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This magnitude −1 Perseid was photographed by Luis Sálas López of the Agrupación Astronómica de Gran Canaria on August 12, 1996, at $1^h42^m28^s$ UT. It was photographed with a 50 mm $f/1.4$ lens on a 3200 ASA film. The exposure was 1 minute. In the upper-right quadrant of the photograph, the constellation of Delphinus is easily recognizable.

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- Practical hints for photographic observers
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Useful Information

The February Issue *(WGN 25:1)*

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From the Editor-in-Chief

Marc Gyssens

November 1996 marks the 90th birthday of Dr. Fred Whipple, one of the founders of modern meteor astronomy. On behalf of the International Meteor Organization, *publisher of this journal, I wish him a happy birthday. To all readers, enjoy this issue, in particular the Leonid results, and, with the year's end within sight, may Godfrey Baldacchino's meteor observers' survey serve as a basis for some reflection on your activities as meteor worker!*

Fred L. Whipple: A 90th Birthday Retrospective

Martin Beech, University of Western Ontario

In this age of glibly employed superlatives, distinguishing and inherently complimentary terms such as "mentor" or "luminary" have become all too common-place. I would argue, however, that the modern-day redundancies of such terms do not apply when attached to the career and achievements of Fred L. Whipple, who can be assuredly described as the founding father of modern meteor astronomy. Fred Lawrence Whipple was born on November 5, 1906 and, as he enters his nonagenarian years, we take this opportunity to reflect, albeit briefly, upon a few of his achievements, influences and contributions to meteor science, made during an outstanding scientific career.

An invaluable and insightful source of material relating to Whipple's many scientific works is the two-volume, 2004-page *Collected Contributions* published by the Smithsonian Astrophysical Observatory in 1972 [1]. Here we find reference to the essential and inspiring contributions Whipple has made to meteor and cometary astronomy. In addition, by simply scanning the headings under which his works are divided, we gain immediate insight into the breadth and depth of Whipple's interests. Headings such as meteors and the interplanetary complex, comets, the space age, and satellite tracking are expected, but headings such as, astrophysics, evolution of the solar system, practical astronomy, and stochastic painting are not ones that might immediately jump to mind.

In the field of meteor astronomy, Whipple's most important contributions relate to his involvement with the Harvard Arizona Meteor Expedition, the Harvard photographic meteor program, his study of meteoroid stream orbits, the development of meteoroid flux models at 1 AU, and the development of a cometary nucleus model capable of accounting for the ejection of cometary grains into a meteoroid stream.

The idea to fund and organize the Harvard Arizona Meteor Expedition came from Harlow Shapley in the early 1930s. Then Director of the Harvard College Observatory, Shapley hired two young astrophysicists, Ernst Öpik and F.L. Whipple to organize and facilitate the work. The specific aim of the Arizona expedition was to determine average meteor velocities, and thereby validate the then commonly held notion that meteoroids were interstellar in origin. Although primarily interested in galactic astronomy, Shapley initiated the meteor expedition because he believed that the study of meteors might reveal useful information on near-by stars and the interstellar medium. The interstellar origin of meteors was revealed, so the argument went, by their high, or so-called hyperbolic velocities as a consequence of which they could not be on bound orbits about the Sun. Cuno Hoffmeister, for example, had concluded in 1925 that about 80% of all observed meteors had hyperbolic velocities. The Harvard Arizona Meteor Expedition was primarily controlled by Ernst Öpik. Observations ran from October 1930 until July 1932 [2]. Öpik oversaw the reduction of the expedition's observations and concluded in 1935 that about 70% of the meteors observed had hyperbolic velocities and were hence interstellar in origin.

Not every one agreed with Öpik's conclusions, however, and Willard Fisher (again, of Harvard Observatory) in particular questioned Öpik's conclusions based upon photographic velocity estimates. Fisher convinced Whipple that visual observations could not be trusted to derive accurate meteor velocities, and that the only reliable method was that afforded by photographic means. Between 1934 and 1936, Whipple ran a photographic meteor program at Harvard and was able to demonstrate that the majority of meteors recorded did not have hyperbolic velocities and were thus, presumably, derived from objects (comets and asteroids) bound to the Sun.

In 1943, Whipple published an influential paper in the journal *Reviews of Modern Physics* [3]. This article, entitled "Meteors and the Earth's Upper Atmosphere" argued that photographic meteor studies could be used to study the properties of the Earth's atmosphere out to heights of order 100 km—a region completely unexplored at that time. In particular, Whipple argued, careful analysis of the photographic trails recorded could be used to infer the density of the Earth's upper atmosphere. Whipple's *Reviews of Modern Physics* paper apparently caught the eye of the Naval Bureau of Ordinance, and with their growing interest in the upper atmosphere (primarily because of their rocket experiments), a photographic meteor program was funded between 1945 and 1954. In 1948, two cameras were transferred to observing sites in New Mexico, and, in the early 1950s, the new Super-Schmidt cameras designed by James Baker were introduced [4]. Funding for the photographic meteor program was taken over by the United States Air Force in 1954 for 5 more years, finally folding in 1959.

We need not follow all the many fundamental developments that stemmed from the photographic program that Whipple organized. The results were indeed legion. With regard to the photographic meteor program, and with the reader's indulgence, however, I would like to conclude this section with reference to a comment made by Whipple in the introduction to his *Collected Contributions*. The point, it seems to me, is an important one, and one that has startling present-day relevance, raising, as it does, an issue that many modern-day politicians and engineers of science policy should well be reminded of. Whipple wrote *this research exemplifies many scientific endeavors where the expected immediate goal is not attained, but where a systematic long-term effort produces significant results*. The point of this comment is that the program in spite of its apparent failure in the eyes of the funding agency (i.e., with respect to deriving accurate measurements of the density of the Earth's upper atmosphere) produced a wealth of fundamental knowledge about the structure of meteoroids. There is a lesson here: science is not a cut and dry, accountant-run, product-oriented commodity.

Whipple has had a career-long interest in the smaller bodies of the Solar System. Indeed, Whipple's early observing work at Harvard saw 6 new comets "bagged" in his name, and he also discovered a number of asteroids. Minor planet 1975 CA has been named in honor of Whipple.

There is an interesting parallel between Whipple's interest in comets and his early work on meteors. During the first several decades of this century, astronomers argued among themselves about the origin of comets, with as many believing that they were interstellar in origin as believed that they were original members of the Solar System. The debate on the origin of comets came to a head in 1948 when Raymond Lyttleton published his "sand-bank" model of cometary formation [5]. Lyttleton argued that comets were formed whenever the Solar System passed through an interstellar dust cloud, and that having once produced comets it was inevitable that a few of them would share the Solar System's relative motion and thereby be captured into elliptical orbits about the Sun. Whipple, however, was not convinced by Lyttleton's argument, and he preferred to believe that comets had been formed at about the same time as the planets. Whipple also felt that the "sand-bank" model did not adequately explain the observed behavior and properties of cometary nuclei. In particular, Whipple noted that many meteoroid streams contained irregular distributions of meteoric particles—seen as variations in the annual meteor rate, and since meteoroid streams were supposedly derived from the "wearing-down" of cometary nuclei, the observation must be explained in terms of the physical make-up of the cometary nucleus, e.g., its orbit, physical size, and rotation state. Whipple published two important papers [6,7] on the structure of cometary nuclei in the early 1950s. These two papers described his well known "dirty snowball" model, and indeed, the essential correctness of Whipple's cometary model was gloriously confirmed by the Comet Halley rendez-vous missions in 1986.

During the early years of the space age, Whipple was deeply involved with a number of programs to describe the flux of meteoroids at the Earth's orbit. These studies were designed to address the fundamental issue of spacecraft survivability. Early-on in these studies Whipple recognized the potential risks to spacecraft and wrote *meteorites represent a potential hazard to a pressurized space vessel. Of fundamental interest is the value of the probability that the skin of the vessel will be punctured by a meteorite. In case this probability is appreciable the problem of protection from meteorites becomes important* [8], a fundamental point that is still of concern to this day. Whipple's solution to the meteoroid impact problem was to add a thin bumper shield to the outside of critical pressurized bulkheads. Upon encountering a bumper, or Whipple Shield as they are known today, a meteoroid will burst into a spray of hot gas and very fine particles, neither of which will puncture the spacecraft's bulkhead. Much of Whipple's early work on meteoroid protection and the possibilities of space travel was classified, because of its relationship to ballistic missile research, but, ultimately, the various military-run programs allowed for the development of the Vanguard satellite program. This program of artificial satellite launches was designed as a US technical show-case, with the first scheduled launches to take place during the International Geophysical Year (IGY) in 1957 [9]. History, of course, tells us that the Russians piped the American program with the launch of Sputnik-1 on October 4, 1957.

We have mostly dwelled upon Whipple's contributions to meteor astronomy in this article, and yet, even by doing this, we have hardly scratched the surface of his publications. In conclusion, what more can be said than that Fred Whipple has had a most distinguished scientific career, and that we are all much the wiser for his interests in meteoric phenomena.

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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. At the time of this writing, local observers are gathered here for the Leonid campaign, trying to accomplish as many things as possible at this early stage of the organization.

A registration form is provided in this issue of *WGN*. To keep informed, you should return it as soon as possible to Treasurer Ina Rendtel. If you need or want to stay in Petnica, Valjevo, or Belgrade, some days before or after the *IMC*, you will be offered various solutions. The first circular is to be sent soon.

I would like to urge observers from nearby countries to encourage their meteor friends not to miss the unique opportunity provided by the *IMC* being held in their neighborhood and observers from not-so-nearby countries to come and meet their colleagues!

If you have any questions, please feel free to write to *Petnica Science Center/IMC 97, P.F. 118, YU-14000 Valjevo, Yugoslavia* or to send an e-mail to the author (`f2lukicv@rcub.rcub.bg.ac.yu`).

Looking forward to your registration!

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, Gontardstraße 11, D-14471 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 regarding this matter.

For participants wishing to contribute to the program:

Lecture: ____

Duration: ________min. Required equipment: ______________________

Workshop or discussion: ______________________________________

Poster presentation: ______________________ Space: ________ m^2

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- 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.

Errata

compiled by Marc Gyssens

Jürgen Rendtel noticed the following error in the article about the 1995 and 1996 Perseids on p. 144: Figures 2 and 3 were transposed. We apologize for the inconvenience.

Alastair McBeath noticed in his articles in WGN 24:5 *two pairs of figures were transposed: Figures 2 and 3 in the update article on the 1995 late Summer and Fall results (p. 173) and Figures 1 and 2 of the March–April 1996 observational results (pp. 181–182). We apologize for the inconvenience.*

Miloš Weber, the author of the article on the 1996 June Lyrids in WGN 24:5, *p. 151, has communicated the following erratum to his article. In Table 2, the first line refers to the June Lyrids, and the second line to the sporadics. The numbers quoted in the text are correct. The author apologizes for the inconvenience.*

Observing the Meteor Observer

A Global Survey of Meteor Observers

Godfrey Baldacchino

1. Origins

The idea of a global survey of meteor observers took root some two years ago. I was corresponding with Peter Jenniskens, long-time amateur meteor observer in the Netherlands and now professional astronomer studying meteors and related issues at the *Ames-NASA Research Center* in California, USA. I had known Peter for a number of years, and we had met in the Netherlands in 1983. Almost casually, I asked Peter whether he could chart for me the evolution of his life as a meteor observer. The outcome of this prompt was a very long letter. It described what got him started onto meteor watching; the friends which helped him persevere and perfect his observational and analytic skills; how he organized his observational spurts throughout the years; the highlights of his hobby; his pursuit of further studies and eventual move to *NASA*. In short, this was a longitudinal, time-based study of one, rather particular, meteor watcher.

This personal saga is indeed extraordinary in the sense that the person concerned ended up as a professional meteor observer. However, every meteor observer, even the most amateurish and casual, has his/her own history and evolution in "meeting" the activity. There must always be a first contact, some kind of observational history; some kind of preference for certain showers, or for observing in a certain way; and eventually (in most cases) a parting with the hobby... In this respect, in spite of the obvious dissimilarity and uniqueness of each personal experience, there are still common elements, shared variables and episodes which serve as the basis of a comparable meteor watching experience.

Since I am a social scientist by profession; and since I have set myself up to survey quite a motley band of research "subjects" over the years, I recognized both the potential and the challenge that this opportunity presented. Being one of the few social scientists who are members of *IMO* meant that few were those likely to espy this research topic, and still less the number of those keen, able or interested in pursuing it to its logical conclusion.

2. Proposal

I decided to write to the *IMO* Secretary General and share the idea of carrying out some kind of study which would investigate meteor watchers for a change. An attempt would be launched to build a profile of the contemporary meteor observer. The specific features about which information would be sought soon presented themselves as research questions: What was the meteor observer's age? What was his/her academic and occupational background? Was their any regularity or patterning of observation? What were the aims for pursuing the hobby? What motivated and demotivated observation? When and why did they try meteor watching? Did they prefer group or solo based watches? Did they observe only shower or also sporadic activity? Were they involved in local, regional, national, or international groups?

My initiative met a positive response, also because it dovetailed with developments taking place within the *IMO* itself. The work of the *IMO* depends on a regular supply of data from dedicated meteor observers, voluntarily forsaking sleep, rest, and warmth, as well as on a differently dedicated group who process and analyze the data and communicate the results to a wider audience, this apart from the other administrative chores which are part and parcel of an international organization. Here, the scientific purpose of meteor watching is bound to reign supreme, but it would be a pity to consider this as the exclusive motivation behind the massive effort put in it by all and sundry. There is an invariable social and personal touch—it was part of the survey objectives to come to better grips with this—which somehow justified the effort that so many people put in on a voluntary basis. Meteor watching, and the *IMO* itself, would not survive were the clinical and calculating dimension treated as the be all and end all of so many individual choices to observe meteors.

3. Operation

The survey initiative was discussed at an *IMO* Council meeting and given the green light. This set the ball rolling on a number of fronts.

First of all, this was a major exercise in participation and discussion. A draft questionnaire was circulated to *IMO* Council members. This was then tested at the *International Meteor Conference* held in Brandenburg in September 1995. A total of 35 questionnaires were received and analyzed with the intention of perfecting the research instrument. The revised questionnaire was once again circulated to *IMO* Council members and still more suggestions for improvement received and incorporated. The objective was to produce a simple and self-explanatory questionnaire with the least possible number of questions, most of them being pre-coded to allow quick analysis, a few open-ended interrogatives to allow qualitative comments which would have to be coded afterwards, the whole hopefully fitting on the front and back side of the same sheet of paper, to make copying and circulation less expensive.

Secondly, the survey was only possible given the international character of the *IMO* itself. I wrote/faxed/e-mailed one *IMO* member in all the 30 countries where the *IMO* is represented. Each contact person was identified after a discussion with Paul Roggemans in January 1996. Every contact person was invited to act as national survey coordinator for his/her country. With only 2 exceptions, everyone accepted and the retractors were quickly replaced. This meant that "master" questionnaires would be sent to each national coordinator and then it would be up to him/her to make copies, pass/post these to all the known individual meteor observers in the country plus any known local associations, and ensure that completed forms are returned by a given deadline. The definition of what constituted a meteor observer for the purpose of this study was clarified. Strict anonymity has been maintained, making it easier for respondents to be as sincere and critical as they felt, without any suspicion that any comments would be traced to specific persons.

Thirdly, the option to translate the questionnaire into the local language was also considered. The danger associated with such a move was that certain questions might lose their original and intended meaning in the process of translation, but this risk was considered more than acceptable in the face of the obvious difficulty of many observers to read and write in English, the official language of the *IMO*. In such cases, some national coordinators took upon themselves the extra burden of translating the questionnaire and then translating the results received back into English.

Fourthly, all this, of course, had to take place within a rather narrow time period. As things turned out, the national coordinators were contacted and their support quickly confirmed during April 1996, and the "master" questionnaires were sent out in May 1996, with national coordinators being instructed to collect completed questionnaires from their country by mid-August 1996. A copy of the questionnaire was published in *WGN* 24:3, June 1996, pp. 85–87, both for information as well as to widen the net of potential survey participants. All national coordinators were asked to perform a part-processing of the national data collected and to send this, along with all questionnaires, to me by end-August 1996. Actually, 50% of completed forms were received by that date while the others trickled in over the next three weeks. The last dozen or so questionnaires were completed during the *IMC* held in Apeldoorn during September 19–22, 1996. During this *IMC*, the opportunity was also taken to present an interim report based on a quick analysis of the questionnaires received until then. This report has been completed by early November 1996 and it will hopefully be published by early 1997, thus assuring an almost immediate feedback.

4. Support

All national coordinators who made this international exercise possible must be thanked wholeheartedly for their efforts. Special thanks go to Ichiro Hasegawa, who accepted to organize the survey through the *Nippon Meteor Society* and through whose efforts 64 completed questionnaires were received, and to Daniel Očenáš who labored over the part-processing of no less than 114 questionnaires from Slovakia, the highest national data set received. The survey was—as far as I know—translated into Chinese, German, Japanese, Spanish, and Slovak. It was also published in some local astronomical publications, as was the case in Malta, Switzerland, and the United States. The survey also benefited from information technology, with some two dozen completed surveys being downloaded via electronic mail, particularly from the United States. Only 3 out of the 30 national coordinators who accepted to take part in this project did not (by the time of writing this article) submit any completed forms. Two other questionnaires were received, one each from Syria and Singapore, where there was no designated national coordinator.

5. Submissions

Table 1 summarizes the numbers of questionnaires that have been submitted for further analysis by the respective national coordinators.

Table 1 – Numbers of questionnaires submitted for further analysis by the respective national coordinators. In total, 443 questionnaires were completed.

Country	Number	National Coordinator	Country	Number	National Coordinator
Slovakia	114	Daniel Očenáš	Romania	8	Vasile Micu
Japan	64	Ichiro Hasegawa	Argentina	6	Carlos Francisco Sosa
Belgium	26	Cis Verbeeck	Croatia	6	Korado Korlević
USA/Canada	26	G. Zay/R. Lunsford	Finland	6	Marco Toivonen
United Kingdom	22	Alastair McBeath	Germany	6	Rainer Arlt
China	20	Pin Xin Xu	Yugoslavia	6	Vladimir Lukić
Spain	18	Luís Ramon Bellot	Bolivia	5	Hans Salm
New Zealand	16	Graham Wolf	Denmark	5	Per Tjyberg Aldrich
Slovenia	15	Aram Karalič	Norway	3	Trond Erik Hillestad
Jordan	14	Khalil Konsul	Sweden	3	Ake Lysell
Netherlands	14	Casper Ter Kuile	South Africa	3	Tim Cooper
Malta	12	Michael Schembri	Austria	2	Erich Weber
Bulgaria	11	Ivanka Getsova	Switzerland	2	Bruno Mancusi
Australia	8	Jeff Wood	*Others*	2	

I would argue that the very act of administering, collecting and part-processing the questionnaire has been a worthwhile exercise in itself. It has deployed many members within *IMO* as well as strengthened personal links on a national basis. I must also add that certain national coordinators went through considerable effort and even expense to circulate the questionnaire far and wide in their respective country. Not all of them obtained encouraging response rates, however.

Furthermore, in my unenviable capacity as overall coordinator, I found myself entering into very interesting correspondence with meteor observers world wide. Letters, faxes and e-mail messages were received, some including specific suggestions for the *IMO* to consider in its action program. In other cases, I found myself the beneficiary of honorific titles or of astronomical publications. All along, I feel I have tapped a lot of positive energy forthcoming from grass roots meteor organizations and their inspiring leadership from all over the world. (More about this below).

6. Result validity

The grand total of questionnaires received therefore amounts to 443, from 29 countries, and from all 5 continents. This is by far a very satisfactory figure, although it must immediately be stated that the research project was intended as an exploratory study and there is therefore no attempt at having some kind of scientifically determined sample. The weight of numbers, however, grants sufficient confidence in the widely representative basis of the respondents. Furthermore, the validity of results increases when trends are identifiable across most or all national sub-samples. The division of the data into national groups permits some degree of national discrimination. Certain comments can and will be made on the basis of national distinctions, highlighting specific features of meteor observers which only come to light when seen in contrast to similar features exhibited by comparative groups in other territories. Of course, in such cases, one should refrain from making rash judgments when the sample size is extremely small.

What follows is a break-down of the results obtained, along with my interpretation of the results. Readers are invited to serve as independent judges of the data and possibly to reach conclusions different from my own. Along with a scrutiny of the survey questionnaire, readers are also invited to suggest further manipulations of the data available.

7. Gender and age

The mean age and sex distribution of the respondents are give in Table 2. There is a clear gender distribution here, which is also reflected in the age distinction between males and females. There appear to be 5 male meteor observers for every female meteor observer. This male domination is consistent throughout all national sub-sets, except for Bulgaria, Slovenia, and Yugoslavia. In these three cases, however, the average age of both male and female observers is rather young, suggesting that the observers concerned have not yet spent many years observing. Such evidence points towards a relatively lower exposure of females to, and an earlier withdrawal from, meteor observational practice. Are females exposed to less opportunities to learn about or to try meteor watching, just as, in many societies, they continue to be socialized to expect a non-scientific education and career? Is it the fact that night activities are considered in many societies as inappropriate or taboo for females? Do family responsibilities and domestic work (apart from paid employment) make it more difficult for women to persevere in meteor watching? Definitely, local meteor groups and astronomy associations must try harder to involve more females in their educational and observational projects, or to consider carrying out activities and field events specifically for female audiences.

Table 2 – Mean age and sex distribution of the respondents.

Country	Males	Females	Male age	Female age
Slovakia	90	24	23	25
Japan	59	5	41	33
Belgium	23	3	23	20
USA/Canada	24	2	42	43
United Kingdom	20	2	39	33
China	17	3	37	33
Spain	17	1	26	25
New Zealand	10	6	43	26
Slovenia	6	9	23	23
Jordan	11	3	37	28
Netherlands	12	2	34	33
Malta	9	3	23	25
Bulgaria	5	6	18	21
Australia	7	1	39	26
Romania	8	–	21	
Argentina	5	1	33	
Croatia	3	3	21	19
Finland	6	–	35	
Germany	6	–	35	
Yugoslavia	1	5	23	20
Bolivia	5	–	38	
Denmark	5	–	45	
Norway	3	–	25	
Sweden	3	–	36	
South Africa	3	–	35	
Austria	2	–	25	
Switzerland	2	–	40	
Singapore	1	–	20	
Syria	1	–	54	
Total	364	79	32	25

8. Relation to education and occupation

A set of questions elicited information from respondents about their status as either students or workers, and whether in either of these roles, their activity was in any way meteor-related. The answers are summarized in Table 3.

Note, first of all, that various national sub-groups exhibit a particular bias in favor of either student or worker members. This would reflect the history and characteristics of a national meteor organization. A student basis usually suggests a younger mean age, a stronger bond of friendship and a stronger tendency for group-based observations. In contrast, worker-based groups—which are more common—usually involve observers of a higher mean age who will also tend to carry out solo watches. (These comments will be supported by more data below.) A mix of these two sub-sets of observers is possibly a healthy combination, combining enthusiasm, a sense of adventure, fun, and a fresh crop of meteor observing recruits with the more morose and serious interests of mature and typically more dedicated observers.

Countries whose meteor observing population is suggestively more, or exclusively, student oriented—like Bulgaria, Croatia, and Yugoslavia—are either in the early years of establishing a meteor group or else may experience difficulty in enticing their young observers to continue observing, especially after they leave secondary/high school. In contrast, worker-skewed, meteor observing national populations—as are China, Japan, the USA/Canada and the United Kingdom—might be finding it difficult to recruit new and young observers. This is in part to be expected when there are few grass roots, local meteor groups, or where vast distances preclude group meteor work. Here, one is bound to find mainly regional or national associations where communication is not so much on a personal, face to face, basis.

The relationship of one's studies or work to meteor watching may serve as an added incentive to get to know about the activity, start the hobby or persevere in it. Of course, some meteor watchers are professional astronomers as well. This possibility of combining and connecting business with pleasure can be considered to be a healthy mix, mainly because it introduces an element of professionalism to one's pastime and puts people in contact with "experts" who are abreast with developments in the field and who can provide support facilities. Note that the Netherlands, New Zealand, Slovakia, and Slovenia all enjoy this distribution, with a good proportion of observers in each of the four cells.

Table 3 – Break-down of observers in students and workers, and relationship between study or job to astronomy.

Country	Students	Related to astr.	Workers	Related to astr.
Slovakia	66	10	48	22
Japan	3	1	56	1
Belgium	18	–	8	–
USA/Canada	3	–	23	3
United Kingdom	3	–	13	2
China	4	1	16	7
Spain	13	3	5	–
New Zealand	4	2	10	2
Slovenia	11	2	4	2
Jordan	1	1	12	1
Netherlands	4	1	10	1
Malta	6	–	6	1
Bulgaria	10	–	1	1
Australia	2	1	6	3
Romania	2	–	6	–
Argentina	3	–	3	–
Croatia	6	–	4	–
Finland	1	1	5	–
Germany	1	1	5	2
Yugoslavia	6	3	–	
Bolivia	2	1	3	1
Denmark	1	–	4	–
Norway	1	–	2	–
Sweden	1	–	2	–
South Africa	1	–	2	–
Austria	–		2	–
Switzerland	–		2	2
Singapore	–		1	–
Syria	–		1	–
Total	173	32	256	51

Note that, on a global level, 40% of those who answered the questionnaire are students, while the other 60% are employees. Also, 18% of all students report having studies somehow related to meteor astronomy (such as basic astronomy, astrophysics, geography, or environmental science). Similarly, 19% of workers report occupational duties which are akin to some extent to meteor work (professional astronomers, physics teachers, or meteorologists).

9. Observing patterns

Respondents who report carrying out visual meteor observation were also asked how many hours of observation they have undertaken during 1996 by the date of filling in the questionnaire. They were also asked on what date had they observed last. These two questions provide the data in Table 4.

There is a remarkable consistency in the mean time elapsed since the last watch reported. Most observers appear to spend very long periods of inactivity and are then galvanized into a short observational spurt, most often in conjunction with the arrival of a reliable, annual meteor shower. This means that for 2–4 months at a time, so-called "meteor observers" observe no meteors at all.

This suggestion is confirmed when one examines the data of the first six months of 1996. Filtering out the specifically post-end-June (and mainly Perseid) data, this works out as an average of some 7 observing hours per person per half-year, or 14 hours per year.

The standard deviations reveal a certain diversity, but the figures are very low where there is the tendency of observers to observe together and therefore they report approximately equal numbers of observing hours over the same observing epoch. This is especially true of Croatia, Finland, Malta, and Slovenia.

10. Nature of watches

The respondents were asked to identify a preference for solo or group-based observation and for a certain type of observational technique. The cumulative answers work out as follows: 97 prefer solo watches, 217 prefer group-based watches, and 129 have no outspoken preference.

Table 4 – Observing hours in 1996 (Hours), standard deviation (σ), and mean number of days since last watch per observer (Days). For the countries not mentioned in this table, data are not available or too sketchy.

Country	Hours	σ	Days	Country	Hours	σ	Days
Slovakia	16	8	27	Australia	61	4	77**
Japan	14	20	144	Romania	37	20	7*
Belgium	9	14	136	Argentina	3		140
USA/Canada	16	18	73	Croatia	9	2	23
United Kingdom	14	18	114	Finland	6	4	194
China	11	11	155	Germany	12	12	96
Spain	9	8	121	Yugoslavia	19	13	12*
Slovenia	2	4	215	Bolivia	10	10	42
Jordan	6	9	162	Denmark	9	11	270
Netherlands	9	6	94	Sweden	3	3	130
Malta	5	4	106	South Africa	11	12	130
Bulgaria	32	15	30				
				Mean average	11		117

*Responses completed after Perseid campaign of August 1996.

**One observer reported 450 observing hours during 1996, not considered in the averages.

Clearly, both types of observational format must be recognized. Indeed, the option for social meteor watching is distinctly preferred. Such a format has its own pros and cons. Without going into the details here, it is simply important at this stage to acknowledge that this format exists, it accounts for the experience of some 50% of meteor observers worldwide, and it perhaps merits much more attention and investigation than has been carried out so far. Suggestions for codes of behavior, activities, and experiments which can be carried out in a group setting should also improve the resort to this activity as well as improve its scientific procedures.

The preference for solo versus group-based observation is subject to further scrutiny on the basis of national differences, as results from the data tabulated in Figure 5.

Table 5 – Preferences for solo versus group-based observations.

Country	Solo	Group-based	Indifferent
Slovakia	1	79	34
Japan	45	7	12
Belgium	2	22	2
USA/Canada	7	2	17
United Kingdom	12	1	9
China	6	3	11
Spain	2	12	4
New Zealand	5	10	1
Slovenia	–	13	2
Jordan	1	9	4
Netherlands	–	11	3
Malta	–	10	2
Bulgaria	–	7	4
Australia	1	5	2
Romania	–	2	6
Argentina	–	5	1
Croatia	–	4	2
Finland	3	1	2
Germany	1	–	5
Yugoslavia	–	6	–
Bolivia	3	2	–
Denmark	3	–	2
Norway	–	1	2
Sweden	1	2	–
South Africa	1	1	1
Austria	–	2	–
Switzerland	1	–	1
Singapore	1	–	–
Syria	1	–	–

These statistics provide interesting evidence of the great preference for group-based observation in practically all countries. Only in Japan is there a firm commitment to the solo format, while China, the United States/Canada, and the United Kingdom show a slight preference for the solo version. Otherwise, most of the data reveals the opposite preference. Even were one to refrain from passing comments on national data where the number of entries is too small, there is a spectacular preference for the group observation in Belgium, Jordan, Malta, the Netherlands, New Zealand, Slovakia, Slovenia, Spain, and Yugoslavia. The group-based observation is in itself a social gathering and likely to appeal to many friends who do not live considerable distances away from each other. However, those individuals who admit to prefer observing under group conditions would be less likely to observe on their own and will find that their enthusiasm to pursue the hobby will wane abruptly when and if other group members lose interest or if and when the group disintegrates for some reason or other.

Indeed, also interesting is that data which affirms respondents' willingness to accept both solo and group-based meteor watching. In a way, such observers reveal a certain maturity and inbuilt motivation in that they are disposed to work alone yet do not mind an opportunity for observing with others when such an occasion turns up. A substantial percentage of such "no difference" preferences is found in the case of China, Germany, Japan, Romania, Slovakia, and the USA/Canada.

11. Choice of observational technique

In relation to the choice in favor of visual or other observational techniques, the respondents replied as shown in Table 6.

Table 6 – Preferences for observing techniques.

Choice	Priority				
	1st	2nd	3rd	4th	Total
Visual	358	30	10	–	398
Photographic	22	139	14	1	176
Radio Echo/VLF	22*	12	10	10	54
TV/Video	7	9	14	6	36
Telescopic	6	14	20	4	44
Total	415	204	68	21	708

*9 of these are Japanese.

The data confirm the extraordinary preference for the visual mode. Indeed, visual meteor watching is the most inexpensive, the most accessible, and still today a rewarding branch of astronomy for its scientific contribution. (More on this below.) Yet, it is not the sole observational mode practised. Photography comes across as a distinct second choice for many visual meteor watchers; but then 12% of respondents actually admit to having non-visual pursuits as their primary observational interests. TV/Video is an increasingly popular practice, given the rapid technological advances and reductions in the cost of basic equipment in this area. Along with radio echo and telescopic/binocular observation, more attention needs to be devoted to these branches of meteor astronomy. Nevertheless, meteor photography by far merits more attention and investment from organized groups and in the meteor literature.

12. Reasons for interest

Why do people observe meteors? Answering the question "why?" is always difficult, and to make this task easier, a number of pre-determined answers were presented for respondents to choose from and to place in order of importance. Still, space was left for individuals to write in other reasons which were not explicitly spelled out. The results to this question are tabulated in Table 7.

Table 7 – Reasons for interest in meteor observing. The "points" were computed by according 5 points to a 1st choice, 4 to a 2nd, and so on.

Reason	Preference						
	1st	2nd	3rd	4th	5th	Total	Points
Contribution to science	196	89	47	22	24	379	1546
Fascinated by nature	139	125	40	24	3	331	1366
Spiritual/emot. experience	30	63	59	50	33	235	712
Friendship building	21	64	90	59	19	253	768
Fun	37	32	48	36	49	202	578

Other reasons mentioned are listed below. These should be given a different weight because they have been offered on the respondents' own initiative, rather than simply being ticked off a provided list:

- a good introduction to other aspects of astronomy;
- part of school work;
- sharpens observational skills;
- a relaxing night-time experience;
- no need for telescope;
- last bastion of naked-eye astronomy;
- good observational practice;
- first practical work in astrophysics;
- the gathered data is unique, irreplaceable, and not predictable;
- excitement of monitoring rates;
- can compare own results over various nights;
- can reduce own results and compare them with those of other observers.

The main preference shown by 75% of respondents is towards the possibility that meteor astronomy still has towards the advancement of knowledge and science. This confirms the importance of taking each meteor observation to a scientifically useful conclusion. This, in turn, implies following certain observational procedures, noting down relevant data, reducing the data, pooling it, and passing it on for further analysis. If observing meteors is simply a night-time activity for fun or an excuse to meet friends and stops there, it will not by itself provide much meaning and few incentives for more than a short term flirtation with the practice.

However, a scientific justification by itself is often just as empty and will not, in the main, make for sustained commitment to the practice. Over 95% of respondents mentioned more than one reason for observing meteors; and the fascination with the wonders, spectacles and surprises of nature scores very highly, even as a first choice. The activity allows an encounter and exposure to a variety of skills, experiences, and pleasures. The element of fun, a sense of emotion, and the opportunity for friendship building do not score dismally, although they are distinctly not as heavily subscribed as the other two options. All in all, there is clearly a fairly rounded and multifaceted interest in meteor watching; and further inroads among potential meteor watchers should not dismiss or underestimate each of these separate and disparate yet complementary characteristics and rewards. Indeed, meteor organizations should take those measures which support, facilitate, and develop as many of these features as possible, while widening access to, and awareness of, the hobby.

13. The first meteor watch

What were the reasons which encouraged respondents to have their first feel of a meteor observation? A large variety of reasons were provided, with some fascinating personal experiences. These were categorized in the following manner to permit analysis:

• Simple curiosity	66	
• Casual meteor observation	26	
• Information from		
– radio		6
– popular magazine		22
– talk/conference/convention		10
– TV reports on a strong shower		6
– books		6
– publicity on a strong return		15
– a local society		16
– internet		4
• After participating in		
– local science center activity		10
– astronomy camp		18
– locally organized group watch		64
– a visit to a local observatory		14
• After an invitation by		
– role model/teacher to participate in project		16
– friends/colleagues to try it out		57
– parent		10
• Astronomy class in high school	33	
• Only way to practise naked-eye astronomy	14	
• Part of one's work	23	

Mere curiosity, the chance encounter with a splendid fireball, or the witnessing of a spectacular meteor outburst have been mentioned as some unexpected and unplanned ushers to a sustained practice of meteor observation. These by themselves are the explanations provided by just over a fifth of all respondents. The remaining 79%, however, report events which are structured or explicitly prepared by people and which therefore can be incorporated into recruitment drives for more and better meteor watchers.

First comment concerns the importance of popular literature and media channels. Almost a fifth (19%) of all respondents claim that their entrance to the world of meteor observation is due to the reception of some form of information. Various respondents commented on specific publications such as the *Sky and Telescope* Magazine or one of Patrick Moore's astronomy books. Certain potential meteor watchers will never be met face to face. The only way that these can be informed about the practice and invited to try it out must continue to remain dependent on impersonal, mass communication channels. Of course, certain specific audience and readership markets—such as general astronomy lovers or science students—are more likely to harbor would-be meteor enthusiasts; more sustained attempts should be made at communicating the existence of organized meteor watching and its contributions to science, friendship, skill development, etc., to these, more select, pockets.

Secondly, note the critical importance of some local association in making personal contacts with individuals who then decide to pursue the hobby. One quarter (24%) of respondents claim this form of introduction to meteor observation, and especially after having "tasted" the experience of a meteor watch first hand. Nothing can replace the motivational baggage of a direct experience and it is here that local associations are irreplaceable to help structure and organize such events at appropriate occasions, particularly in combination with reliable annual meteor shower displays.

Thirdly, and just as importantly, there is the personal touch. Sometimes, both the necessary information and the local meteor association will be alive and active; yet, unless some attempt is made at reaching out and actually inviting people to come and experience the event, then so many will remain unconcerned with meteor astronomy. This is the experience reported by almost another fifth (19%) of respondents. The initiative must be taken by someone, and when one waits for this to be taken by someone else, so many opportunities may be lost. How often do the extant meteor watchers actually and consciously try to conscribe new and fresh recruits into the hobby—from among friends, schoolmates, workmates, relatives, or acquaintances? The issue of succession planning is an important concern for any organization which seeks to remain alive and dynamic. It is too serious and important an issue to be left simply at the mercy of Lady Luck or market forces.

Finally, another small but significant sub-set of responses (7%) identify that their first encounter with meteor astronomy occurred via a school-based program. These data lead us to consider the importance of accessing young, especially secondary or high school age youths, via some kind of school-based meteor astronomy activities. This is already the case in certain countries or schools which enjoy a relatively liberal curriculum, such as the United States. Meteor astronomy also has fairly close affinities with various aspects of the traditional curriculum which particularly include general science, environmental science, physics, and geography. Local, regional, or national associations may seek to enter into agreements with local schools to offer introductory courses on meteor watching to students on a voluntary basis after school hours; or to invite schools to take part in specific educational events relating to meteor astronomy, including casual meteor observation. The relationship of actual meteor work to school education is probably one area which still remains underexploited today. Indeed, science teachers are mentioned by quite a few respondents as role models and/or as those who introduced them to meteor astronomy. Data below will confirm that the middle teens, when individuals are still students in most countries, constitute the critical period for embarking on a meteor watching hobby.

14. Role models

More information about the nature of this personal touch in being a catalyst to joining the practice of meteor observation has been provided from answers to other questions. Over half of the respondents (271 out of 443, or 61%) confirm that their beginning and continued practice as meteor watchers has benefited significantly from the advice, example, efforts, or other features of another person, summarily referred to as a "role model." The status of such persons differs, but the categorized results suggest some interesting insights:

• Astronomy association leaders	131 of which	
– local		74
– national		24
– international		3
– unspecified		30
• Friends	42	
• Teachers	32	
• Parents	13	
• Public/professional astronomer	9	
• Authors	4	
• Unspecified	40	

The data confirm the comments made earlier about the features and circumstances which led individuals to start meteor astronomy practice. It strengthens the arguments in favor of the personal touch, especially from those best placed to do so. These are invariably local astronomy or meteor association leaders, along with friends who already practise the hobby. As described by the respondents, these role models act to provide a variety of services. They offer the warmth of a personal relationship, often friendship, between persons; they issue words of encouragement for more or better effort; they create the space for the relatively young or inexperienced not to feel overawed by the seasoned veterans and to integrate just as well with the group. They also provide concrete expressions of appreciation for the observing hours clocked and for the reports submitted by words of praise or by printing such appreciation in local newsletters and magazines, often with the names of the observers concerned. This latter feature is one source of great encouragement and should be taken up by all meteor groups. It does not take much, but the gesture can be a big morale booster.

I will list below the names of role models which have been volunteered by the respondents. Many of these are mentioned over and over again by respondents hailing from the same country, although some role models are not co-nationals. The list is not meant to be exhaustive: I am sure that there are many other exemplary characters out there. It may be useful, however, to investigate at some point what this smaller group of meteor watchers have in common: how is that as an idea for another smaller survey? Here are the names:

> Hans Salm, Grover Soria, Hedy M. Teidons (Argentina); Michael Buhagiar, Maurice Clark, B.J. Harris, Cliff Smith, Lance Taylor, Jeff Wood (Australia); Jan Van Elst, Dirk Engelen, Hendrik Vandenbruaene, Cis Verbeeck (Belgium); Ivanka Getsova, Simeon Vladimirov (Bulgaria); Mei Bao, Tang Bing, Yang Chunping, Chen Donglin, Chen Donhua, Ouyang Tianjing, Ha Xianheng, Pin Xin Xu, Sun Xuayuan, Feng Zhan-Liang (China); Slaven Garaj, Korado Korlević (Croatia); Gotfred M. Kristensen, A.V. Nielsen (Denmark); Jürgen Rendtel, Hans Georg Schmidt (Germany); Neil Bone, John Bonsor, Alan W. Heath, Alastair McBeath, Tom McEwan, Michael F. Pace (United Kingdom); Marcus Hetakainen (Finland); Kojiro Komaki, Y. Kushida, Y. Matsumoto, M. Shibata, M. Sioya, K. Suzuki, M. Takanashi, Yasuo Yabu, H. Yamaguchi, I. Yamamoto (Japan); Khalil Konsul, Ala'a Shahin, Khalid Tell (Jordan); Godfrey Baldacchino, David Mizzi (Malta); Ben Apeldoorn, Peter Jenniskens, Koen Miskotte (the Netherlands); Mike Potter, Graham Wolf (New Zealand); Valentin Grigore (Romania); Josef Bezak, Igor Chromek, J. Gerboš, Juraj Humenansky, Ivan Kopal, Peter Majchrak, Martin Makuch, Dikova Marta, Jan Masiar, Michal Maturkanic, Ivo Micek, Radovan Mirovic, Daniel Očenáš, Pavol Rapavý, Lubomira Sesvickova, Julius Sliz, Svetozan Štefeček, Vladimir Topinka, Peter Trojak, Peter Zimnikoval, Miroslav Znášik (Slovakia); Aram Karalič, Bastjan Kosir, Gorazd Martincic, Jože Prudič (Slovenia); Moises Gil Bernabe, Luís Ramon Bellot, Domingo Doreste, Eduardo Martinez Moya, José Trigo (Spain); Jack Bennett, Tim Cooper (South Africa); Anna Levina (Ukraine); Robert Lunsford, Norman McLeod, Gary Schmidt, George Zay (USA); and Dragana Okolić , Branislav Savic, Stanislav Žabić (Yugoslavia).

Note how very few of the above are women, confirming the male domination of the meteor observer population and making it of course less likely for women to find inspiration from other female friends and colleagues to consider starting the hobby.

15. Starting age

At what age did the respondents' exposure to the practice of meteor observation begin? Firstly, note the average age at which the first meteor observation was undertaken, divided by country, as shown in Table 8.

Table 8 – *Mean age at which respondents started meteor observing.*

Country	Mean starting age	Country	Mean starting age
Slovakia	17	Japan	17
Belgium	15	USA/Canada	27
United Kingdom	22	China	28
Spain	20	New Zealand	24
Slovenia	17	Jordan	31
Netherlands	15	Bulgaria	17
Malta	16	Romania	21
Argentina	32	Croatia	17
Finland	25	Germany	29
Yugoslavia	17	Bolivia	30
Denmark	23	Norway	15
Sweden	22	South Africa	25
Switzerland	19	Australia	19

The spread of mean ages at which national groups have commenced their experience with meteor watching covers a rather narrow band: from a younger limit of 15 years (Belgium, Netherlands, Norway) to an upper limit of 30–32 years (Argentina, Jordan, Bolivia). The lower limit is likely in the case of individuals who first got to know about meteor astronomy when they were students, whereas the upper limit represents individuals who got to know about meteor astronomy out of school, after they have typically settled down at work and with a family. The lower limit is however much more common, and 50% of national means above fall within the age band of 15–20 years.

For a more detailed analysis of the above figures, the age at which each respondent reported having started his/her experience with meteor watching was noted. These data are tabulated in Table 9.

Table 9 – Distribution of the age at which respondents started watching meteors.

Age	Respondents	Age	Respondents	Age	Respondents
6	3	22	9	38	1
7	2	23	9	39	2
8	1	24	6	40	1
9	3	25	6	41	4
10	6	26	5	42	3
11	7	27	8	43	3
12	16	28	3	44	2
13	38	29	3	46	1
14	42	30	3	48	1
15	45	31	2	50	2
16	55	32	3	51	3
17	45	33	2	52	2
18	26	34	6	54	2
19	22	35	4	56	2
20	14	36	2	57	2
21	12	37	3	60	1

The total spread is suggestively from six to sixty. But the modal age is sixteen: 12% of respondents claim that their first exposure to meteor watching occurred at that particular age. The 5-year spread from 13 to 17 represents the first experience with meteors for just less than half (46%) the whole population of 438 respondents.

The implications to be drawn from such data are concerned with the variety of public relations efforts which need to be deployed at the critical age range of 13–17 years. Enticing and inviting newcomers to meteor watching at this age is best done via schools but also youth clubs, volunteer organizations and other social, leisure and sports associations which youths are particularly keen to join. Literature and information may also be targeted at these bodies; and current enthusiasts should consider organizing that one-off lecture or field experience open to, or organized specifically for, members of such groups.

Of course, nature can come in handy here and a particularly spectacular natural display may serve as that critical variable which gets meteor observers "hooked" to this pastime. That much is evident when one examines the data relating to the year when the first meteor observation was held, as shown in Table 10.

Note some obvious spikes within the overall steady increase as one approaches the present time. Many of these spikes correspond to very good meteor displays in that particular year or to an astronomical event which in itself generated much more interest among the general public in events meteoritic. Note such spikes in 1966 (Leonid storm); 1969 (Apollo-11 moon landing); 1972 (Giacobinids); 1978-80, 1988 and 1993 (good Perseid returns) and 1986 (Comet Halley's return and the η-Aquarid/Orionid coverage as part of the *International Halley Watch*). Using the same line of reasoning, one may expect a fresh crop of meteor enthusiasts to follow in the wake of the expected Leonid storm in 1998-99.

However, the figures above also point indirectly to another feature: a strong attrition rate among meteor observers. The spectacular Perseids or Leonids may do their part to entice new meteor observers to the fold; but what happens to these new observers after a few years? The above statistics reveal a clear problem of perseverance. Indeed, 150 out of the 443 respondents to the questionnaire (34%) only started observing in 1993 or later.

16. Balance of experience and youth in national groups

Other data reveal a problem which is exactly the opposite of the attrition one mentioned above, but which is just as significant. This concerns the relative absence of new recruits in many national groups and where older members persevere without a regular injection of newcomers. This phenomenon may spell danger to the long-term survival of such national groupings. Consider the data collated in Table 11.

Table 10 – Distribution of the year in which respondents started watching meteors.

Year	Respondents	Year	Respondents	Year	Respondents
1930	1	1967	4	1982	6
1939	1	1968	4	1983	10
1940	1	1969	10	1984	11
1943	2	1970	4	1985	10
1950	2	1971	5	1986	16
1952	1	1972	11	1987	10
1957	1	1973	2	1988	25
1959	1	1974	3	1989	13
1960	4	1975	5	1990	17
1961	1	1976	6	1991	24
1962	1	1977	5	1992	27
1963	2	1978	8	1993	48
1964	2	1979	9	1994	33
1965	3	1980	8	1995	46
1966	6	1981	6	1996	28

Table 11 – Break-down per country of average years of observation per person (Duration), standard deviation (σ), number of observers who started since 1993 (Obs. since 1993), and total number of observers (Obs.). (For countries not considered, there are only 8 respondents or less, which is insufficient to permit any valid comments).

Country	Duration	σ	Obs. since 1993	Obs.
Slovakia	7	8	60	114
Japan	23	11	2	55
Belgium	8	6	6	26
USA/Canada	14	15	7	26
United Kingdom	17	12	4	22
China	8	8	6	20
Spain	7	3	5	18
New Zealand	10	15	8	16
Slovenia	6	4	6	15
Jordan	3	1	14	14
Netherlands	17	9	1	14
Malta	9	5	1	12
Bulgaria	3	2	8	11

Most respondents in such countries as Jordan and Bulgaria have very limited observational experience. No Jordanian respondent has more than 4 years of observational experience. In contrast, countries such as Japan, the Netherlands, Malta, and, to a lesser extent, the United Kingdom may be relying too strongly on the existing corps of observers. It may be high time to launch a campaign for new recruits in these countries. The succession problem becomes more glaring when one realizes that the existing corps of observers have a strong group identity, prefer group watches, and may therefore, by their own clannish behavior, act unconsciously in such a way as to preclude newcomers from feeling comfortable with the existing group. Such a group consciousness is relatively clear in the case of Bulgaria, Jordan, Malta, Slovenia, and Spain, with their low levels of standard deviation.

17. Participation in association activities

There seem to be two essential types of meteor observers: the solo type and the gregarious type. There are 55 respondents (13%) who claim not to participate in the work of any association. A fair number of these—36—also admit that they do not keep records of their meteor observation. So much potential data is therefore not being recorded and is sadly lost to the scientific community.

In contrast, some 40 respondents (9%) claim a multi-level participation in local, national, and international associations. But then, there is an almost equal number—33—(8%) who prefer plugging into international associations to the exclusion of a link with the local or national level of activity. This is of course a personal decision and is to be respected as such; but the failure to link up with grass roots organizations may prove to be a key factor which eventually leads to an early abandonment of what remains a very private pastime.

The following participation figures were obtained:

• No associations	55
• Local level	185
• National level	223
• International level	73
• International level only	33
• All three levels	40

18. What is done with one's observations?

So much precious data is apparently not finding its way to centers of analysis and data collection, be they national or international. Only 274 respondents (63%) actually pass on their data to national coordinators or to the *International Meteor Organization*, often to both. This is a surprising discovery and may have to do with a number of features. These would include a lack of familiarity with standardized observing or data reduction techniques—an issue which some groups may be even embarrassed to admit. The corollary to this would of course be that the standardized observing procedures and report forms are seen as too stringent, and the intentions behind each step are not fully understood by, or have only been poorly explained to, the observers.

Of 443 respondents, 37 do not keep their data; of the 406 that do, 128 filed their data away, whereas 278 pass them on, either with some analysis (126) or without (152).

19. General remarks

This section is devoted to a review of the plentiful comments and suggestions that many individual respondents chose to make, in response to an invitation to this effect at the end of the questionnaire. Such responses are very difficult to categorize and the synopsis below is only undertaken with the full realization that it does not do justice to the detail and intention of each and every comment. Such is the necessary evil to permit a general and collective analysis, however.

One often quoted suggestion is the need for wider and better publicity to the meteor observation. Advertising by means of writing articles in key magazines and journals, especially *Sky and Telescope* and any local astronomy publication, were often mentioned. The mass media and their coverage are important allies in the struggle to disseminate more and better information to a still wider catchment group. One concrete suggestion is to contact local radio and television stations and to inform them of forthcoming spectacular meteor events, volunteering them information, and offering to act as contact persons or expert resource persons on such and related subjects, such as that somber and very real threat posed by light pollution. The media is generally only too glad and relieved to oblige. Other activities would be to exploit the potential of the internet and to produce more video productions on meteor watching or meteor displays. So many people remain unaware that it is so easy to observe meteors; and it costs nothing.

One other often mentioned suggestion was the production of an observing handbook in the local language. This is an evident need, particularly where English is not readily understood and all the more where the logic of the rigor of observational procedure, particularly as demanded by the *IMO*, is not well comprehended. Extending information about meteor astronomy in the vernacular will also help to make larger chunks of the local population conscious to what the practice is all about. A special kind of text may also be prepared with younger audiences in mind.

Another recommendation consisted in the preparation of an astronomy workbook which concentrates on what one can actually see and do before, during and after a meteor watch. These tips may also profitably find their way to educational science project suggestions at secondary school level. (I have already made such a suggestion to the *IMO* Council and they have agreed to launch such a venture. I shall soon be issuing an invitation for submissions to such a workbook in the near future.)

The extension of personal contacts must not be underestimated, especially today with the advent of mass communication technologies. One underutilized dimension in the *IMO* is the regional one. Horizontal, rather than vertical, networking can be resorted to at supra-national but sub-international scale. It should be possible to organize small scale, regional encounters between meteor observers from neighboring countries to co-organize conferences or observational camps on the subject, share results, practise observations together and analyze data together as well. Short training courses may thus be organized, based on practical methods of observation and data analysis. Some meteor groups have issued requests for knowledgeable "experts" to come over and instruct them in observational procedures and data reduction. Surely, observer empowerment—in the sense that observers will be able to record data and then derive comparable results by themselves at a local level—will help to increase a sense of meaning and therefore boost perseverance and commitment in the practice of meteor observation.

Some comments have been addressed at the *IMO* itself. Different and contradictory comments have been lodged concerning *WGN*, the *IMO* Journal. On one hand, there has been a spate of concern about ensuring that articles in *WGN* are scientific, well-researched, and subjected to a rigorous reviewing process. On the other hand, somewhat more respondents protest that *WGN* tends towards the unreadable and too heavy-going, quickly removing any shred of enthusiasm that meteor observers may have with their hobby. Furthermore, the existence of the *IMO* does not imply a monopoly over the collection and reduction of data. The advantage of global organization is by now quite self-evident: the potential of the *Visual Meteor Data Base* (*VMDB*) is enormous, to mention one example, and this has led to startling discoveries such as the double Perseid peak in the late 1980s. However, this is not to detract from comparative national or regional initiatives in data analysis, while the *VMDB* itself is available for specific processing following request. One objective of the *IMO*, after all, is also to help support local, national, and regional associations in promoting quality meteor astronomy practice.

20. Conclusion

This is only the end of the beginning. I would therefore consider it proper to bring this pioneering investigation to a close without a tight and comprehensive conclusion. So many issues have been raised and there are no doubt different lessons to be drawn, and different details to be debated further. These initiatives need to be carried out with respect to particular national groups, meteor astronomy generally, individual meteor observers, actual or prospective role models, and for the *IMO* itself.

I am confident that the *IMO* Council will consider the above results carefully in the context of the organization's long-term goals. May I also invite individual readers of *WGN*, national coordinators, and both respondents and non-respondents to the questionnaire to use the pages of *WGN* profitably and thus to continue the discussion on the results which I hope I have launched adequately. This can be done by means of contributions in the form of "letters to the editor." Otherwise, one may resort to private correspondence, all of which I promise to answer in as satisfactory a manner as possible. Let the profitable observation of the meteor observer continue.

Practical Meteor Photography
Part V: Planning of Double-Station Photography

Marc de Lignie

Preface

The *IMO* Photographic Handbook provides a wealth of information, but in some parts additional practical hints would be useful. This series of short articles intends to fill this gap and to support beginning meteor photographers in deciding which materials to use, which methods to apply, etc. The information in this series originates from experienced meteor photographers and has proven its value in practice.

Introduction

Previous issues in this series provided technical information about the construction of a camera set-up. With two such set-ups, it is possible to photograph the same meteor from two different stations: double-station photography. As is generally known, such a pair of photographs allows to calculate the trajectory of the meteoroid through the atmosphere and its orbit around the Sun.

When you want to experiment with double-station photography, you will have to select the locations of the two stations and to determine the best point in the atmosphere to aim the cameras at. There are two criteria to take into account:

1. The further the meteor is photographed from the radiant, the more accurate its velocity can be determined (with an optimum of 90° distance). Usually, it is best to avoid aiming the camera directly at the radiant of the active shower.
2. When you draw great circles through the meteor paths on the celestial sphere, the angle between the two circles is the so-called angle of convergence, or Q. The greater this angle, the more accurate are the results of the calculations. Usually, you want an angle larger than 20°.

1. General behavior of the angle of convergence

It is useful to look first at the general behavior of Q, in order to choose the optimal locations of the stations. The important parameters are the length of the baseline (distance between the stations) and the angle between the baseline and the azimuth of the active radiant. Figure 1 shows how Q changes as a function of these parameters, when the radiant has an elevation of 45°. This figure does not show Q for a specific camera direction, but rather an average Q for all possible camera directions between 30° and 90° elevation and between 0° and 360° in azimuth (an average of a large number of Q values, such as in Figures 2 and 3).

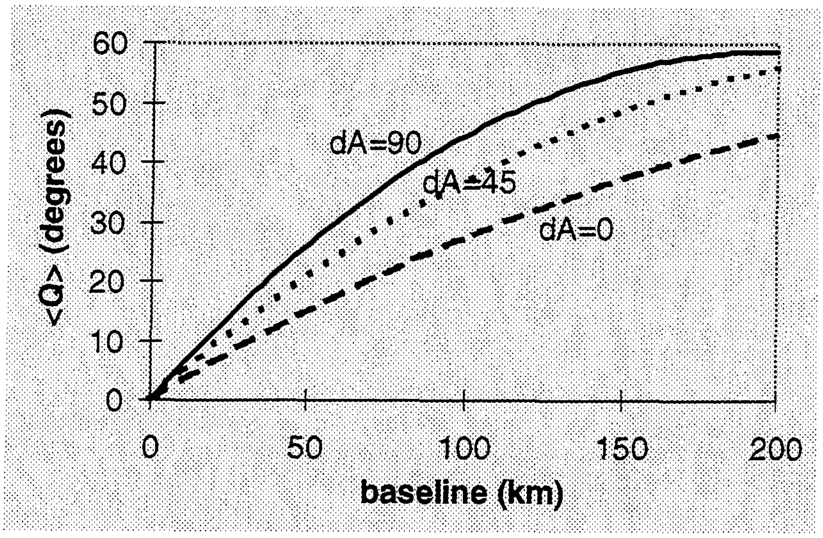

Figure 1 – Average angle of convergence of double-station sets of meteor photographs for different values of the baseline length and the angle (dA) between the baseline and the azimuth of the active radiant.

From Figure 1, we can derive two general rules:

1. the larger the baseline of the cameras, the larger the average Q; and
2. the larger the angle between the baseline and the azimuth of the radiant, the larger the average Q. So, preferably the cameras should not be lined up with the radiant at any time during the night.

The first rule has a practical limit of about 200 km, in which case the two cameras have to be pointed in opposite directions towards each other. For camera batteries, the practical limit is even as small as 100 km, because for larger distances the overlap in covered areas of atmosphere becomes very small. In general, any baseline larger than 50 km is all right.

When the radiant has an elevation higher than 45°, the second rule becomes less important. With an elevation of 90°, the values of Q lie just below the upper line of Figure 1.

2. Predictions for a specific set of locations

Once you have chosen the locations of your stations, you need to determine the optimal aiming point for your cameras. The need for this is clear from Figures 2 and 3, which show the values of Q for different aiming points for two different configurations of stations. Figures 2 and 3 can either be interpreted as a large circular geographic area (with a diameter of 350 km) or as the projected celestial sphere as seen from a point between the two stations. The aiming point is a point in the atmosphere 100 km above a particular geographic location in the figure.

In Figure 2, the best values for Q are found when the aiming point is chosen in the direction of the radiant. This corresponds with fields of the two cameras just left above and right above the radiant. Figure 2 also shows that there is no problem when the radiant moves during the observation period, because the value of Q does not vary strongly as a function of the aiming point.

In the situation of Figure 3, with the two stations lined up with the radiant, choosing the right aiming point is difficult. Large values of Q are only found when the cameras are pointed close to the radiant or at low elevations left below or right below the radiant. You can choose left or right depending on the movement of the radiant during the observing period.

3. Computer program

Figures 2 and 3 may be difficult to interpret, but they are meant to help you work with a computer tool called `qricht.exe` (for DOS). This tool can be obtained from the "Photographer's page" of IMO's WWW site. This tool requires the following input information:

- start date of the observing campaign;
- end date of the observing campaign;
- geographic coordinates of 2, 3, or 4 stations;
- height in the atmosphere of the aiming point; and
- geographic coordinates of the aiming point in the atmosphere.

```
             8  7  6
       15 14 14 13 12 10  7
    19 20 21 21 21 20 18 14  6
 19 22 24 26 28 30 31 31 28 15 17
 21 24 27 31 34 38 42 48 54 51 53
18 22 26 29 34 38 44 51 62 80 56 64 56
18 22 26 30 35 40 46 55 67 90 42 49 60 radiant
18 22 26 29 34 38 44 51 62 80 56 64 56
 21 24 27 31 34 38 42 48 54 51 53
 19 22 24 26 28 30 31 31 28 15 17
    19 20 21 21 21 20 18 14  6
       15 14 14 13 12 10  7
             8  7  6
```

Figure 2 – Angles of convergence for aiming points 100 km above different locations on the Earth's surface. The geographic distances between these locations correspond to roughly 10° in a camera field. The stations are geographically located 30 km above and below the center of the picture. The radiant is to the right at an elevation of 45°.

```
                 radiant
                16  0 16
          39 56 87  0 87 56 39
       28 39 57 89  0 89 57 39 28
    19 25 33 41 45  0 45 41 33 25 19
    18 22 27 28 22  0 22 28 27 22 18
 13 16 20 21 20 13  0 13 20 21 20 16 13
 12 15 17 17 15  9  0  9 15 17 17 15 12
 11 14 15 14 11  6  0  6 11 14 15 14 11
    12 13 11  9  5  0  5  9 11 13 12
    11 11  9  7  3  0  3  7  9 11 11
        9  7  5  3  0  3  5  7  9
           5  4  2  0  2  4  5
                 1  0  1
```

Figure 3 – As in Figure 2, but now the radiant is located upwards in the figure, in line with the two stations, at an elevation of 45°.

Subsequently, it calculates the following figures:

- azimuth and elevation for the camera at each station;
- right ascension and declination for the camera at each station at different times during the night; and
- the value of Q for the active streams at different times during the night.

So, the tool provides you with all required information to aim your cameras for double-station observations. Only, it does not find the geographic coordinates of the optimal aiming point in the atmosphere. You can find this by trial-and-error, or you can try to apply the general rules and explanation provided in the previous sections.

A good value for the height of the aiming point is 100 km. Table 1 shows more specific values for a few major showers. A distinction is made between photographic observations (typical limiting magnitude of +1) and video observations (typical limiting magnitude of +6).

Table 1 – Average heights in the atmosphere (in km) of meteors of a few major showers.

Stream	Photographic	Video
Quadrantids	89	96
Lyrids	94	101
Perseids	96	104
Orionids	99	107
Leonids	102	108

4. Conclusion

Double-station work requires careful selection of locations for the stations. In addition, when selecting an aiming point, the expected angle of convergence for the active shower has to be taken into account. With the computer program `qricht.exe`, selecting a suitable aiming point and calculating the corresponding camera fields is straightforward.

The Leonids

ILW Bulletin 9: Results of the 1996 Leonid Maximum

Rainer Arlt, Jürgen Rendtel, and Peter Brown

The activity profile for the 1996 Leonids derived from 114 observations comprising 1920 shower meteors is given. A double maximum may be recognized in the ZHR-profile occurring at $\lambda_\odot = 235.^\circ 15$ (eq. 2000.0) and $\lambda_\odot = 235.^\circ 37$ with a maximum ZHR of 46 ± 4. The population index drops to $r = 1.66 \pm 0.03$ in the period $\lambda_\odot = 235.^\circ 30$–$235.^\circ 40$ contemporaneously with the second maximum. The shower profile is $0.^\circ 5$ wide and rich in large meteoroids around the nodal crossing as evidenced by the low value for r in this region. It is suggested that this portion of the profile consists of older material and that if any significant amount of "fresh" cometary ejecta is currently present in the stream it is located before the nodal crossing, but does not dominate the profile. If material prior to the nodal crossing (slightly higher r values observed during the first maximum) is associated with more recent ejecta, this might be an early precursor to the meteoroids associated with any meteor storm in 1998 or 1999.

1. Introduction

The Leonid shower is currently on the upswing of its 33-year period, presaging the return of the parent comet, 55P/Tempel-Tuttle. In 1996, we encountered the orbit of 55P/Tempel-Tuttle some 473 days before the comet itself reached its descending node, while still 0.008 AU outside 55P/Tempel–Tuttle's orbit [1]. This year's Leonid return was favored with good lunar conditions, and in [2] it was suggested that some enhanced activity would be visible this year over the interval $\lambda_\odot = 235.^\circ 0$–$235.^\circ 5$. The possible peak times favored Eastern North America and Western Europe. Good weather conditions in the former region will ensure that a healthy quantity of observational data will be available for a more complete analysis at a later time. Here we present some preliminary analysis of the shower based on observations quickly communicated to the *IMO*. It appears that much of this prediction has come to fruition and that a shower slightly higher than in 1995 occurred over this interval.

2. The observations

While North America had reasonably clear weather in many locales, a lot of European observers were clouded out for the Leonid maximum. Clouds were particularly prevalent over the central and northern parts of Europe on the night of maximum. Several observers put immense efforts into driving to possibly clear areas. Finally, we can present a first activity graph derived from the patchy results of all the keen amateurs who sent in their reports quickly after the maximum night. The following observers contributed to this preliminary analysis of the Leonid maximum:

> Rainer Arlt (Germany), Joseph Assmus (USA), Orlando Benítez Sánchez (Spain), Peter Brown (Canada), Mark Davis (USA), George Gliba (USA), Lew Gramer (USA), Peter Gural (USA), Marco Langbroek (the Netherlands), Wayne T. Hally (USA), Marc de Lignie (the Netherlands), Vladimir Lukić (Yugoslavia), Robert Lunsford (USA), Nick Martin (UK), Tom McEwan (UK), Kevin McKeown (USA), Sirko Molau (Germany), David Moore (Ireland), Dragana Okolić (Yugoslavia), Tim Printy (USA), Ina Rendtel (Germany), Jürgen Rendtel (Germany), Brian Shulist (Canada), Manuel Solano Ruiz (Spain), Ulrich Sperberg (Germany), Jon Stewart-Taylor (USA), Richard Taibi (USA), George Varros (USA), Björn Voss (Germany), George Zay (USA), and Florian Zschage (Germany).

3. The population index and activity profile

The magnitude distributions of 15 observers contained enough meteors to compute reliable population indices r. These values were averaged to provide 5 points as shown in Figure 1. The values show very consistent behavior; a minimum r-value was observed after the time of the closest approach to the orbital node of Comet 55P/Tempel–Tuttle ($\lambda_\odot = 235.^\circ 22$). The minimum is $r = 1.66 \pm 0.03$ at $\lambda_\odot = 235.^\circ 32$ (all solar longitudes are with respect to eq. 2000.0). For the nights before and after the maximum a standard value of $r = 2.5$ was assumed. The r is significantly higher earlier in the peak night close to the first rate maximum.

The magnitude distributions of all observations with limiting magnitudes between $5.^m 9$ and $6.^m 5$ were summed after the perception probabilities (taken from [3]) for each of the magnitude class (according to its distance to the limiting magnitude) were applied. The magnitude distributions were grouped in two periods, one for 1^h–5^h UT, the other for 5^h–$13^h 30^m$ UT. The result is shown in Figure 2 in a logarithmic scale. The population index, which is the slope of the regression line, seems to be constant over the entire magnitude range except for the bright end of the pre-nodal distribution. But the error margins are large as the number of bright meteors is small, and the change in r may not be significant. In the interval $m = [-4^m, -1^m]$ we get $r = 1.4$ but with a low correlation coefficient of $\kappa = 0.95$ between the logarithmic true meteor numbers and magnitude. The second interval $m = [-1^m, +4^m]$ reproduces the r-value of 1.9 with a very high correlation coefficient of $\kappa = 0.998$.

The ZHR-profile is shown in Figure 3; no personal perception coefficients were calculated because of the small data sample available. The exponent for the zenith correction of the radiant was set to 1.0—no ZHRs with radiant elevations below 20° were used. Additional ZHRs were obtained at $\lambda_\odot = 234.^\circ 3$ (November 16) and $\lambda_\odot = 236.^\circ 1$ (November 18) for the days before and after the maximum with 15 and 25, respectively.

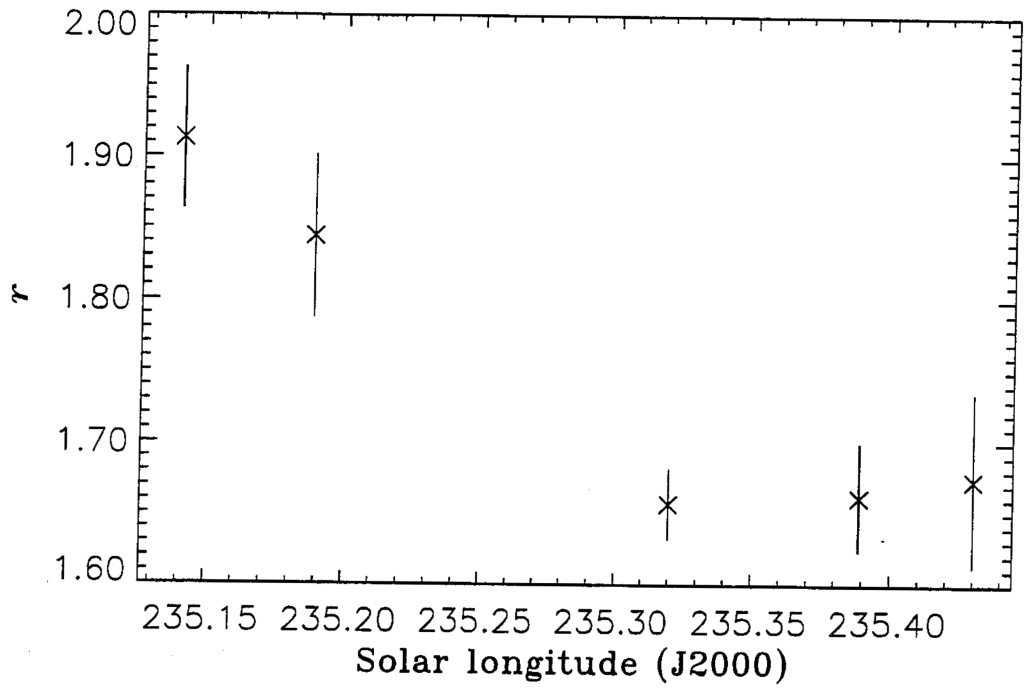

Figure 1 – Population index r versus solar longitude. The profile is derived from individual r-values of magnitude distributions of 15 observers.

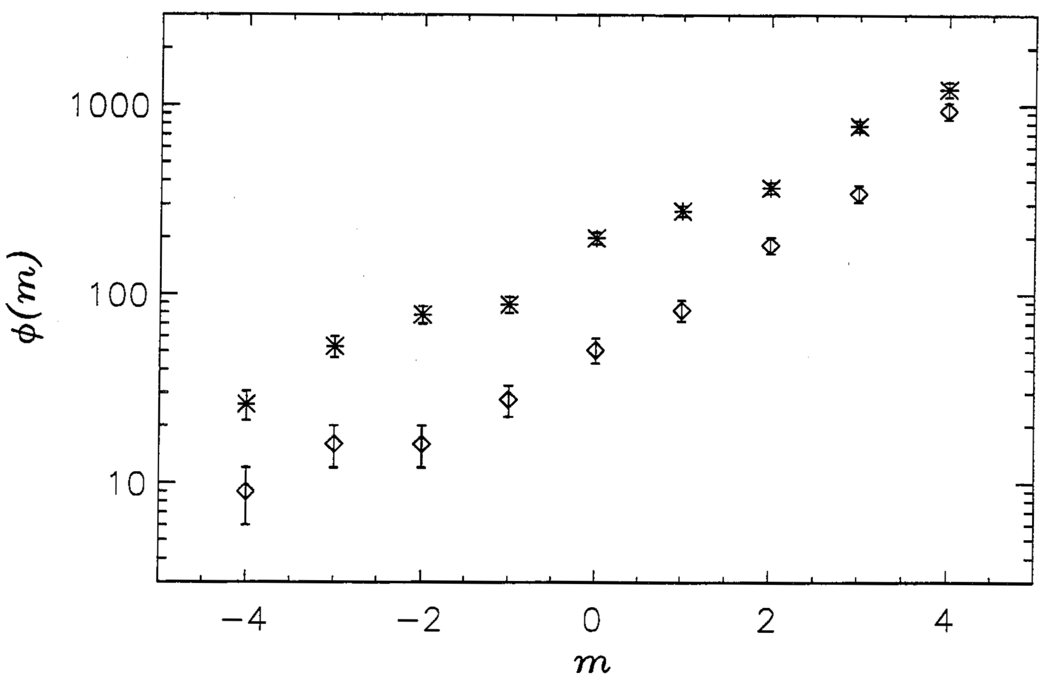

Figure 2 – True meteor numbers $\phi(m)$ per magnitude class m corrected by perception probabilities for the periods November 17, 1^h–5^h UT (diamonds) and 5^h–13^h30^m UT (asterisks). Both curves are separated by a factor of 2 for convenient comparison. The population index r does not appear to vary as a function of magnitude for these data.

The graph does not show a sharp peak close to the comet's orbital node. An activity plateau with a ZHR of about 45 was observed between $\lambda_\odot = 235\overset{\circ}{.}1$ and $\lambda_\odot = 235\overset{\circ}{.}4$. Actually, we may interpret the result as a double maximum structure with highest values at $\lambda_\odot = 235\overset{\circ}{.}15$ and $\lambda_\odot = 235\overset{\circ}{.}37$. The barely pronounced dip between both maxima occurs at the nodal approach time.

It should be mentioned that the overlap of observational intervals between the various regions (Europe, North America) is large enough to exclude systematic effects of different radiant elevations [4]. The ZHRs are fairly consistent for radiant elevations between 22° and 70° for observers at different locations at the same time (see Section 4). This also indicates that the double maximum is not an artifact.

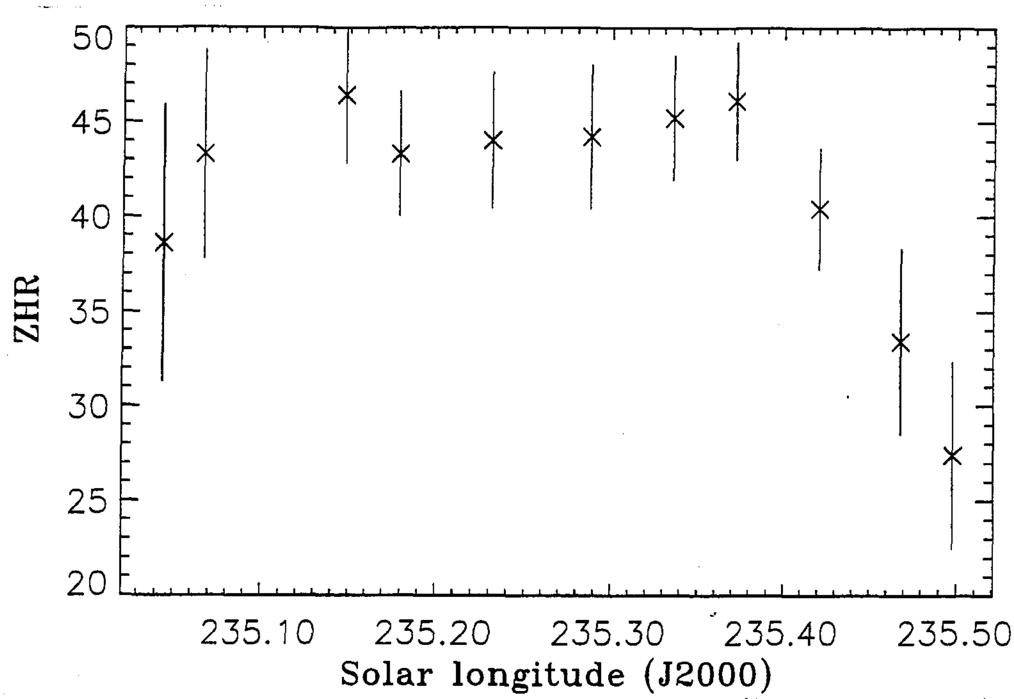

Figure 3 – ZHR-profile of the 1996 Leonids as derived from 114 observations reporting 1920 Leonids. A double maximum is suggested with a dip at the closest approach to the orbital node of Comet 55P/Tempel-Tuttle.

At the location of the first rate maximum we found a population index of $r = 1.91 \pm 0.05$, at the second maximum $r = 1.66 \pm 0.03$, which is distinctively lower. The errors of the population indices are small enough to conclude that this change is significant. The currently available data did not allow the study of the fine structure of the population index, which could show the faint-meteor component expected with the approach of freshly released meteoroids.

A ZHR-profile with a similar structure was observed in 1995 with both maxima being much further from the comet's node [2], but in the same way symmetrical. The distance between the maxima in 1995 was roughly $0\overset{\circ}{.}5$ in solar longitude (with the first maximum being uncertain in time and ZHR peak value), the 1996 distance of the maxima was only $0\overset{\circ}{.}22$, with both maxima approaching the position of the orbital node of comet 55P/Tempel–Tuttle. The maximum ZHR value did not increase considerably: from 35 in 1995 to about 45 in 1996.

4. Zenithal exponent

Since the nights in November are long for northern hemisphere observers, we have the chance to compare observations made from Europe and America at the same time, i.e., observations which represent the same ZHR at very different radiant elevations. The radiant elevation h of a shower's radiant is generally corrected for by $\sin^{-\gamma} h$, where γ is the zenithal exponent, depending on various parameters of meteor physics and often set to 1. We used the period $\lambda_\odot = 235\overset{\circ}{.}20$–$235\overset{\circ}{.}25$ (05^h30^m–06^h40^m UT) with 9 observations at radiant elevations of 22°–70°. As we can assume that the ZHR is constant over that period, a plot of ln(HR) versus $\ln(\sin h)$ shows the zenithal exponent γ as the slope of the regression line, with HR being the meteor number corrected for limiting magnitude, obstruction and effective observing time. The interesting result is that $\gamma = 0.8 \pm 0.1$ which is less than unity, although all other computations (theoretical and empirical) show $\gamma \geq 1.0$. In a second period $\lambda_\odot = 235\overset{\circ}{.}33$–$235\overset{\circ}{.}36$ (08^h40^m–09^h20^m) with 8 observations made at the east and west coasts of North America we get $\gamma = 0.7 \pm 0.2$. Although we may not claim that γ is in fact less than unity, as the physical processes of meteors do not imply $\gamma < 1$, the estimates of γ suggest that it is *not larger than 1.0* for the Leonids. Bellot Rubio [5] suggests $\gamma = 1.0$ for visual observations of the Perseids, which is also a high-velocity cometary meteor shower like the Leonids. The application of the zenithal exponent to the ZHR-profile does not balance the double peak, it only lowers the average ZHRs by about 10%.

5. Discussion

The ZHR-profile shown here is similar to that derived from the 1995 analysis [2]. A possible significant difference between the two years concerns the r-values; in 1996 a difference is apparent in the particle make-up between the two maxima, while in 1995 the two maxima have essentially the same r values (which was also similar to the overall r value for the stream for the entire period of activity in 1995). On the other hand, the available information suggests that the maximum may be only one broad component (about $0\overset{\circ}{.}5$ full width at half maximum) which consists of large meteoroids. This broad nodal distribution lacking in faint meteors is the characteristic signature of older stream meteoroids. Precisely the same behavior was noted in 1965 both by radar observations and visually [6]. McIntosh [7] noted that such a wide sheet of material as observed in 1965 has a nodal spread many times the size of the mean nodal perturbations on the stream as a whole over several revolutions, and hence must have suffered planetary perturbations over a much longer time period. Precisely this behavior (though not for as long as in 1965) is seen for the whole maximum in 1996 and we suggest that this is the reason for the low values for r and the long duration of this portion of the shower. We further suggest that these meteoroids are of order 10 revolutions old. (cf. [8])

Similar Comet-Earth geometries have previously produced similar activity to what was seen in 1996. This is to be expected as such older material is broad in extent and hence more likely to encounter the Earth despite slight changes in nodal distance for the comet and also because the high proportion of bright meteors make the shower visually noteworthy. In 1930, for example, with the Earth at the node of 55P/Tempel–Tuttle's orbit more than 600 days before the comet and less than 0.002 AU closer to the comet than in 1996, Olivier [9] noted that *the shower was remarkable for the number of brilliant fireballs seen.* The available visual observations from 1930 suggest (with the Moon only 4 days from New) that the ZHR was slightly less than 100, $0\overset{\circ}{.}2$ from the nodal point of the comet falling to half this value $0\overset{\circ}{.}2$ later.

When considering the double maximum real, the position of the first maximum is at $\lambda_{\odot} = 235\overset{\circ}{.}15$. This is the same location as that for the 1966 maximum and also that of radar data from 1965, which shows a local maximum at this location [10]. A recent numerical model of the stream [11] predicts that any strong showers during the current Leonid cycle will take place at $\lambda_{\odot} = 235\overset{\circ}{.}16 \pm 0.04$ and that such features are most likely associated with meteoroids ejected in 1932 and 1965. The first maximum in 1996 and the less well defined first maximum in 1995 located near this location may lend support to this model. However, only future Leonid observations will be able to confirm this suggestion.

Acknowledgments

The authors are deeply indebted to all the observers who so promptly submitted their observations to the *IMO*.

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1997 Meteor Shower Calendar Erratum

Alastair McBeath

Perceptive readers of the 1997 *Meteor Shower Calendar* might be forgiven for thinking they had slipped through a time-warp into the 1840s, rather than be still living in the 1990s. For those of you who have not yet spotted the mistake, please amend the 1997 Leonid maximum date and time to 1997 November 17 at around 11^{h} UT, given incorrectly on p. 11 of the *Calendar*.

Observation of a Narrow Component of Faint Leonids in 1996

Marco Langbroek

We report on observations by Dutch observers observing from France during the interval of 2^h50^m–5^h00^m UT, November 17, 1996. There is evidence that two observers (at one locality) observed the ascending slope of a narrow peak of faint Leonids in the period of 3^h30^m–5^h00^m UT. They observed an abundance of faint Leonids during this interval, besides a large number of fireballs. According to their observations, the population index seems to be split into two components: $r \approx 1.5$ for meteors brighter than +1 and $r \approx 3.4$ for meteors fainter than +1. While the observed ZHRs are at a level of ZHR $= 62 \pm 8$ for the early part of the observational interval (2^h50^m-3^h40^m UT), the observed ZHR is 155 ± 19 for the final part of the observational interval (4^h40^m-5^h00^m UT), the increase inbetween being exponential. The slope of the ZHR profile has a B-value of about 30, similar to that of the 1966 and 1866 storm peaks [1,2]. Confirmation is called for.

1. Introduction

We report on a peculiar observation made by the Dutch *DMS* observers Koen Miskotte (KM) and Marco Langbroek (ML) during the Leonid outburst of November 17, 1996. These two experienced observers (Miskotte observed 145 hours effectively in 1995, Langbroek 69) observed the Leonids from Woignarue ($\lambda = 1°29'$ E, $\varphi = 50°06'$ N near Abbéville in the Somme estuary) in Northern France. Observations were possible during two clear periods: 0^h–1^h UT (with the radiant still very low) and 3^h30^m–5^h UT (with the radiant high in the sky). Two other Dutch *DMS* observers, Jos Nijland (JN) and Marc de Lignie (MD), observed from 2^h50^m to 3^h30^m UT at a locality some 50 km distant.

2. An abundance of faint meteors

The magnitude data (Table 1) of Miskotte and Langbroek contain an odd feature. When corrected using a probability function [3], the distributions of both observers for the period 3^h30^m–5^h00^m UT show that the population index was observed to be not constant over the covered magnitude ranges (−6 to +6), but appears to be split into two components. For brighter magnitudes the population index is in the order of $r \approx 1.5$. For fainter magnitudes, the distribution is much steeper and the population index is in the order of $r \approx 3.4$. The turning point is around magnitude +1 to +2. This explains the odd phenomenon reported by these observers in a first impression sent around by e-mail: the observation of both a considerable number of true fireballs and, in addition, the observation of many, many faint Leonids, already judged to be "odd" (and unlike their 1995 observations) by the two observers involved in the field. It shows that in addition to a component of bright meteors, an additional abundance of faint meteors seems to be present.

Table 1 – Magnitude distributions, 3^h30^m–5^h00^m UT (Lm $\approx$ +6.5).

Observer	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6
Langbroek	0	1	3	3	3	2	3	8	10	17	25	26	6
Miskotte	1	0	4	3	2	1	3	11	12	20	25	23	2

3. A steep increase in rates towards the morning?

The observations of Miskotte and Langbroek were done under relatively good (though not excellent due to low haze) sky conditions with limiting magnitudes at or near +6.5. Nijland and de Lignie observed in the preceding interval (2^h50^m–3^h30^m UT) with limiting magnitudes in the range +5.7 to +6.4. The ZHRs as calculated from de Lignie's and Nijland's data nicely fit the ZHRs as calculated for the early part of the observational interval of Miskotte and Langbroek, which in turn agree with early results presented by the *IMO* in the *IMO* Internet newsgroup. Over the full range from 2^h50^m to 5^h00^m UT however, a sharp increase in rates can be seen (Table 2). The increase is exponential and fits the equation of Jenniskens [1,3] for meteor rate behavior:

$$\mathrm{ZHR} = \mathrm{ZHR}_{\max} \times 10^{-B|\lambda-\lambda_{\max}|}.$$

They suggest that a short-lived narrow activity component with a maximum ZHR of at least 100 (for this additional component alone) was present superimposed on a background ZHR of about 50–60 (the broad background outburst component of bright meteors that was also present in 1994 [2] and 1995: see the *NASA* Leonid Web page and [4]), which together accounts for an observed maximum ZHR of 155 ± 19 near 5^h UT. The value for the exponent B of this additional short-lived component is about 30, and $\lambda_{\max} \geq 234.^\circ48$ (eq. 1950.0). At this solar longitude (4^h57^m UT), the observations were stopped because of a rapidly nearing cover of stratus clouds. Later observations during a short period in twilight (5^h40^m–5^h54^m UT) when it had cleared again suggest that the rates observed around 4^h55^m UT might have been the peak rates indeed when we assume a symmetric peak profile [1].

Table 2 – Rate data.

Time (UT)	$T_{\rm eff}$	Lm	$h_{\rm rad}$	Leo	Spor	ZHR	Obs	C_p
3^h05^m	$0^h.52$	6.4	43°	14	6	50.4 ± 13.5	MD	1.0
3^h11^m	$0^h.50$	5.7	43°	18	7	64.0 ± 15.1	JN	2.0
3^h34^m	$0^h.18$	6.3	47°	8	8	68.9 ± 24.4	ML	1.2
3^h39^m	$0^h.35$	6.3	48°	15	5	65.0 ± 16.7	KM	1.2
3^h53^m	$0^h.23$	6.5	50°	19	10	100.0 ± 22.9	ML	1.2
3^h56^m	$0^h.13$	6.5	50°	7	4	65.2 ± 24.6	KM	1.2
4^h09^m	$0^h.28$	6.6	52°	24	12	91.0 ± 18.6	KM	1.2
4^h11^m	$0^h.32$	6.5	52°	24	17	87.0 ± 17.8	ML	1.2
4^h29^m	$0^h.38$	6.5	54°	30	12	88.5 ± 16.2	KM	1.2
4^h30^m	$0^h.25$	6.5	54°	20	14	89.7 ± 20.1	ML	1.2
4^h48^m	$0^h.28$	6.3	56°	36	20	167.3 ± 27.9	ML	1.2
4^h49^m	$0^h.28$	6.3	57°	31	12	141.8 ± 25.5	KM	1.2
5^h47^m	$0^h.20$	5.6	61°	6	1	68.8 ± 28.1	KM	1.2
5^h47^m	$0^h.15$	6.2	61°	10	5	88.2 ± 27.9	ML	1.2

The observations have been reduced following the procedure outlined in [1–3]. In particular, a correction factor for systematic perception differences between observers (C_p), has been applied to reduce the scatter between the results of individual observers. I have used a population index of $r = 2.5$ in the calculations, which is the average of the $r = 1.5$ and $r = 3.4$ components. It should be noted however that the observations of Langbroek and Miskotte were conducted with a limiting magnitude of about 6.5, in which case the population index cancels out and has no influence on the ZHR calculations. In radiant altitude dilution, $\gamma = 1.4$ was chosen, following [1–3].

4. Discussion

The rates as observed at the end of the observational interval of Miskotte and Langbroek are 3–4σ above the rates as observed early in the observational interval by Miskotte, Langbroek, Nijland, and de Lignie. This certainly may be called significant: it seems very unlikely to us that this is due to statistical scatter alone. The observations were done in a limited time period with the radiant high in the sky: this excludes the possibility that the peak in the profile is an artifact of the radiant altitude dilution correction. Since the observed limiting magnitudes were about 6.5, the possibility that ambiguities in the population index determination caused the peak-like appearance can be excluded too. The rates as seen by the two observers individually (as well as the fit with the observations by Nijland and de Lignie) agree well. In other words, the peak is unlikely to be an instrumental artifact or an artifact of the reduction procedure.

However, since the two observers were observing from the same locality (and in the same general sky area), the possibility that the peak is a local artifact cannot be excluded. Therefore, we strongly call for confirmation of this observation by visual or radar techniques if such exist and are appropriate to the task. In this respect, it should be emphasized that an observer observing with low limiting magnitudes (worse than 6.0) might well miss this peak of faint meteors completely so care should be taken in interpreting results.

The B-value of the ascending slope in the data is about 30, which interestingly enough is the same as that observed for the narrow storm peaks in 1866 and 1966 [1,3]. Another similarity between the discussed feature and the 1866/1966 narrow storm peaks is the emphasis on faint meteors [1,3]. Could this therefore be an early modest appearance of this "storm peak" dust component? If so, it should re-appear with larger strength in 1997 at a solar longitude slightly later in time, closer to the cometary node. The behavior over 1996–1997 might enable a better prediction for the 1998 occurrence. It is interesting to note that a possible short-lived period of high activity, though uncertain, was also reported for 1995 [4] around solar longitude $\lambda_\odot = 234^\circ.3$ (eq. 1950.0), slightly earlier, which fits the pattern.

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