Proposed research

Multiple station meteor observations: an international program for studying minor showers exploring IMO potentiality

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The International Meteor Organization (IMO) should promote between its members and collaborators the development of multi-instrument campaigns in order to study minor meteor showers. It is well known that amateurs can contribute to professional research by participating in the atmospheric monitoring of the night sky for meteor and fireball recordings. The determination of atmospheric trajectories and heliocentric orbits of meteoroids is a valuable contribution to different research fields such as: orbital dynamics, non-gravitational effects, interplanetary processes (collisions, fragmentation, etc...), meteoroids' physical properties and atmospheric interaction. At the same time, these studies can be complemented with meteor spectroscopy that can provide valuable information on the meteoroid (and parent body) chemical composition and the effects of space weathering.

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1 Minor showers: a challenge for professional and amateur astronomers

The study of minor meteor showers is really a challenge from all points of view.

In the last decade the priority of IMO for promoting the interest of meteor studies and for making recognized the effort of hundreds of amateurs has been remarkable. However, future studies for the unequivocal identification and analysis of minor streams should be seriously considered now that IMO is enjoying a phase of growing international cooperation. At this point, many members are providing valuable information on the Zenithal Hourly Rates (ZHRs) and spatial fluxes of large and moderate meteor showers with typical ZHR > 50. In any case, during the year many minor showers (with $3 <$ ZHR < 50) can be interesting targets for our teams, but usually the low activity of these streams makes it difficult to get conclusive studies. In fact, the study of minor streams will require full collaboration between the members and the different countries represented in IMO. Since its creation IMO has been a reference for collaboration between amateur and professional astronomers, and also a nice example of international cooperation. We would like here to send a call for a new step, a new spirit for collaboration in minor showers research that would be perfectly programmed from WGN. This journal informs us periodically of current activities and activities of IMO members. However, we have realized that although the IMO Meteor Shower Calendar is an excellent initiative for promoting the observation of major streams, it should be complemented with the publication in WGN of particular campaigns to study (or, in some cases, to confirm) the activity of minor meteor showers. The main reason to propose this is because we should obtain the maximum possible information on meteor showers that produce low levels of meteor activity in order to progress in our knowledge in some areas of meteor science: dust trail evolution, orbital diffusion, etc. Nice examples of meteor campaigns promoted from WGN were the different Aquarid or Leonid Projects (e.g. Koschack and Rendtel, 1991; Brown, 1991). The current status and quality level of meteor studies performed by IMO teams suggest that we can start to promote image recording to increase in our knowledge on minor meteoroid streams.

2 Exploring IMO potentiality for minor shower studies

The excellent spatial coverage around the globe of IMO members can help us to confirm or discard the presence of meteors associated with minor showers. To observe minor showers can be very time consuming, and not everybody can regularly spend a whole night recording the meteors. That is why the development of automatic devices is encouraged. The already existing software such as *MetRec* is of considerable value, and it is clear that electronic cameras are the best way to conduct automatic surveys. We are trying to be practical here, but perhaps the best way is to take profit of the existing amateur groups in order to promote multiple-station observations from IMO. This is an important step because single-station meteor observations in this particular case should be complemented with other optical techniques like photography, video or/and CCD imaging (Figure 1 and back cover). Then, in the campaigns we should include as many observers and techniques as possible. Novel observers can initially feel that the fact to incorporate cameras to their observations is increasing the degree of difficulty, but the methodology is quite simple (see e.g. Rendtel, 1993). However, some basic details are given in sections 2.1 and 2.2. In any case, it is clear that experienced amateur groups should lead the

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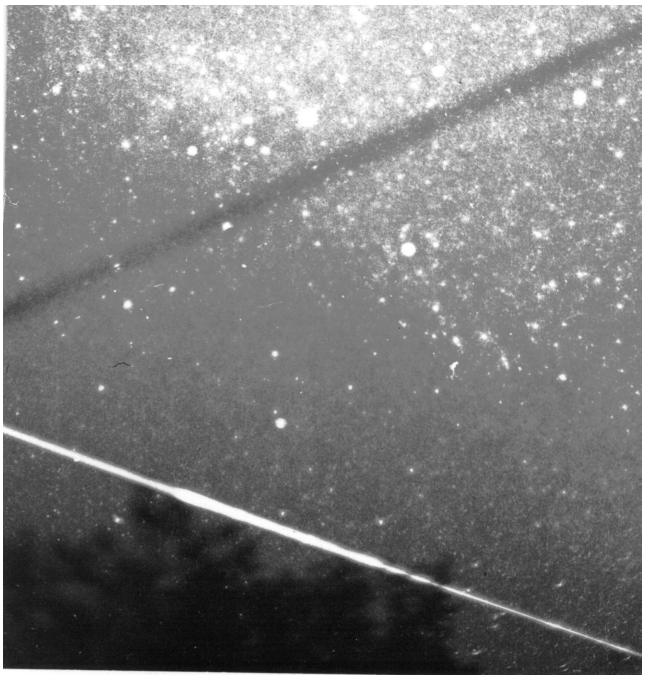

Figure 1 – The study of the activity of rare meteor showers is feasible with the help of amateurs. This $m_V = -6$ fireball photographed on 1981 November 2 by José Berenguer from Valencia (Spain) was probably associated to the Bielids, a highly perturbed stream that nowadays presents a few members crossing the orbit of the Earth. The photograph was exposed for two minutes using a lens of $f = 50$ mm at $f/1.4$. A cable was also photographed crossing the field. The fireball flight is from left to right, crossing Cygnus. Deneb is at top center. Image from the SPMN archive.

initiatives for minor meteor research, promoting these studies 'around' their countries at the same time that they are contributing to IMO.

2.1 Multiple-station camera observations

Multi-station observations are of considerable value since they provide information on the orbit of a meteoroid, which is the best way to link it with a shower. Any dynamical study is based on such association, and new parent bodies are expected to be discovered using this method. To program multiple-instrument recording of meteors from different stations is not an important deal today. Several software applications are currently available, developed by IMO and the Dutch Meteor Society (DMS). We would like only to remark that the Spanish Meteor Network is using the *Photographic centers for multiple station meteor observations* (Trigo-Rodríguez, 2002). This software is currently available for groups of other countries on request. Basically, by defining the different network stations the software derives the common atmospheric center for each station depending on the geometry of meteor apparitions and the geographical coordinates of each station. The program provides the equatorial coordinates of the projected vector in the celestial sphere, and a plot of these centers in celestial gnomonic charts. The centers and charts can be printed out nicely.

The basic procedure is simple. From each station several photographic cameras, or CCD detectors equipped with rotating shutters should be installed (Trigo-Rodríguez et al., 2004, 2005). Camera operators should record exposure times and time of meteor appearance with an accuracy of one second. Later on, common meteors should be astrometrically reduced by using standard methods (Steyaert, 1990; Trigo-Rodríguez et al., 2003). Visual observations are perfectly compatible and recommended during multi-instrument recording. For example, one member of the team could be in charge of the camera exposures, while the rest monitor meteor activity using standard IMO procedures. Meteor plotting is also recommended when the activity level allows it.

In recent years video systems have increased their capabilities, and automatic analysis software has been developed. This is important because the amount of generated video data every night can be huge and it is very time consuming to analyze manually. Recent software that has been used in the *Ursa Astronomical Association Meteor Section* has been SkyPatrol and UFOCapture. UFOCapture especially has proved itself to be a good analyzing software package and it has already helped with the discovery of October Camelopardalids (Jenniskens et al., 2005). By developing a video network, a few operative stations can provide significant amount of information about meteor activity in almost real time.

Another important topic that would be included at the same time is the record of additional information on large fireballs. We will not go over this topic here, but it is evident that increasing the number of multiple-station recording hours worldwide we will get valuable information on fireball events. Collaboration between professionals and amateurs in the last decade has been very important, with nice examples to remark (Spurný et al., 2004; Trigo-Rodríguez et al., 2004, 2005b)

2.2 Meteor spectroscopy

At the same time that multiple-station meteor recordings are performed, diffraction gratings can be easily installed on the front of the camera lenses in order to get the spectral lines associated with the different chemical elements ablated along the meteor trail. We are not including here more details on the procedure because general overviews are available in Millman (1954), Rendtel (1993), and Majden (1998a). However, photographic spectra are limited to bright meteors (or fireballs) while the new video and CCD camera systems are allowing the recording of spectra from faint meteors. Meteor spectra are being considered as a valuable technique that can provide complementary information to high-cost missions to comets. In fact, detailed analyses of meteor spectra provide direct information on the meteoroid chemistry (Borovička, 1993; Borovička et al., 2005; Trigo-Rodríguez et al., 2004, 2005). In the last decade, the amateur contribution to meteor spectroscopy has been remarkable (Majden, 1998b; Weber, 2005) and should encourage other people to develop spectroscopic campaigns in the near future. Although

Table 1 – Minor meteor showers in good lunar conditions to be studied during 2006. The Program column recommends coverage: 'Fol' from general following (intensive effort from all IMO members), 'Ver' from verification of the existence of the shower. References: [1] (Arlt & Vaubaillon, 2006); [2] (Lyytinen & Jenniskens, 2003); [3] (Jenniskens et al., 2005).

Stream Name (Ref)	Program	Activity Period	Maximum	V_g (km/s)	ZHR_{max}	Ref	Moon conditions
Lyrids (LYR)	Fol	Apr 16–Apr 25	Apr 22	49	< 20	IMO	Last quarter
π Puppids (PPU)	Ver	Apr 15–Apr 28	Apr 23	18	Variable	IMO	Last quarter
η Aquarids (ETA)	Fol	Apr 19–May 28	May 6	66	60	IMO	First quarter
τ Herculids	Ver	May 28–Jun 6	June 1–2	16	Variable	[1]	First quarter
τ Cetids (CET)	Ver	Jun 18–Jul 4	Jun 27	66	< 5	IMO/AMS	New moon
June Bootids (JBO)	Fol/Ver	Jun 26–Jul 2	Jun 27	18	Variable	IMO	New moon
κ Pavonids	Ver	Jul 16	23^h23^m UT	?	Dust trail	[2]	Full moon
Piscis Austrinids (PAU)	Fol	Jul 15–Aug 10	Jul 28	35	< 10	IMO	New moon
South δ Aquarids (SDA)	Fol	Jul 12–Aug 19	Jul 28	41	20	IMO	New moon
α Capricornids (CAP)	Fol	Jul 3–Aug 15	Jul 30	23	5	IMO	First quarter
β Perseids	Ver	Aug 8	02^h50^m UT	?	Dust trail	[2]	Full moon
Kappa Cygnids (KCG)	Ver	Aug 3–Aug 25	Aug 18	25	< 10	IMO	Last quarter
π Eridanids (ERI)	Ver	Aug 20–Sep 5	Aug 27	59	5	IMO	New moon
δ Aurigids (DAU)	Ver	Sep 16–Oct 10	Sep 23	64	< 5	IMO/AMS	New moon
October Camelopardalids	Ver	Oct 1–Oct 10	Oct 5	47.3±0.5	20 (in 2005)	[3]	Full moon
α Monocerotids (AMO)	Ver/Fol	Nov 15–Nov 25	Nov 21	65	Variable	IMO	New moon
Coma Berenicids (COM)	Fol	Dec 12–Jan 23	Dec 20	65	< 10	IMO	New moon
Ursids (URS)	Fol	Dec 17–Dec 26	Dec 22	33	Variable	IMO	New moon

the chance of capturing a fireball associated with a minor shower is very low, there is an intrinsic interest in recording as many spectra as possible, even if they are produced by sporadic fireballs. Although the information provided by meteor spectra is very important, the truth is that spectroscopic observations are still a marginal occupation of amateur meteor observers. One of the reasons is that only a few people do have the courage to take the time to analyze and understand a meteor spectrum. Then, we encourage the creation of a basic tool (software) able to perform a first and simple analysis. A database of spectra can also be created, like the one recording every fireball. This would enable a quick comparison between different showers.

2.3 Identifying some first targets: working list of 2006 minor streams

In order to promote minor meteor stream monitoring by IMO members we are here proposing a first working list for the rest of 2006 (Table 1). Of course, not all minor streams are included, and some that can be considered major streams are also included (like e.g. Lyrids or η Aquarids). We should consider Table 1 as only a small selection to be used for the different groups for planning common research. Please note that in the column 'program' we emphasize the type of coverage that should be made: 'Fol' from general following (intensive effort from all IMO members), and 'Ver' from verification of the existence (or e.g. its *presence* in some particular return in case of dust trails). We remark this because the verification campaigns should include mainly optical recording (video, photography, CCD, etc...) while those of general following would be also based in visual observations.

The *Ursa Astronomical Association's Meteor Section* also suggests observing the December Draconids first noticed by the experienced Leo Rajala. The activity of this likely minor shower needs confirmation; it starts in the last week of November and ends in the first week of December. The apparent radiant is located at $\alpha = 135^\circ$ and $\delta = +65^\circ$.

Probably we are missing some important targets here. However, the important thing is that we will be able to identify common targets to be studied in common, and we start a new epoch of close collaboration among our groups. We offer our help in the organization of some specific campaigns by joining efforts with other groups worldwide. Other particular stream research proposals should be send to the next issues of WGN. Please feel free to contact us for additional ideas.

3 Conclusion

International cooperation between amateur and professional astronomers can be very useful in order to obtain orbital and spectroscopic information on minor stream meteoroids. IMO has developed the necessary infrastructure to promote this kind of programs, and WGN should be an excellent place to announce international campaigns that allow us learning more on these fascinating meteor sources.

References

Arlt R. and Vaubaillon J. (2006). "The meteors from 73P/Schwassmann-Wachmann 3 in 1930 and 2006". *WGN*, **34:1**, 15–18.

Borovička J. (1993). "A fireball spectrum analysis". *Astronomy & Astrophysics*, **279**, 627–645.

Borovička J., Koten P., Spurný P., Boček J., and Štork R. (2005). "A survey of meteor spectra and orbits: evidence for three populations of Na-free meteoroids". *Icarus*, **174**, 15–30.

Brown P. (1991). "Bulletin 1 of the International Leonid Watch". *WGN*, **19**, 193–197.

Jenniskens P. (2006). *Meteor showers and their parent comets*. Cambridge University Press. In press.

Jenniskens P., Moilanen J., Lyytinen E., Yrjölä I., and Brower J. (2005). "The 2005 October 5 outburst of October Camelopardalids". *WGN*, **33**, 125–128. See also correction on page 145.

Koschack R. and Rendtel J. (1991). "Aquarid project 1989". *WGN*, **17**, 90–92.

Lyytinen E. and Jenniskens P. (2003). "Meteor outbursts from long-period comet dust trails". *Icarus*, **162**, 443–452.

Majden E. P. (1998a). "Meteor spectroscopy with inexpensive holographic gratings". *J. Roy. Astron. Soc. Canada*, **92**, 91–92.

Majden E. P. (1998b). "A Perseid meteor spectrum". *J. Roy. Astron. Soc. Canada*, **92**, 153–156.

Millman P. M. (1954). "Meteor photography". In *Amateur Telescope Making*. Scientific American.

Rendtel J. (1993). *Handbook for photographic meteor observations*. IMO publication. Currently downloadable at: `http://www.imo.net/photo/handbook`.

Spurný P., Olech A., and Kędzierski P. (2004). "Trajectory and orbit of the EN200204 Łaskarzew fireball". *WGN*, **32:2**, 48–50.

Steyaert C. (1990). *Photographic Astrometry*. International Meteor Organization, Belgium.

Trigo-Rodríguez J. M. (2002). *Spectroscopic analysis of cometary and asteroidal fragments during their entry to the terrestrial atmosphere*. PhD thesis, Universitat de Valencia, Servei de Publicacions, Spain. In Spanish. Downloadable from `http://tinyurl.com/9cnbd`.

Trigo-Rodríguez J. M., Castro-Tirado A., Jelinek M., and 18 co-authors (2005b). "The 2004 Perseid fireball night over spain". *WGN*, **33**, 5–8.

Trigo-Rodríguez J. M., Castro-Tirado A., Llorca J., Fabregat J., Martínez V. J., Reglero V., Jelínek M., Kubánek P., Mateo T., and de Ugarte Postigo A. (2005a). "The development of the Spanish Fireball Network using a new all-sky CCD system". *Earth, Moon & Planets*, **95**, 553–567.

Trigo-Rodríguez J. M., Llorca J., Borovička J., and Fabregat J. (2003). "Chemical abundances determined from meteor spectra: I. Ratios of the main chemical elements". *Meteoritics & Planetary Science*, **38:8**, 1283–1294.

Trigo-Rodríguez J. M., Llorca J., Borovička J., and Fabregat J. (2005c). "Spectroscopy of a Geminid fireball: its similarity to cometary meteoroids and the nature of its parent body". *Earth, Moon & Planets*, **95**, 375–387.

Trigo-Rodríguez J. M., Llorca J., Lyytinen E., Ortiz J. L., Sánchez Caso A., Pineda C., and Torrell S. (2004). "2002 Leonid storm fluxes and related orbital elements". *Icarus*, **171**, 219–228.

Weber M. (2005). "Results of 10 years of photographic meteor spectroscopy". *WGN*, **33:1**, 21–22.