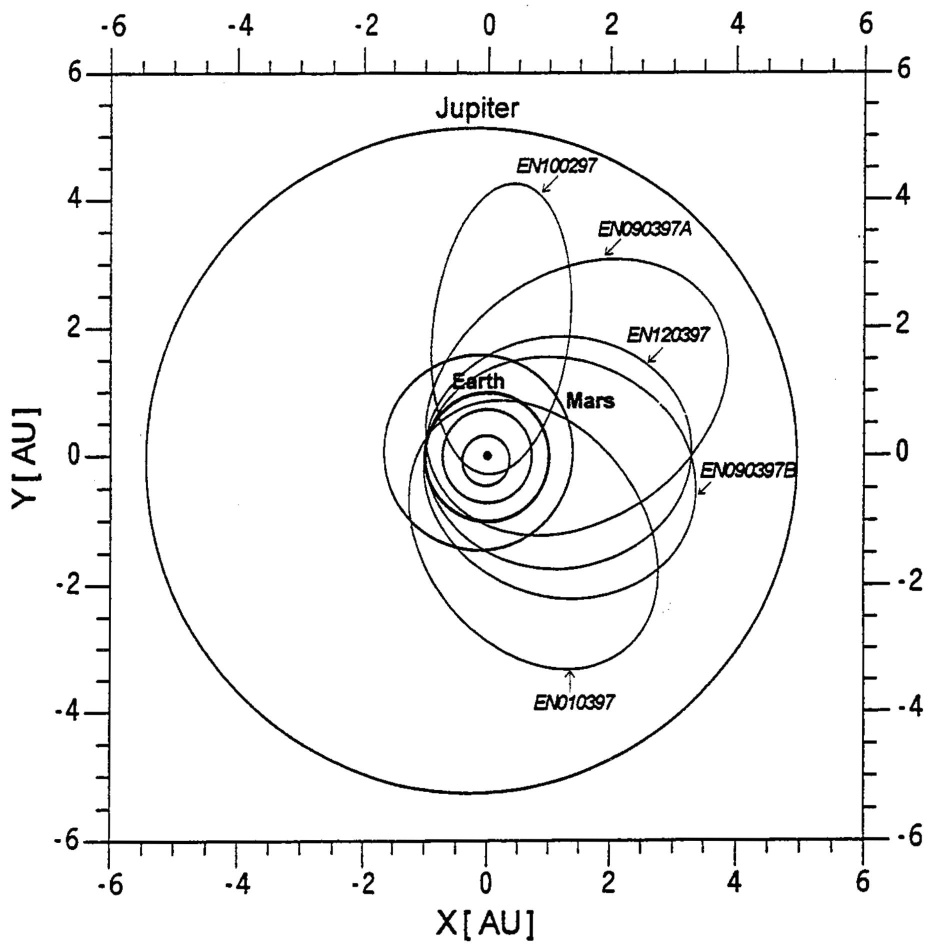

Figure 1 – Heliocentric orbits of the 5 EN fireballs discussed in this article projected onto the ecliptic plane. The axes show X and Y coordinates in AU.

Impressive Perseid Fireball over Spain

Josep M. Trigo, València University

This paper shows the analysis of the most spectacular fireball that appeared over the east of Spain during the new Perseid maximum in 1993, on August 11 at $23^h51^m40^s$ UT and was observed by two stations in the Teruel and Castelló provinces during the *SOMYCE* program of meteor research. The results obtained are: the trajectory in the atmosphere of the meteor and its mass obtained from the apparent magnitude. Assuming an atmospheric entry velocity of 59 km/s, we find an orbit which is close to that of 109P/Swift-Tuttle.

1. The 1993 Perseid Meteor Campaign in Spain

An intensive meteor campaign was made by members of the *IMO* and *SOMYCE* during the 1992 and 1993 Perseid returns. A short activity maximum where the ZHR was more than three times the normal maximum activity was detected. This strong activity preceded the normal maximum and corresponded well to the approximate position of the comet's descending node. The meteor research groups of *SOMYCE* (*Spanish Meteor and Cometary Society*) prepared an intensive watch during the 1993 maximum to capture photographic Perseids from Castelló, València, Teruel, and other Spanish provinces.

During the night of August 11-12, about ten bright fireballs appeared and more than thousand other Perseid meteors were registered visually, many of them showing persistent trains and explosions, indicative of their recent cometary origin.

The photographed fireball is an example of a "new" meteoroid ejected from the comet nucleus during one of the previous returns of comet 109P/Swift-Tuttle which still has an orbit very similar to that of the comet.

2. Data obtained

On August 11-12, 1993, the new maximum was observed from Spain between solar longitudes $\lambda_\odot = 139\overset{\circ}{.}2$ (eq. 2000.0) and $\lambda_\odot = 139\overset{\circ}{.}6$. Three stations in the east of Spain were established to capture photographic Perseids.

The participants at the 3 sites were as follows:

> Timoteu Briet, Francesc Campos, Oscar Cervera, Raúl Fernández, Antonio Francisco Violeta Gracia, Manel Marin, Germán Peris, Sebastià Torrell, and Josep Trigo.

A bright -9 fireball has been identified from two stations, in spite of several hundreds of meteors having been captured. It was photographed from stations near Peñarroya Peak (Teruel, $\lambda = 0°38'02''$ W, $\varphi = 40°23'37''$, $h = 1940$ m) and Penyagolosa Peak (Castelló, $\lambda = 0°20'31''$ W, $\varphi = 0°15'05''$ N, $h = 1270$ m).

During 1994 and 1995, the author and Sebastià Torrell inspected the negatives of the Barcelona and València groups to distinguish meteor trails. With posteriority, several collaborators of Castelló (some of them members of the *Societat Astronòmica de Castelló*) indicated to the author that the brightest Perseid that appeared that night was also captured by the Castelló site.

3. Astrometric reduction

The procedure to obtain the astrometric measurements is based on the use of a microscope and a Vernier scale. Measuring the Cartesian coordinates of the beginning and ending points of the stars and meteors and conversion to equatorial coordinates was done using the astrometric method of the `ASTFMX` software. This program developed by Christian Steyaert is based on the dependences method [1] to determine the exact meteor position. It also uses an iterative method to estimate the center of the plate.

Figure 1 – Photograph of the −9 Perseid fireball made by Josep M. Trigo from Teruel (Spain). Limiting Magnitude was +6.40. This great fireball showed a persisting train that lasted for 1.5 minutes visually and for 4 minutes with 7 × 50 binoculars. The upper-atmospheric winds caused distortion of the train. The fireball was photographed from several stations by members and collaborators of SOMYCE.

In general, the trajectory model of the meteor is very accurate, and cannot deviate more than one hundred meters from the real trajectory. However, errors in the determination of the longitude and latitude of beginning and terminal points have to be considered. In spite of this problem, the determination of the radiant position and the orbital elements is not greatly affected. In conclusion, the determination of the direction of the the meteor is very accurate.

4. Results obtained

The fireball was named `SOMYCE93-01`. The exact duration of the meteor was unknown, but no rotating shutter was used. In spite of this problem, the orbital elements of a parabolic orbit were calculated using our software and a positive association with comet 109P/Swift-Tuttle was obtained. Also the radiant position is very similar to that of the Perseids. After this confirmation was obtained, a geocentric velocity characteristic of Perseid fireballs of 59.0 km/s, was assumed to determine an approximate elliptic orbit.

Our software [2] calculates the following data of the photographic meteor: apparent and corrected radiant position, beginning and ending points, path length, geocentric velocity, and all the orbital elements. In the future, the deduction of the atmospheric wind velocity from the photographed train distortion of the fireball will be studied.

In addition, I obtained the mass of the meteoroid using the formulae of Hughes [3]. From the photometric analysis of the negative, a magnitude of −9 was obtained. With this data and the assumed geocentric velocity of 59 km/s, a meteoroid mass of approximately 275 grams was calculated.

Concerning the trajectory data, the beginning point was determined at $\lambda = 0\overset{\circ}{.}024 \pm 0\overset{\circ}{.}001$ W, $\varphi = 40\overset{\circ}{.}220 \pm 0\overset{\circ}{.}001$ N, and $h = (112.7 \pm 0.1)$ km, and the terminal point was determined at $\lambda = 0\overset{\circ}{.}445 \pm 0\overset{\circ}{.}001$ W, $\varphi = 40\overset{\circ}{.}831 \pm 0\overset{\circ}{.}001$ N, and $h = (69.9 \pm 0.1)$ km. The absolute magnitude was −2 at the beginning point and about −9 at the terminal point. The observed radiant position (eq. 2000.0) was determined at $\alpha = 44\overset{\circ}{.}2 \pm 0\overset{\circ}{.}5$ and $\delta = +55\overset{\circ}{.}2 \pm 0\overset{\circ}{.}5$; the corrected radiant position was determined at $\alpha = 45\overset{\circ}{.}1 \pm 0\overset{\circ}{.}5$ and $\delta = +60\overset{\circ}{.}8 \pm 0\overset{\circ}{.}5$. The approximate orbital elements are shown in Table 1.

Table 1 – Orbital data (eq. 2000.0).

Orbit (2000.0)	
a	53.55 AU
e	0.982
q	0.959 AU
ω	153°0
Ω	139°44
i	108°4

When the D-criterion of Soutworth and Hawkins is applied to the obtained orbit, the probability that the meteor was associated to comet 109P/Swift-Tuttle is 1, to no great surprise. Also when considering the range of probable Perseid geocentric velocities (between 58.5 km/s and 60.0 km/s), the orbit is related to comet 109P/Swift-Tuttle with great probability, however.

References

[1] C. Steyaert, "Photographic Astrometry", book and software, IMO, 1990.

[2] J.M. Trigo R. et al., "Orbital Elements of Three Photographic 1991 Perseids", in *Proceedings of the Third International Workshop on Positional Astronomy and Celestial Mechanics*, October 17–21, 1993, Cuenca, Spain, pp. 595–599.

[3] D. Hughes, "Meteoroids—An overview", in *Meteoroids and Their Parent Bodies*, Smolenice, Slovakia, July 6–12, 1992, Astronomical Institute of the Slovak Academy of Sciences, pp. 15–28.

SPA Meteor Section Results: November-December 1996

Alastair McBeath

Details extracted from observations submitted to the *SPA Meteor Section* from November and December 1996 are presented. November saw visual observers active for the Taurid maxima early in the month, and some useful results were derived by including Taurid observations from October as well, but an especial concentration of effort was reserved for the Leonids, whose mean peak ZHR on November 16–17 was about 45 in these data. Several spectacularly long-lasting Leonid trains were reported, along with some impressive Leonid fireballs. Significant radio results were also obtained throughout November and December, with all the main shower maxima well-detected during this time. The Geminid maximum was heavily covered by visual workers on December 13-14, when mean peak ZHRs were around 100. The highest reliable ZHR was 120–130 around 21^h UT then ($\lambda_\odot = 262°2$, eq. 2000.0), with a possible minor secondary peak to ZHRs of 110–120 around 1^h–2^h UT ($\lambda_\odot \approx 262°4$, eq. 2000.0), but activity was at a high level all night. The first suggested maximum time was also found in radio data, and the overall activity profile was well shown by this method. Numerous bright Geminid fireballs were seen on December 13-14 especially, but the brightest meteor of the month was seen from Northern England on December 6.

1. Introduction

When the Moon is not a problem, the year always ends on a high note for meteor observers particularly in the northern hemisphere, with the prospect of the Geminids, perhaps the single best, reliable meteor shower currently visible from Earth, but with recent years having brought increasing Leonid activity as well as the α-Monocerotid outburst of November 1995, observers have begun to consider November as a good month, too. Unfortunately, both months often coincide with some poor early winter weather north of the equator, and conditions were not perfect in either month in 1996. Even so, some healthy observing totals were achieved, as given in Table 1.

Table 1 – Visual, photographic, and radio hours' totals, and visual meteor numbers recorded in each month, including a partial breakdown of meteor types, and the number of photographed trails reported so far.

Month	Visual	STA	NTA	LEO	GEM	Meteors	Photo	Trails	Radio
November	$86^{\mathrm{h}}.6$	101	62	696		1546	$165^{\mathrm{h}}.93$	0	3558^{h}
December	$155^{\mathrm{h}}.0$				5517	7405	$213^{\mathrm{h}}.44$	15	3423^{h}

The bulk of November's and December's photographic results were provided by members of the *Arbeitskreis Meteore* (*AKM*) team all in Germany, contributing to the *European Fireball Patrol Network*, from summary reports provided by Jürgen Rendtel. The full list of contributing photographers is as follows:

> Neil Bone (England; data from *The Astronomer* (*TA*), kindly provided by Meteor Editor Tony Markham), Steve Foggo (England), Valentin Grigore (Romania), A. Haubeib (*AKM*), André Knöfel (*AKM*), Peter McBeath (England), Jürgen Rendtel (*AKM*), H. Ringk (*AKM*), and N. Wünsch (*AKM*).

Most of the recorded trails were Geminids from December 13-14.

Radio observations came from

> Peter Bus (Spain, *RMOB*), Maurice de Meyere (Belgium, *RMOB*), Ghent University (Belgium, *RMOB*), Werfried Küneth (Austria, *RMOB*), Kimio Maegawa (Japan, *RMOB*), Ingo Reimann (Germany, *RMOB*), Ton Schoenmaker (the Netherlands, *RMOB*), Chikara Shimoda (Japan, *RMOB*), Kazuhiro Suzuki (Japan, *RMOB*), Robert S. White (England), Ilkka Yrjölä (Finland, *RMOB* and via *RSGB*), and Wim Zanstra (the Netherlands, *RMOB*).

Christian Steyaert kindly provided copies of the *Radio Meteor Observation Bulletin* data (*RMOB*: [1–4]), while Norman Fitch of the *Radio Society of Great Britain* (*RSGB*) sent in some results and notes from other radio amateurs' experiences in November and December.

The analysis procedures given in [5] for dealing with unprocessed radio data have been followed, with the graphs presented here generally representative of the radio results as a whole during this period.

Next we come to the list of visual contributors:

> *AKM* members (Detlef Koschny, Ralf Koschack, Sirko Molau, Andreas Rendtel (Tenerife), Ina Rendtel, Hendrik Sielaff, Ulrich Sperberg, Björn Voss, Florian Zschage, in Germany except where noted; data via observer Jürgen Rendtel), Rainer Arlt (Germany; contributor to *AKM* summaries too), *Astroclub Canopus* members (notably Plamen Stoychev and Valentin Velkov, Bulgaria; data summary from Eva Bojurova), Neil Bone (England; data via *TA*), Jay Brausch (North Dakota, USA), John Burns (Scotland), Tim Cooper (South Africa), Steve Foggo (England), Pierre Girard (location unstated; data via *TA*), Shelagh Godwin (England), Valentin Grigore (Romania), Ron Johnson (England; data via *TA*), Geoffrey Johnstone (England; data via *TA*), Tony Markham (England), Nick Martin (Scotland), Alastair McBeath (England), Tom McEwan (Scotland), Vasile Micu (Romania), Jürgen Rendtel (Tenerife), Ian Rigney (England), *Solaris Group* members (Galin Borisov, Ivaylo Ivanov, Petar Petrov, Vladislav Shiderov, Bulgaria; report from Eva Bojurova), George Spalding (England), James Stewart (Scotland), Melvyn Taylor (England; data via *TA*), and Graham Winstanley (England).

In addition, further visual observing comments were received from John Bortle (via *TA*) and Sirko Molau (also on his video work), with many thanks due to every one of the contributors listed above. My thanks also go to John Lambert and Dave Newton for providing meteor information from the WWW during this period, particularly just after the Leonids, and also to David Weldrake for collecting and submitting reports on the December 6 fireball, detailed below.

2. November

Visual observations were quite well-spread across the opening three weeks of November, with many nights prior to November 20-21 covered by one or more watchers. Low Taurid rates were readily detected, particularly from November 5–10, and with 259 meteor plots submitted to the Section's special Aurigid and Taurid plotting project during October and November, it was possible to more easily define meteors as belonging to one or other branch of the stream in 1996 than previously. Although only a preliminary analysis has been carried out on the plots, the double nature of the Taurid radiant is generally quite obvious overall, so far with little evidence for other substantial sructures beyond the established parameters in, for instance, [6].

Mean Taurid ZHRs for the better-covered, clearer nights (limiting magnitude at least +5.5, cloud cover less than 20%) are given in Table 2, while Table 3 gives magnitude distributions for the Northern and Southern shower branches. In terms of persistent trains, 3 from 31 Southern (9.7%) and 1 in 48 Northern Taurids (2.1%) displayed them, too few to derive any meaningful further results. The Taurid rates overall gave a combined total mean ZHR of about 10 around their expected maximum, much as found in other analyses. Very few shower fireballs were seen, but if the main Taurid fireball "phase" occurs around late October to early November as earlier results indicate, bright moonlight undoubtedly deterred prospective observers then in 1996.

Table 2 – Mean Taurid ZHRs on the indicated dates.

Date	STA	NTA
November 08-09, 1996	4.0 ± 0.5	5.0 ± 1.0
November 09-10, 1996	3.0 ± 0.5	6.0 ± 1.0
November 12-13, 1996	7.0 ± 2.0	2.0 ± 0.5
November 15-16, 1996	–	3.0 ± 2.0

Table 3 – Global magnitude distributions, including mean limiting magnitudes and corrected mean magnitudes for the Taurids (combined totals from October and November), Leonids, Geminids, and November and December sporadics seen in good sky conditions (limiting magnitude of +5.5 or better; cloud cover less than 20%).

Shower	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5^+$	Tot	Lm	$\overline{m}_{6.5}$
STA				2	7	4	11	4	3	31	5.82	3.23
NTA	1	1	1	5	6	8	15	10	3	50	5.78	3.02
LEO	8	7	10.5	18.5	22.5	29.5	19.5	13	2.5	131	6.06	1.55
GEM	24	28	49.5	121	253.5	350	413	236	73	1548	6.08	2.56
SPN		0.5	8.5	16.5	29	66.5	69	55.5	128.5	374	6	4
SPD		1	4	18.5	36.5	64	90.5	105.5	110	430	6.08	3.82

Radio results from early November suggested a continuation of the marginally enhanced activity commented upon earlier in late October [7] (see Figures 1 and 2), perhaps indicative of this Taurid fireball "phase." Most observers detected another enhancement from around November 4-5 to 10-11, coincident with the expected peak Taurid activity. For some reason, this showed up especially in the raw daily counts of Kazuhiro Suzuki (not shown here), which may suggest his data sampling technique is better at picking up short-duration echo count numbers (his results indicated a drop in count numbers below the normal level during the Leonid peak [5], for example), which perhaps the almost trainless Taurids are more liable to produce. He was also very successful in recording the Geminids, as detailed below, another shower with a poor train record.

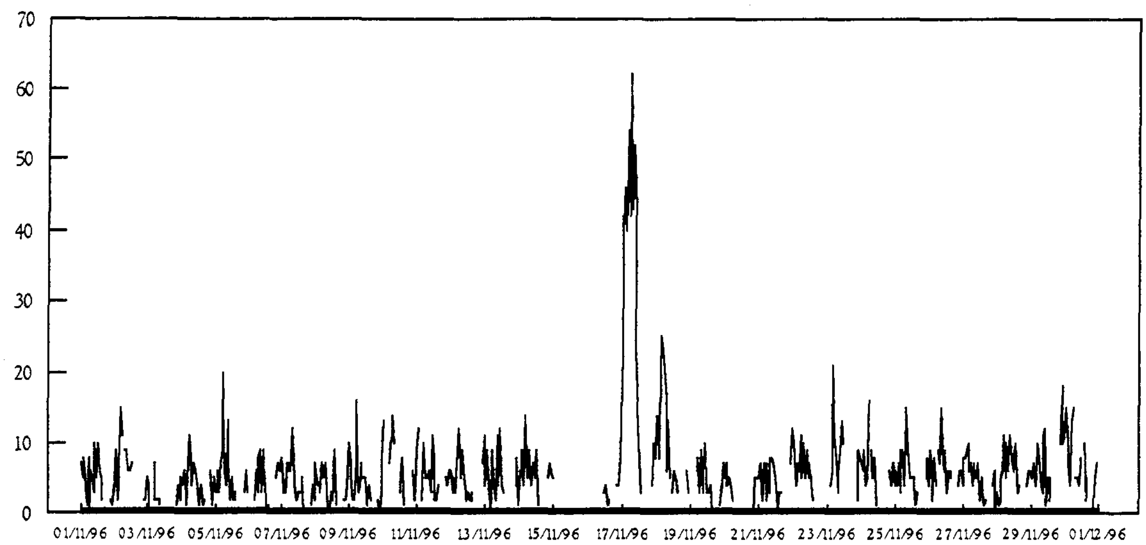

Figure 1 – Raw hourly radio meteor echo counts between November 1 and 30, 1996, from data collected by Werfried Küneth, given in [1]. In general, coverage was about 13–20 hours a day, with gaps indicating when the system was non-operational. Note that in all the radio count graphs here, the vertical and horizontal scales vary from graph to graph.

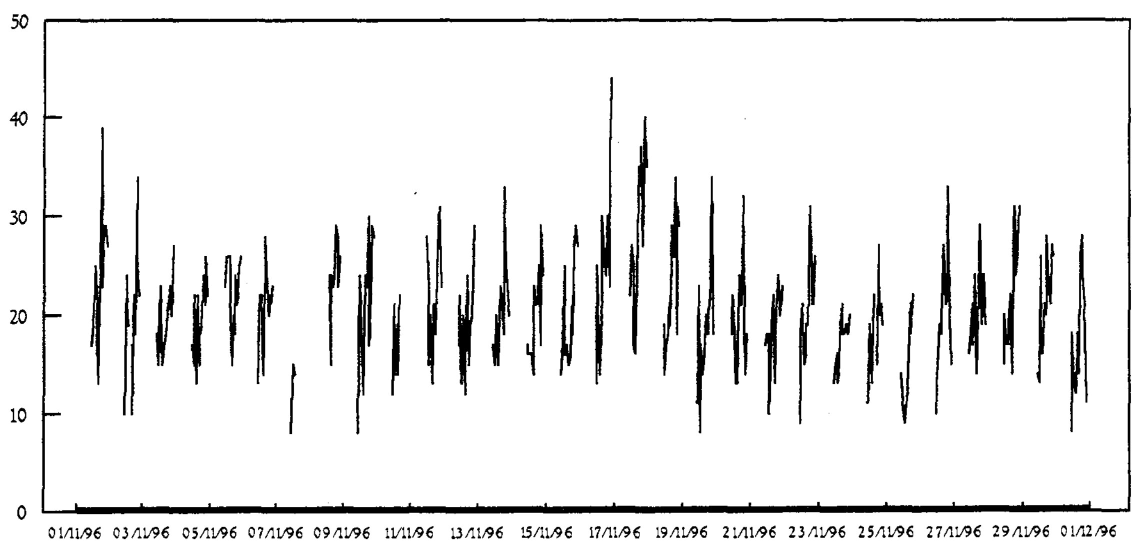

Figure 2 – Raw hourly radio meteor echo counts between November 1 and 30, 1996, from data collected by Chikara Shimoda, given in [1]. His set-up provided around 12 hours coverage each day, except on November 7. Note the very slight enhancement in rates around the Leonid peak. This was very typical of the low echo counts detected from the shower over Japan in 1996 [5].

The bulk of the radio Leonid details reported have already been discussed in [5]. One completely new set of data to arrive since that report was prepared has come from Ghent University, which in general supports the conclusions reached in that earlier paper. The Ghent data favor two particular Leonid peaks, around $3^{\rm h}$ UT and $7^{\rm h}$ UT on November 17, with the $3^{\rm h}$ UT event being somewhat stronger. Activity from these results was at a greatly increased level from $0^{\rm h}$ to $11^{\rm h}$ UT on November 17, however, and enhanced reflection times were registered between November 15 and 18. Kimio Maegawa has also provided additional details of his long-duration echo counts, from $21^{\rm h}$ UT on November 17 to $20^{\rm h}$ UT on November 18. These give strong support for Suzuki's observations (shown in [5], Table 1), essentially confirming that long-duration echoes were particularly in evidence on November 17-18 around $21^{\rm h}$ and $0^{\rm h}$ UT over Japan, albeit at a reduced level compared to the previous day.

Mean visual Leonid ZHRs are given for several nights including their peak in Table 4, with magnitude details given in Table 3. The mean peak ZHR on November 16-17 is well in-line with the most complete 1996 visual Leonid analysis [8], but there is the suggestion here that activity was still quite reasonable the following night, as also indicated in the radio analysis [5]. This too is a feature of the Ghent radio observations.

Table 4 – Mean Leonid ZHRs for the stated dates.

Date	ZHR	Date	ZHR
November 13-14, 1996	3 ± 2	November 17-18, 1996	21 ± 5
November 15-16, 1996	7 ± 2	November 20-21, 1996	5 ± 2
November 16-17, 1996	45 ± 3		

Comments from the visual watchers on the shower's performance were generally favorable, although activity was not as high as some had hoped. Several casual reports mentioned the large numbers of bright Leonids seen, even when skies were not especially clear, which is borne out in the r-values of [8] and in the shower's magnitude distribution here, where 70% of Leonids were of magnitude +2 or brighter. There were also letters from three continents (Europe, South Africa, and North America) complaining about how poor the weather had often been for the critical night of November 16-17!

Most Leonid fireballs were indeed seen on November 16-17. The brightest was of magnitude −14 (?), which left a train visible for around 30 minutes! The meteor appeared at $1^{h}45^{m}$ UT, and produced two flares. The train was photographed by AKM member Volker Gerhardt on Tenerife three times before it faded out, and two superb photos, one an enlargement of the other, are presented in [9], showing the heavily-kinked train against the stars of Hydra. This train was also shown and briefly discussed in [10]. Several other brilliant Leonids left long-lasting trains on this night, including a magnitude −7 event with an 8 minute train seen by members of the *Solaris Group* in Bulgaria, and a magnitude −5 Leonid at $5^{h}37^{m}$ UT, which left a 12 minute train as observed by Nick Martin in Scotland. Nick managed to sketch the train and make detailed notes on its appearance as time passed, and a retracing of his sketches by the author is given here as Figure 3, while his verbatim report on the train's appearance is given below:

> *"13 seconds: kink appeared. 35 seconds: distinct bend; 5° long. $1^{m}30^{s}$: upper end of train expanding giving a comet like appearance. 2^{m}: train broadening and becoming fuzzy; head broadening. $2^{m}30^{s}$: bend more conspicuous. 3^{m}: 'Head' more diffuse; tail extending further south. 7^{m}: tail most obvious part but head still distinct. 10^{m}: a faint cloud between ζ-δ-σ-η stars of Hydra. 12^{m}: a faint luminous haze probably persisted up to 12 minutes."*

This description, including the round "head" of the train is remarkably similar to one made by Lewis Swift (co-discoverer of the Perseids' parent comet, 109P/Swift-Tuttle), on November 14, 1876 [11], when a brilliant Leonid left a 20-minute train across the constellation of Cancer. Swift made the interesting comment that as the train transited Praesepe (the star cluster also known as "The Beehive" or Messier 44), no trace of the train could be seen, and the train was finally observed "gathering itself into a globular mass" before fading completely.

Nick Martin noted another long Leonid train, of five minutes duration, belonging to a magnitude −3 Leonid at $3^{h}55^{m}$ UT on November 18, and which again behaved in a comparable manner, first forming an "S"-shape and then condensing into a round mass near κ and λ Leonis before disappearing. More Leonid train details are given in Table 5, where it will be noted that most bright Leonids left a train, which persisted longer than those of other showers presented in SPA Meteor Section analyses in recent times.

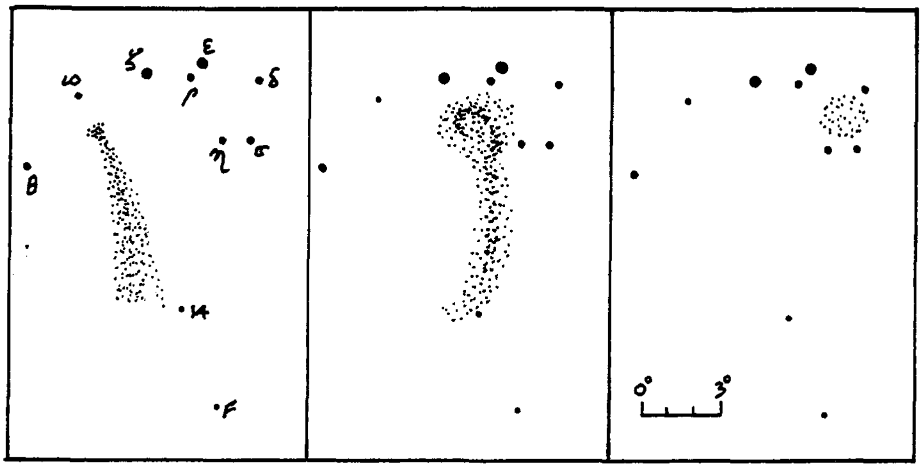

Figure 3 – A series of three train sketches retraced by the author for clearer duplication here, made by Nick Martin after a magnitude −5 Leonid fireball occurred at 5^h37^m UT on November 17, 1996. The train appeared against the stars of Hydra's "head" asterism. The sketches from left to right show the train after approximately one minute, seven minutes and ten minutes had elapsed from the meteor's flight.

Table 5 – Global train percentages and mean duration in seconds per magnitude class for the Leonids, Geminids, and November and December sporadics. Totals and overall percentages for train data are also given. Train details were only available for 70 Leonids, 828 Geminids, 187 November, and 179 December sporadics from the reported totals. Note too that Leonid trains in excess of 1 minute have been excluded from these statistics.

Magnitude	-3^-	-2	-1	0	+1	+2	+3	$+4^+$	Tot	%
Train % LEO	100	100	100	100	66.7	37.5	0	0	40	57
Duration LEO	11	5.3	3.7	2.6	2.4	1.3				
Train % GEM	17.7	33.3	29.6	4.3	0.7	1.5	0.4	0	34	4
Duration GEM	3	1.2	0.6	0.8	< 0.25	0.8	0.5			
Train % SPN	0	0	33.3	33.3	35	3.6	4.1	0	15	8
Duration SPN			0.5	1.2	0.7	1.3	0.5			
Train % SPD		0	50	16.7	5.9	5.9	0	0	9	5
Duration SPD			1	1.5	0.5	0.5				

Radio echo numbers were a little higher again in the final week of November, after the Leonids had died away, but no obvious spike due to potential α-Monocerotid rates was detected around 7^h–8^h UT on November 21, based on the 1995 outburst time at $\lambda_\odot = 239.^\circ321$.

Ghent radio counts suggested enhanced activity around 3^h–5^h UT on November 21, but no other radio results confirm this. The Ghent "peak" on this date may not be significant, since a similarly-timed "peak" occurs in their results frequently, even when no shower activity is expected.

Whether the activity around November 23 and after November 25 or 26 was from some unknown source, or simply representative of gradually rising minor shower rates, expected towards the November-December border, and found to continue after it, is not known. There are inconsistencies between the different datasets as to exactly when the slight enhancement commenced, particularly after November 25, which add further uncertainties. A handful of visual reports contained occasional α-Monocerotid sightings in late month, but nothing comparable to those in 1995.

3. December

Mildly enhanced radio echo counts were reported from early December, before the Geminids, as shown in Figures 4 and 5, with small activity spikes especially in evidence around December 2-3, 5–7 and 9-10 (although not all datasets confirm the December 5–7 period). These times roughly coincide with the expected maxima of the χ-Orionids (December 2), the December Phoenicids, and Puppid-Velids (December 5 and 6 respectively), and the December Monocerotids and σ-Hydrids (December 10 and 11 respectively, confirmed by visual results).

The December 6-7 period was a little more obvious in the Japanese data, sites where the two high southerly declination shower radiants do just rise from at least, but Maurice de Meyere's data from Belgium (not illustrated here) actually suggest a peak fractionally higher than he detected for the Geminids around $7^{\rm h}$ UT on December 7. His results also suggest several other apparently strong maxima in early December which are not confirmed by observations from elsewhere, at least not in their relative strengths, however.

Visual observers were active on only a few nights prior to the Geminid peak, and low activity was seen from the expected minor showers when such monitoring was practical, along with some early Geminids, first detected on December 5-6.

December 6-7 brought a triple-flaring magnitude -12 (?) blue fireball at $22^{\rm h}43^{\rm m}$ UT, which was seen by three observers, David Blenkinsop, Darren Bushnall, and David Weldrake, near Castle Eden in Northern England ($\lambda \approx 1°22'$ W, $\varphi \approx 54°54'$ N).

David Weldrake had also seen the great Sunderland fireball of 1995 July 28 [12] and so knew what might occur with a weaker event, and who provided a particularly detailed report, complete with a color drawing of his impressions of the meteor. Orange fragments were thrown off at each flare, as well as at the meteor's end, and its estimated angular speed was about 2°/s.

The fireball began about 30° above the SSW horizon, and ended about 8° from the SW horizon, passing through Cetus. No sounds were detected during or after the object's flight. It seems likely the meteor was a sporadic, or possibly a χ-Orionid, although the speed was probably too low for this latter source.

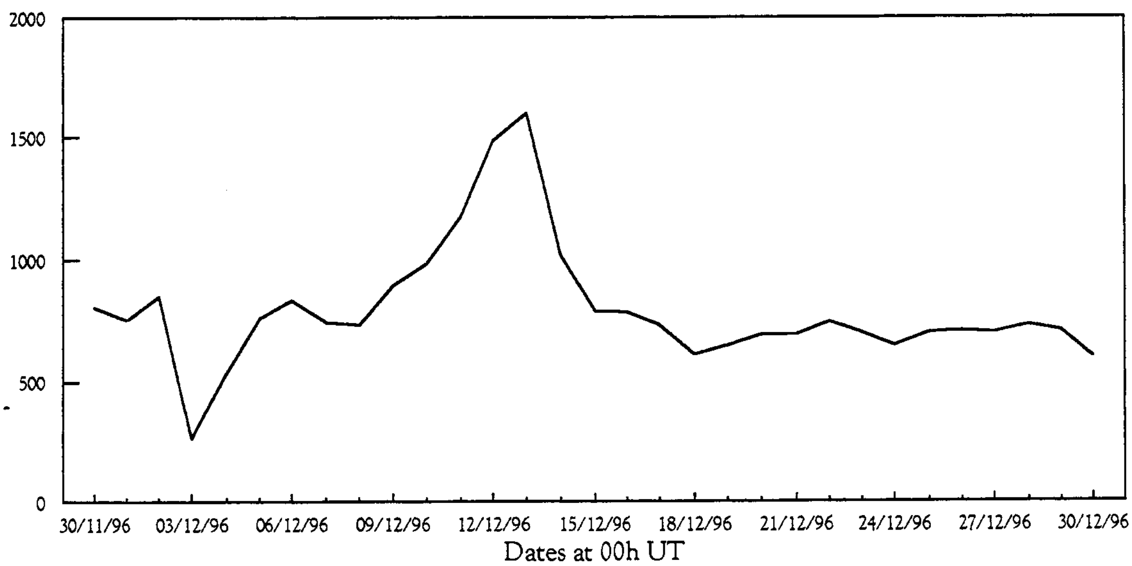

Figure 4 – Raw daily radio meteor echo counts between November 30 and December 30, 1996, from data collected by Kazuhiro Suzuki, given in [2]. His system was operational for only 11 hours on December 3, and 18 hours on December 4, which accounts for the dip in rates then. The Geminids are very obvious around December 12, and the Ursids just detectable on December 22.

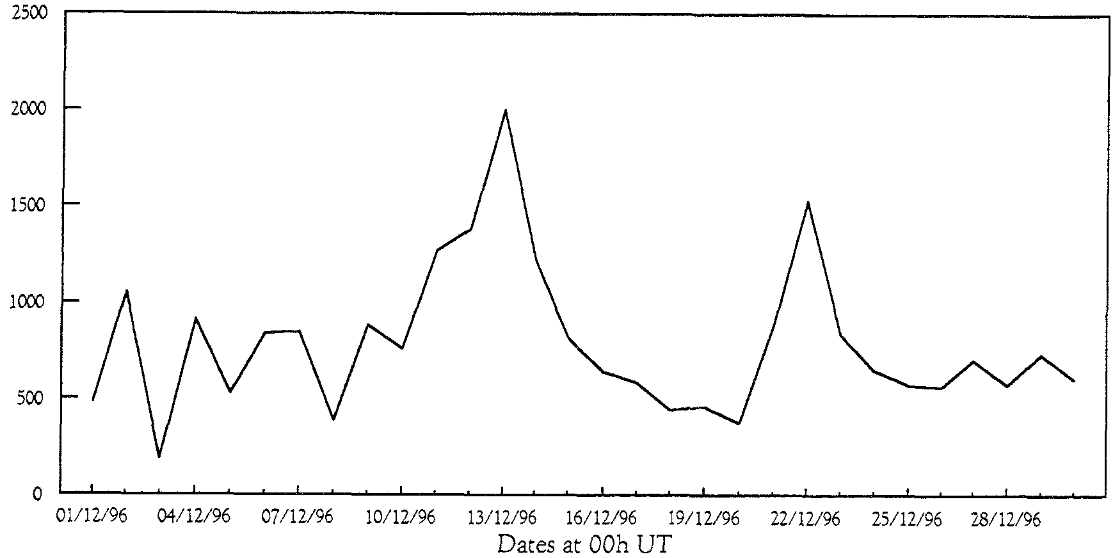

Figure 5 – Raw daily radio meteor echo counts from December 1 to 30, 1996, from data collected by Robert S. White. A program crash resulted in the loss of all but 9^h10^m of data on December 3 (an unfortunate coincidence with Figure 4!). The Geminid and Ursid maxima are clearly shown.

The majority of visual and radio observers were active on December 12-13 and 13-14. Unlike the Leonids, the Geminid epoch was clearly visible in radio results from both Europe and Japan, indicating the shower's longevity at relatively high rates—about 48^h+ from the data available—and the slow rise towards the maximum and rapid decline in activity immediately afterwards are also well-shown in Figures 4 and 5. Only Kazuhiro Suzuki provided details on long-duration echoes throughout December, and his observations show no enhancement in such echo rates at any stage during the month, again by contrast with the Leonids.

Comparing the radiant elevations with local-time radio observations suggests Geminid activity first became significantly obvious, albeit briefly, around 7^h–10^h UT on December 10 over Europe, and was last noticed around 7^h–10^h UT from similar locations on December 14. Raw radio activity was at its highest sustained levels from around radiant-rise to radiant-set on December 13-14, no matter where the observer was located. European radio results suggest the main maximum time was around 21^h UT on December 13, since the data sets from Ghent University, Robert White and Ilkka Yrjölä then indicated a clear peak which had not occurred on the previous day at that time. This peak timing is also suggested by the visual data from December 13-14 (Figure 6), although the radio data give conflicting opinions about the possibility of a secondary enhancement in the visual rates seen around 1^h–2^h UT on December 14. Mean visual ZHRs were 60 ± 7 on December 12-13 and 100 ± 8 on December 13-14, but had fallen away sharply to just 7 ± 2 by December 14-15. The highest reliable ZHR was 120–130 around 21^h UT on December 13, equivalent to $\lambda_\odot = 262.^\circ2$ (eq. 2000.0). The potential lesser peak produced ZHRs of 110–120 around 1^h–2^h UT on December 14, $\lambda_\odot \approx 262.^\circ4$ (eq. 2000.0).

Tables 3 and 5 give details on the better-sky Geminid magnitudes and trains. There were 28 fireball reports from December 13-14 alone, for instance, three of which may have been seen from two or three UK sites each, but with insufficient details given to enable other facts to be established for these events. Visual rates were just too high to allow reliable meteor plotting, with observers frequently recording 400+ meteors for the night on December 13-14, especially in the darker, clearer skies of sites in Eastern Europe, where 600+ meteors overnight, with observed rates over 100 per hour, were common.

Sirko Molau estimated his two video cameras recorded over 1000 meteors that night! Rainer Arlt, who had accompanied Sirko in his search for good skies in a 200 km drive to Northern Germany, could not wait until Sirko had his video cameras set-up, as he realized every casual glance at the sky was bringing more Geminid meteors raining down.

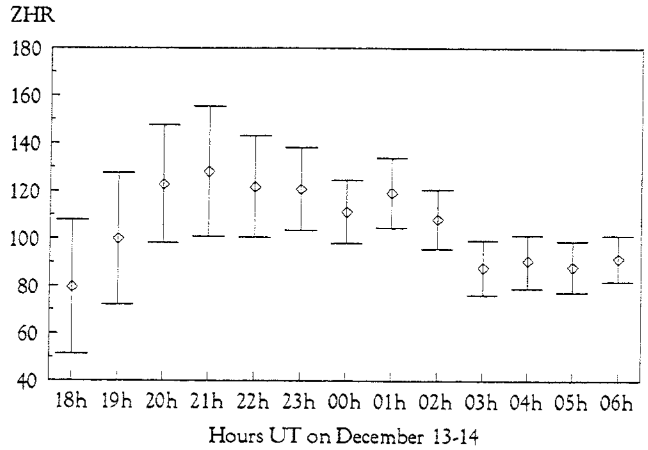

Figure 6 – Mean visual Geminid hourly ZHRs on December 13-14. All data from a given hour have been combined into a single data point. Standard error-bars are also shown.

Rates these two observers saw were up to nine meteors a minute at times! Jürgen Rendtel had decided not to risk the chance of poor conditions at home either, so "fled" to the better skies of Tenerife, where he enjoyed an excellent Geminid campaign, with limiting magnitudes around +6.2 or better all night on December 13-14 in cloudless skies.

Not everyone was so fortunate. Many UK observers found themselves clouded-out before midnight with an approaching frontal system, and only a few lucky and hardy observers in South-East England could keep watching until dawn. At Avren Village in Bulgaria, the *Astroclub Canopus* observing expedition also had cloud problems, which forced a halt at $22^{\rm h}$ UT (local midnight). The observers took a late supper, which was perhaps a little too good, as one of the most experienced observers, Plamen Stoychev, fell asleep afterwards, and missed the clearer skies after $00^{\rm h}$ UT, in which his luckier colleagues witnessed rates of 3–4 Geminids a minute at times!

In South Africa, Tim Cooper felt he had been fortunate to see anything at all on December 13-14, as the clouds parted for just $2\overset{\rm h}{.}7$ to let him spot a few Geminids, while by contrast, Jay Brausch in North Dakota, USA, enjoyed his best-ever skies for the Geminids on December 12-13 (limiting magnitude of +6.9, but with distractions including an auroral glow low to the north and a distinct zodiacal light cone to the SE in the last hour), but was clouded-out on December 13-14. He was still pleased with the Geminid rates he saw.

So too were two British observers, who, through illness, were unable to observe the Geminids outdoors, Shelagh Godwin at Godalming in Surrey, England on December 13-14, and James Stewart at Kilbirnie near Ayr in Scotland on December 12-13. Both were pleasantly surprised at being able to see plenty of bright Geminids despite their restricted fields of view through house windows. This is perhaps a point worth bearing in mind for those who, through no fault of their own, cannot observe outside overnight. Previous results submitted to the Section have indicated the Perseid maxima can also be profitably viewed thus, and can provide considerable cheer for meteor enthusiasts unable to fully contribute to their hobby otherwise.

The brightest probable Geminid waited until December 15 to appear, and even then, it could be glimpsed only with difficulty in clouds over Bunila in Romania, by Vasile Micu. The event was estimated to be of magnitude −12 (?) at its final flaring, and of a green color. It occurred at $21^{\rm h}03^{\rm m}30^{\rm s}$ UT.

After the Geminids, visual observations died away rapidly, with poor skies, for many the holiday festivities around Christmas and New Year, and increasing moonlight at the root. Several radio observers continued their excellent efforts, however, and were rewarded by a well-detected Ursid return, notably from Europe, where most active systems recorded a distinct maximum around December 22.

Visual data from Jürgen Rendtel tend to support this, as the sole visual Ursid watcher. Our Japanese radio contributors recorded a much more modest Ursid peak, at the limit of detectability, perhaps because of the peak's timing, or perhaps because of a low radiant then. The Ghent University data and that of Robert White and Ilkka Yrjölä all suggest a radio maximum around 7^h–9^h UT on December 22 ($\lambda_\odot \approx 270\overset{\circ}{.}8$ (eq. 2000.0), slightly later than the visual prediction at $\lambda_\odot = 270\overset{\circ}{.}7$). There is some confirmation of this time in Maurice de Meyere's data, who ceased recording at 8^h UT, but Werfried Küneth's results show an enhancement suggesting a peak around 5^h–7^h UT. Chikara Shimoda reported his long-duration echoes for the period over December 20–23, recording a slight increase in such echoes from 0^h–2^h UT and 4^h–6^h UT on December 22, with other very minor enhancements around 19^h–21^h UT on December 21 and 7^h–9^h UT on December 22. Robert's and Ilkka's datasets do also support activity somewhat above the baseline for dates to either side of the peak from the late evening hours UT on December 21 (certainly after 22^h UT) through almost continuously until $\sim 14^h$ UT the following day. Although the Ghent results reveal a smaller overall enhancement in activity, they also confirm this general trend, but they suggest high rates at around 1^h–2^h and 3^h–4^h UT on December 22, which are not seen in other data sets. Maurice de Meyere recorded another anomalous spike on December 20, which does not feature in other data then too.

Late December radio activity was lower than at the start of the month, and no clear spike was coincident with the expected Coma Berenicid maximum on December 19. Observations from December 30-31 and after suggested a minor increase in overall echo counts, perhaps as some early Quadrantids began appearing.

Acknowledgments

As always, thanks are due to every observer and correspondent during this particularly interesting spell, the visual observations helping to give further confidence in the ability of radio analyses of this nature to provide information on the more active meteor showers, allowing us to begin attempting examinations of showers that pass almost visually unseen, like the 1996 Ursids. Good luck in all your observing, and clear skies!

References

[1] C. Steyaert, *Radio Meteor Observation Bulletin* 40, December 1996.

[2] C. Steyaert, *Radio Meteor Observation Bulletin* 41, January 1997.

[3] C. Steyaert, *Radio Meteor Observation Bulletin* 42, February 1997.

[4] C. Steyaert, *Radio Meteor Observation Bulletin* 43, March 1997.

[5] A. McBeath, "SPA Meteor Section Preliminary Radio Results: 1996 Leonids", *WGN* 25:1, February 1997, pp. 45–53.

[6] J. Rendtel, R. Arlt, A. McBeath (editors), "Handbook for Visual Meteor Observers", IMO, 1995, pp. 230–235.

[7] A. McBeath, "SPA Meteor Section Results: September–October, 1996", *WGN* (in press).

[8] R. Arlt, J. Rendtel, P. Brown, "ILW Bulletin 9: Results of the 1996 Leonid Maximum", *WGN* 24, 1996, pp. 203–206.

[9] V. Gerhardt, "Cover photograph with enlargement on p. 201, caption on p. 200", *Mitteilungen des Arbeitskreises Meteore* 21, 1996.

[10] S. Molau, V. Gerhardt, "Spectacular Leonid Fireball", *WGN* 25, 1997, pp. 54–56.

[11] P.T. Wlasuk, ""So much for fame!:" The Story of Lewis Swift", *Quarterly Journal of the RAS* 37, 1996, pp. 683–707, esp. p. 687.

[12] A. McBeath, "Fireball over Sunderland, England, 1995 July 28", in: *P. Roggemans & A. Knöfel (eds.), Proceedings of the IMC Brandenburg 1995*, IMO, 1995, pp. 76–82.

SPA Meteor Section Results: January–February 1997

Alastair McBeath

A resumé of results collected by the *SPA Meteor Section* from January and February, 1997, is given. Neither month was especially good for visual watchers, but some useful Quadrantid observations from Europe and the USA suggested activity was still climbing by 10^h UT on January 3. Radio work continued to be prominent, with European and Japanese datasets available throughout the Quadrantid epoch especially. These suggested two maxima were detectable, a minor event from about 3^h–6^h UT on January 3 ($\lambda_\odot 282\overset{\circ}{.}82$–$282\overset{\circ}{.}95$, eq. 2000.0), and the far more substantial main peak at around 11^h UT ($\lambda_\odot = 283\overset{\circ}{.}16$). Enhanced echo counts were observed for roughly 48 hours from January 2–4. February radio data suggests no unusual meteoric events occurred during the month.

1. Introduction

With moonlight difficulties apparent for most of the major northern hemisphere showers in 1997, many observers were hoping for a good start to the year with the almost Moon-free Quadrantids. British observers' hopes were dashed by atrocious weather, but elsewhere some watchers were luckier. February proved a dismal month everywhere, however, as shown in Table 1—even though radio work was again highly prominent in both January and February.

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

Month	Visual	QUA	Meteors	Photo	Trails	Radio
January	$42\overset{h}{.}63$	390	681	$387\overset{h}{.}94$	0	$2552\overset{h}{.}8$
February	$6\overset{h}{.}95$		45	$11\overset{h}{.}23$	2	1431^h

All the photographic observations reported so far are from *Arbeitskreis Meteore* (*AKM*) members in Germany (*AKM* details kindly provided by photographer Jürgen Rendtel): A. Haubeib, André Knöfel, Roland Winkler, and N. Wünsch. The two trails both occurred on February 1, and may well be of the same meteor, caught at Berlin and Potsdam.

Much of the radio data was received in the form of *Radio Meteor Observation Bulletins* (*RMOB*s) thoughtfully submitted by Christian Steyaert [1,2], with Norman Fitch of the *Radio Society of Great Britain* (*RSGB*) contributing comments and some data too. The radio observers included

> Maurice de Meyere (Belgium, *RMOB*), Ghent University (Belgium, *RMOB*), Werfried Küneth (Austria, *RMOB*), Kimio Maegawa (Japan, *RMOB*), Chikara Shimoda (Japan, *RMOB*), Kazuhiro Suzuki (Japan, *RMOB*), Robert S. White (England), Ilkka Yrjölä (Finland, *RMOB* and via *RSGB*), and Wim Zanstra (the Netherlands, *RMOB*).

As usual, the analysis procedures from [3] for dealing with unprocessed radio data were followed, and the radio graphs which accompany this article can be seen as representative of the radio results overall during January and February.

The visual observers comprised

> *AKM* members (Rainer Arlt, Detlef Koschny, Ralf Koschack, Ralf Kuschnik, Sirko Molau, Ulrich Sperberg, Manuela Trenn, all in Germany; data from observer Jürgen Rendtel), Jay Brausch (North Dakota, USA), Shelagh Godwin (England), Roger Venable (Georgia, USA), and M. Della Verita (England).

2. January

No visual Quadrantids were seen from the UK, with all the received shower reports coming from Germany and the USA. Visually, ZHRs were seen to rise during the night of January 2–3 as shown in Figure 1. By dawn over Europe, ZHRs had reached 70 ± 10, but continued to climb even as dawn approached over sites in the USA (ZHRs of 110 ± 15 by 10^h UT, for instance). Table 2 gives a breakdown of Quadrantid and January sporadic meteor magnitudes.

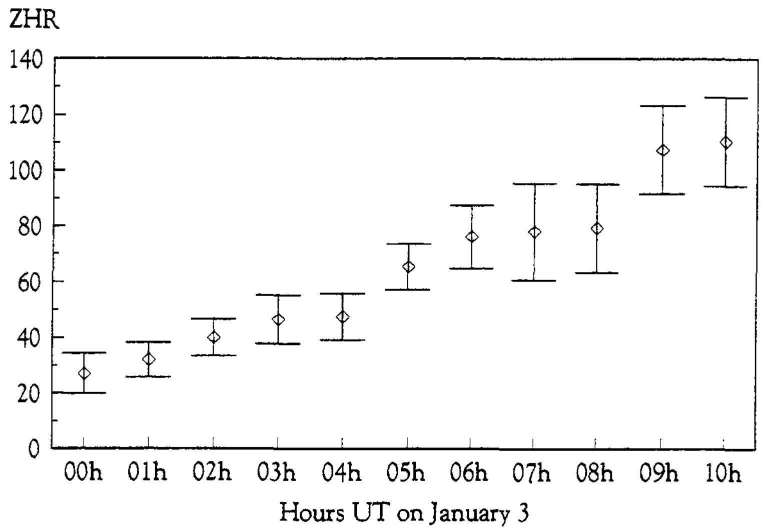

Figure 1 – Mean visual Quadrantid hourly ZHRs on January 3. All data from a given hour have been combined into a single datapoint, and standard error-bars are also shown.

Table 2 – Global magnitude distributions, including mean limiting magnitudes and corrected mean magnitudes for the Quadrantids and January sporadics seen in good sky conditions (Lm +5.5 or better; cloud cover < 20%).

shower	-3^-	-2	-1	0	+1	+2	+3	+4	$+5^+$	Tot	Lm	$\overline{m}_{6.5}$
QUA	5	1	6	10	20	32	45	27	16	162	6.15	2.74
SPO	1	0	0	0	3	6	5	6	12	33	6.03	3.89

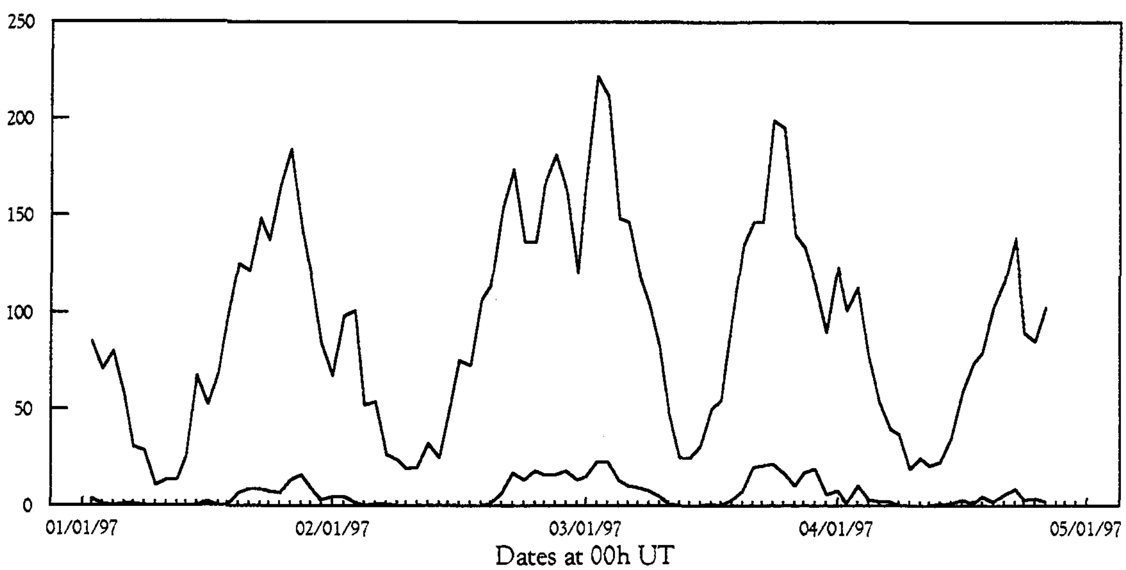

Figure 2 – Raw hourly radio meteor echo counts between 1997 January 1–4, from data collected by Kimio Maegawa, given in [1]. The upper line records all echoes, while the lower one which frequently drops to zero, indicates only those echoes of at least 2.5 s duration, which give a clearer indication of the Quadrantid presence overall. Note that the x- and y-axis scales vary from graph to graph in the radio results here.

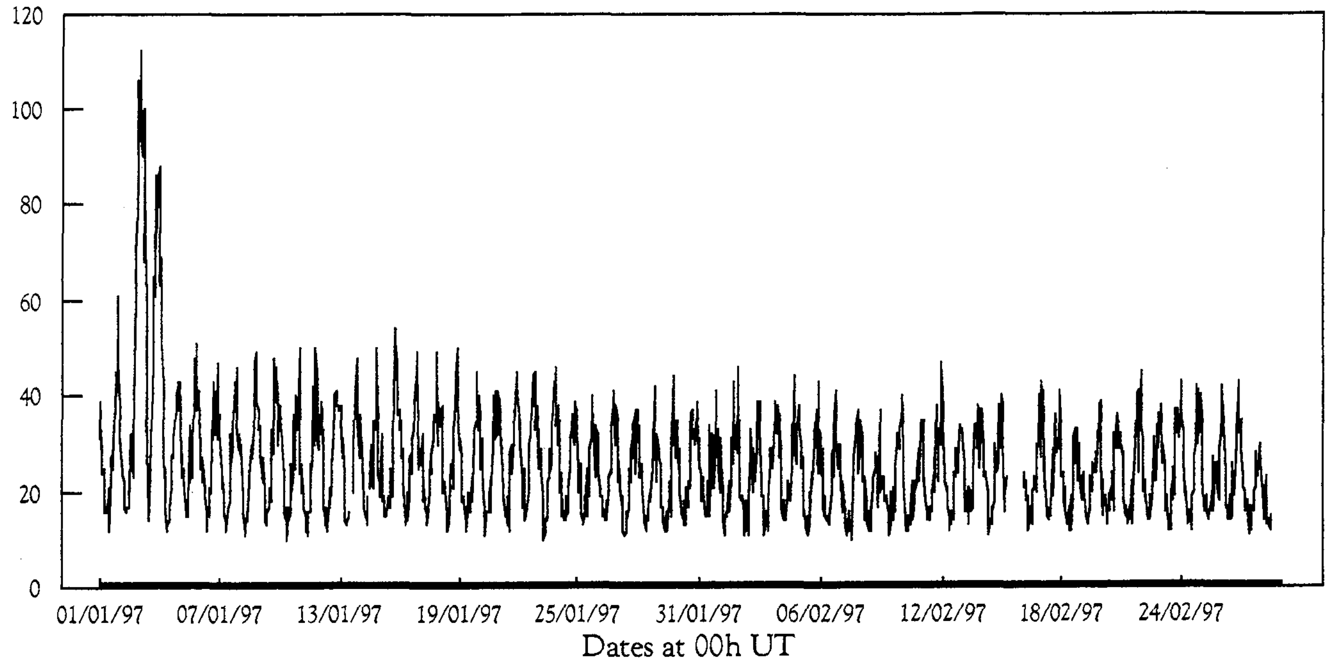

Figure 3 – Raw hourly radio meteor echo counts between January 1 and February 28, 1997, from data collected by Kazuhiro Suzuki, given in [1] and [2]. Short breaks in operations occurred on both January 13 (11^h–14^h UT) and 14 (11^h–12^h UT), with a longer break from 5^h UT on February 15 to 2^h UT on February 16. The Quadrantids are very obvious from January 2–4 inclusive.

Radio data suggests a more complex activity curve. Japanese data (illustrated by Figures 2 and 3) suggests Quadrantid activity was already moderately strong by 17^h–18^h UT on January 2. Long-duration echoes were in abnormal abundance from both Kimio Maegawa's data ($D > 2.5$ s) and that of Kazuhiro Suzuki ($D > 20$ s) from this period until about 8^h UT on January 3 (shortly before radiant-set). They picked up again around 16^h UT, roughly 2–3 hours after radiant-rise, on January 3 and were last detectable around 20^h UT (Suzuki) or 23^h (Maegawa). The Quadrantid radiant culminates around 23^h30^m UT in Japan. High echo counts were noted during the radiant's observable period until around 2^h–3^h UT on January 4.

In Europe, radio observers were better-placed to catch the main Quadrantid peak (see Figure 4). They confirm slightly enhanced activity from the early evening hours UT onwards of January 2, certainly after 20^h–21^h UT. A minor peak in echo counts occurred in most datasets around 03^h–06^h UT on January 3, ($\lambda_\odot = 282\overset{\circ}{.}82$–$282\overset{\circ}{.}95$, eq. 2000.0). The Japanese results suggest this "peak" occurred slightly earlier there, around 1^h–3^h UT perhaps, although Suzuki's long-duration echo counts still favor 3^h–7^h UT. Only the dataset from Ghent University of the operators active at this stage, does not show this feature. Regrettably Maurice de Meyere suffered a series of equipment problems, and was unable to cover the Quadrantids at all well. Visual observers in Germany also found rates slightly increased from around 1^h30^m–2^h UT, with a slight dip until around 3^h30^m–4^h UT [4], though the difference was not large.

After this event, radio rates then dropped marginally for a few hours, before picking up markedly as the main peak approached. This took place at circa 10^h–13^h UT ($\lambda_\odot = 283\overset{\circ}{.}11$–$283\overset{\circ}{.}24$) on January 3, with all the available results indicating the hour centered on 11^h UT as the time of highest counts (or greatest saturation of the system due to longer-duration echoes; Werfried Küneth was able to record data effectively for a mere 27 minutes during the hour from 11^h–12^h UT, for instance, because of this!). This timing equates to $\lambda_\odot = 283\overset{\circ}{.}16$ (eq. 2000.0), a perfect coincidence with the predicted visual maximum time [5], and also identically coincident with the peak radio time found in 1995 [6]. Japanese observers were unable to catch this peak, as the Quadrantid radiant is unfortunately at its lowest beneath the horizon for the day around 11^h30^m UT from there. Clearly, however, radio activity was at a very interesting level for observers in both locations for around 48 hours from January 2–4.

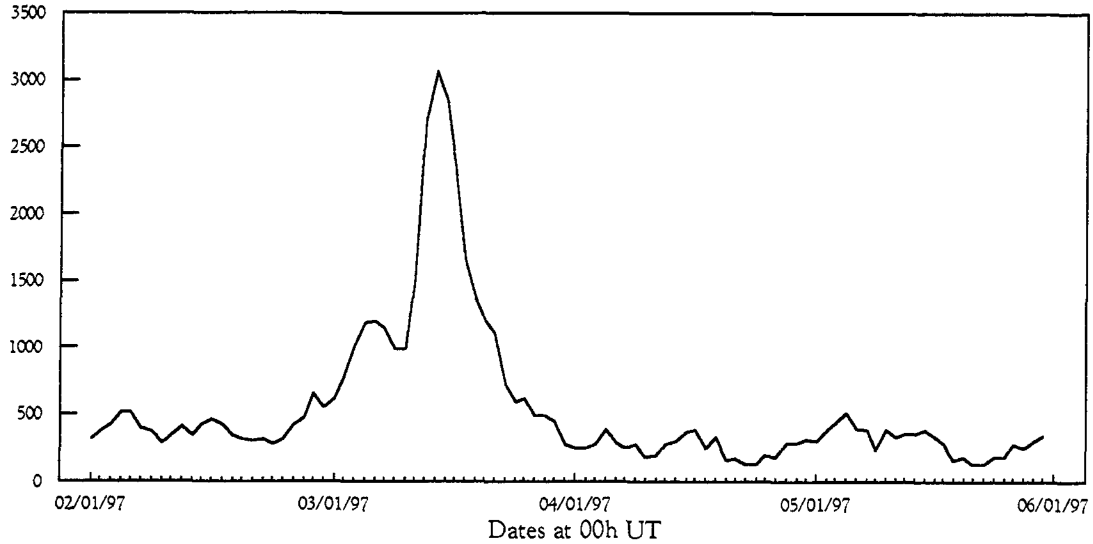

Figure 4 – Raw hourly radio meteor echo counts between January 2 and 5, 1997, from Ilkka Yrjölä's data [1]. The main Quadrantid maximum, and the minor enhancement in the early morning hours UT of January 3 are well seen. The y-axis scale diminishes the diurnal sporadic meteor activity almost to nothing on this graph.

A small number of visual reports arrived from the rest of January, indicating low rates of the expected minor showers. Of these, the δ-Cancrids were most apparent around January 16 and 17 visually (ZHRs of $3\text{–}4 \pm 1$), with some radio results also suggesting a very slight enhancement then, although this is not confirmed in all four datasets available. As Figure 3 demonstrates, the variations in radio activity, other than a gentle decline in echo counts into late January and throughout February, are virtually negligible.

3. February

With comet Hale-Bopp brightening throughout January and February, visual attention seems to have switched to following that object, rather than the weak meteor activity most places in the northern hemisphere are subjected to during this period. From comments received, it is also apparent that weather conditions did little to assist the meteor work especially, witness the very low hours total in Table 1. Radio activity was generally flat, with only one possible minor enhancement recorded by more than one observer, which occurred on February 12 over Japan, but the difference from other dates nearby is almost nonexistent.

4. Acknowledgments

Naturally, grateful thanks are extended to all our contributors and correspondents. The good coverage of the Quadrantids, visually and by radio, and of the lean meteor spell of mid-January and throughout February by radio were notable plus points. The low-activity data were especially welcome, as such are always vital to ensure unexpected meteoric events are not being missed.

References

[1] C. Steyaert, *Radio Meteor Observation Bulletin* 42, February 1997.

[2] C. Steyaert, *Radio Meteor Observation Bulletin* 43, March 1997.

[3] A. McBeath, "SPA Meteor Section Preliminary Radio Results: 1996 Leonids", *WGN* 25:1, February 1997, pp. 45–53.

[4] J. Rendtel, "Quadrantiden 1997", *Mitteilungen des Arbeitskreises Meteore* 22:2, 1997, p. 20 (in German).

[5] A. McBeath (compiler), "Meteor Shower Calendar: October 1996–March 1997", *WGN* 24:4, August 1996, pp. 108–113 (esp. pp. 110–111).

[6] A.McBeath, "SPA Meteor Section Results: January–February 1996", *WGN* 24:5, October 1996, pp. 178–179.

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