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Leonid fireball
19 November 2017 at 02h29m09s UT
photographed by Paul Sutherland, Walmer, Kent, England

- Alpha Monocerotids 2017
- Southern Delta Aquariids 2017
- October Camelopardalids 2017
- Leonids 2017
- Geminids 2017
- CEMeNt first quarter 2017

Contents

New meteor showers – yes or not?

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The development of meteor astronomy associated with the development of CCD technology is reflected in a huge increase in databases of meteor orbits. It has never been possible before in the history of meteor astronomy to examine properties of meteors or meteor showers. Existing methods for detecting new meteor showers seem to be inadequate in these circumstances. The spontaneous discovery of new meteor showers leads to ambiguous specifications of new meteor showers. There is a duplication of already discovered meteor showers and a division of existing meteor showers based on their own criteria. The analysis in this article considers some new meteor showers in the IAU MDC database.

1 Introduction

Meteor astronomy is a very young branch of astronomy; its development began only 200 years ago. Even in the 18th century, there was a presumption that meteors were present in the Earth's atmosphere and that their origin was not extraterrestrial. There are more than 2500 years old observations of meteor showers (the Lyrid meteor shower in 687 BC or the Perseids in 36 AD), but science has not been interested until the end of the 18th century. The great boom of meteor astronomy occurred in the mid-20th century with the advent of new observation methods – radar and photographic observations. However, the emergence of the use of video technology for meteor studies has meant an unprecedented boom of this branch of astronomy since the 1990s, with lots of new meteor data and a huge number of newly discovered meteor showers. And this fact is problematic and shows that the methods used so far will have to be modified to reflect all aspects of new trends in the field of meteor astronomy.

2 History of meteor showers research

The first pioneer of the true nature of meteors was *Ernst F. F. Chladni*, who published in 1794 the book "*Über den Ursprung der von Pallas gefundenen und anderer ihr änlicher Eisenmassen und über einige damit in Verbindung stehende Naturerscheinungen*", which first dealt with the origin of meteoroids and demolished the two myths of the origin of these bodies: (1) fragments of stone and iron bodies fall from the sky and (2) there are no small bodies in the space behind the orbit of the Moon. In 1807 *Atanasije Stojković* published the first monograph on meteors. Nevertheless, the monograph "*О воздушных камнях и их произхождений*" did not deal with the astronomical aspect of this phenomenon and, moreover, was a unique act in the field of nascent meteor astronomy. In 1833, during the great meteor storm of the Leonid meteor shower (on the night of November 12–13), *Denison Olmsted* noticed that the meteors were radiating out of the sky from one place. He was the first who was able to observe the radiant of the meteor shower, and rightly concluded that this was a perspective phenomenon.

In 1866, *Giovanni Virginio Schiaparelli* carried out Perseids observation analysis from 1864–1866 and first calculated a reliable meteoroid orbit in the Solar System. He also found the connection between Perseids and the newly discovered comet Swift-Tuttle-Simons 1862 III. The same was done in co-operation with *Urbain Le Verrier* and *Theodore von Oppolzer* in the case of the Leonid meteor shower in 1866 when a connection between the Leonid meteor storm and comet Tempel-Tuttle 1866 I was established. Thanks to these discoveries, the idea was promoted that the meteors are the result of the disintegration of comets and that they are not different. This view was confirmed after the breakup of the comet 3D/Biela in 1852 and the subsequent meteor storm of the Andromedid meteor shower in 1872 and 1885. Already at the turn of the 19th and 20th centuries, several weaker meteor showers were discovered, due to the lack of observations for their precise determination, there were long disputes about their existence.

The decline of meteor astronomy in the first half of the 20th century was halted in the 1940s when radars and photo chambers began to be used in meteor astronomy to detect accurate meteor paths in the atmosphere. Until the onset of video technology, the IAU MDC Photographic Meteor Orbits Database (Lindblad et al., 2003), along with the catalog of radio observation orbits, was the only source for discovering and analyzing new meteor showers. The first recorded photographic orbit in the IAU MDC Photographic Meteor Orbits Database dates back to 1936, sporadically discovered orbits began to increase rapidly in the 1950s in the context of the development of photographic networks, and currently the IAU MDC Photographic Meteor Orbits Database includes 4873 multi-station orbits. The European bolid network, which was started by Zdeněk Ceplecha in the 1950s and which was fully operational in 1963, played a major role. New meteor showers began to grow at a rapid pace, refining the mean orbits of known meteor showers at that time, both from photographic observations and from radar observations. At this time, the main authors of the study of meteor showers were: C. S. Nilson (1964), B. L. Kashcheyev and

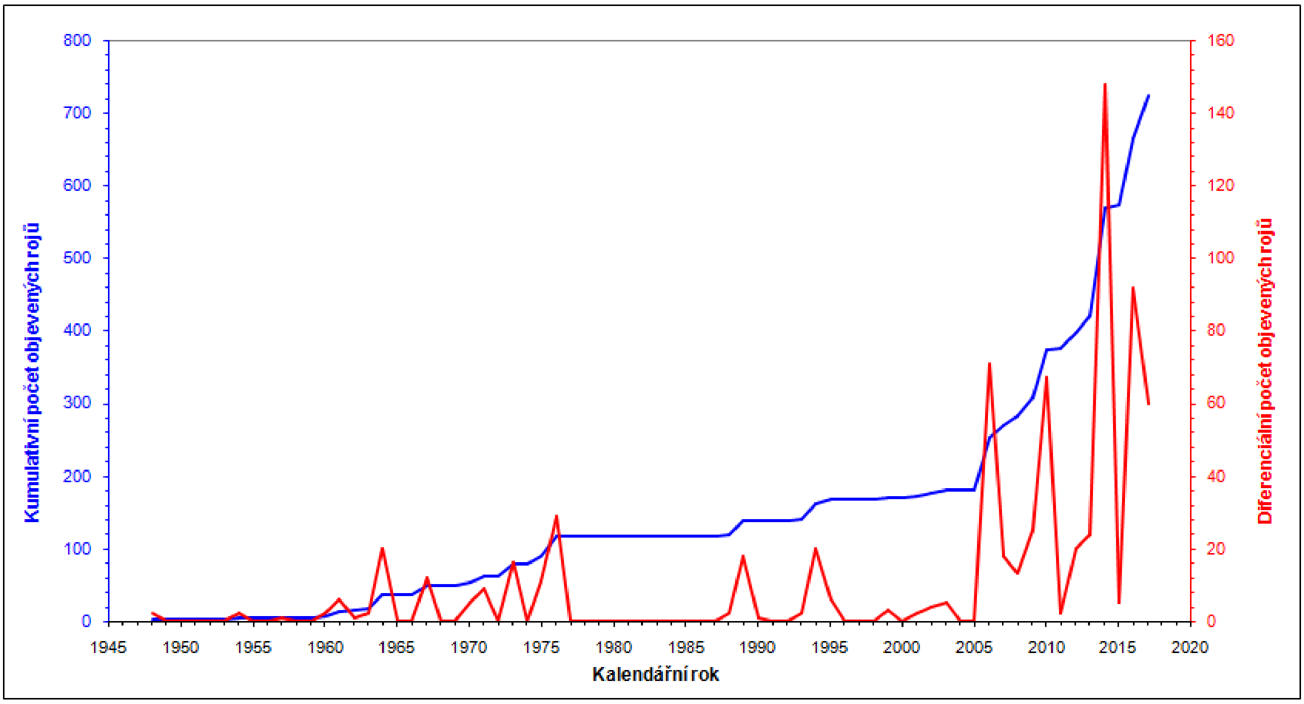


Figure 1 – Differential and cumulative numbers of discoveries of new meteor showers from 1948 to 2017. Author: Jakub Koukal.

V. N. Lebedinets (1967), L'. Kresák and V. Porubčan (1970), B. A. Lindblad (1971), Z. Sekanina (1973, 1976), A. F. Cook (1973), G. Gartrell and W. G. Elford (1975), A. K. Terentjeva (1989), V. Porubčan and M. Gavajdová (1994), etc.

3 Research of meteor showers today

Due to the massive growth of video technology over the past 30 years, there has been a significant increase in the number of multi-station meteor orbits (or meteoroid orbits). Hand in hand with this trend, of course, the number of newly discovered meteor showers is rapidly increasing. At present, the following databases of meteoroid orbits are available: CAMS (Cameras for Allsky Meteor Surveillance), IMO VMN (International Meteor Organization Video Meteor Network), SonotaCo, EDMOND (European viDeo MeteOr Network Database), CMN (Croatia Meteor Network), IAU MDC (Photographic Meteor Orbits Database), etc. The highest number of newly discovered meteor showers comes from the CAMS database (Jenniskens, 1994; 2006; 2012-2014; 2016) and CMN (Šegon, 2012-2015). The increase in the number of newly discovered meteor showers is shown in *Figure 1*. Before 2005, it was mostly the refinement of the mean orbits of already known meteor showers, not the discovery of new showers with the exception of radio observations (e.g. Z. Sekanina, A. F. Cook, etc.) which were mostly new meteor showers active in the day, i.e. out of reach for visual or photographic observers.

At first glance, it may seem that a huge increase in the number of newly discovered meteor showers was caused only by the development of the observation techniques. Looking closer, however, it is obvious that the current methods for detection of new meteor showers are failing, and a high number of controversial cases can be found in the flood of new discoveries.

4 Methodology for discovery of new meteor showers

New meteor showers can be searched using the so-called independent clustering. Here is a dual approach possible, either all meteors will be included in the calculation, irrespective of their meteor showers – so all orbits are seen as sporadic or only sporadic meteors will be included in the calculation – so all meteors belonging to already known showers are excluded in advance. The first approach is more appropriate, it is possible to calculate the new mean orbits of already known showers without affecting the original mean orbit, which has been calculated in the past. The so-called orbit similarity criteria are used to assign individual meteor orbits. Basic criteria include only orbital elements, such as the Southworth-Hawkins (Southworth and Hawkins, 1963) criterion (D_{SH}), the Drummond (Drummond, 1981) criterion (D_D) or the Jopek (Jopek, 1993) criterion (D_J) other criteria also bring in the observed quantities (geocentric velocity, radiant position, etc.) – e.g. the Valsecchi (Valsecchi et al., 1999) criterion (D_N). A sample of equations for calculating the Southworth-Hawkins criterion (D_{SH}) is shown here:

$$D_{\mathrm{SH}}^2 = (q_1 - q_2)^2 + (e_1 - e_2)^2 + \left(2\sin\frac{I}{2}\right)^2 + \left(\frac{e_1 + e_2}{2} \times 2\sin\frac{\Pi}{2}\right)^2,$$

$$I = \arccos[\cos i_1 \cos i_2 + \sin i_1 \sin i_2 \cos(\Omega_1 - \Omega_2)]$$

$$\Pi = \omega_2 - \omega_1 \pm 2\arcsin\left(\cos\frac{i_2 + i_1}{2}\sin\frac{\Omega_2 - \Omega_1}{2}\sec\frac{I}{2}\right).$$

All criteria have their limitations and are, for example, sensitive to low-slope orbits and also have different maximum values for differentiating the sporadic background from meteor showers. Increasing the limit value of the criterion results in the assignment of sporadic meteor orbits to the meteor shower. If the meteor shower is strong and clearly defined, the differential count of the number of meteors decreases (or stagnates) with the increasing value of the similarity criterion used. However, if the meteor is not clearly defined (for example, if it is a random cluster of sporadic meteors without a common origin) there is a steady increase in the number of orbits associated with the meteor shower. The "break-point" method (Neslušan et al., 2013) is based on this principle, which assesses the cumulative increase in the number of orbits by increasing the value of the criterion and also the differential increase in the number of orbits in the intermediate values of the criterion. With a sufficient number of shower orbits, the "core" of the meteor shower can be well defined by differential growth and the sporadic meteors can be distinguished by the cumulative growth from shower meteors. The principle of the method for cumulative numbers of associated orbits is shown in *Figure 3*.

The practical use of the "break-point" method can be demonstrated on the strongest regular meteor shower, the Perseids. Using Drummond's criterion of orbits similarity (D_D) on the EDMOND (Kornoš et al., 2014a,b) database it was found that the width of the "core" of the Perseid meteor shower corresponds to the limit value D_D < 0.03 and the total width of the meteor shower activity corresponds to the limit value D_D < 0.17. *Figure 4* also shows clearly how the shower "core" is defined (the differential orbit count) and how this increase in differential orbit counts stagnates with the increasing of the D_D criterion.

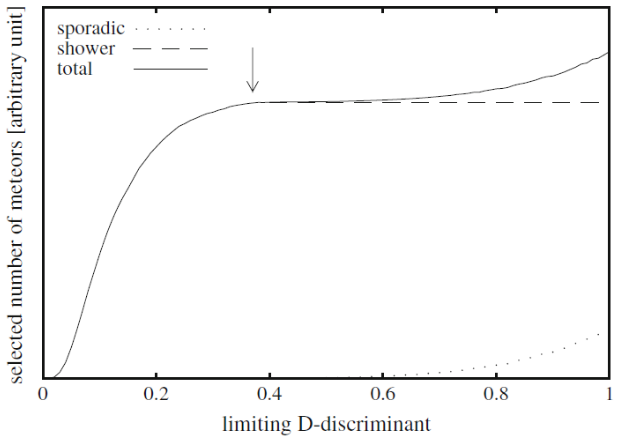


Figure 3 – The "break-point" method principle with the marked break point. With a further increase in the value of the similarity criterion, the sporadic background is assigned to the meteor shower. Author: Neslušan et al.

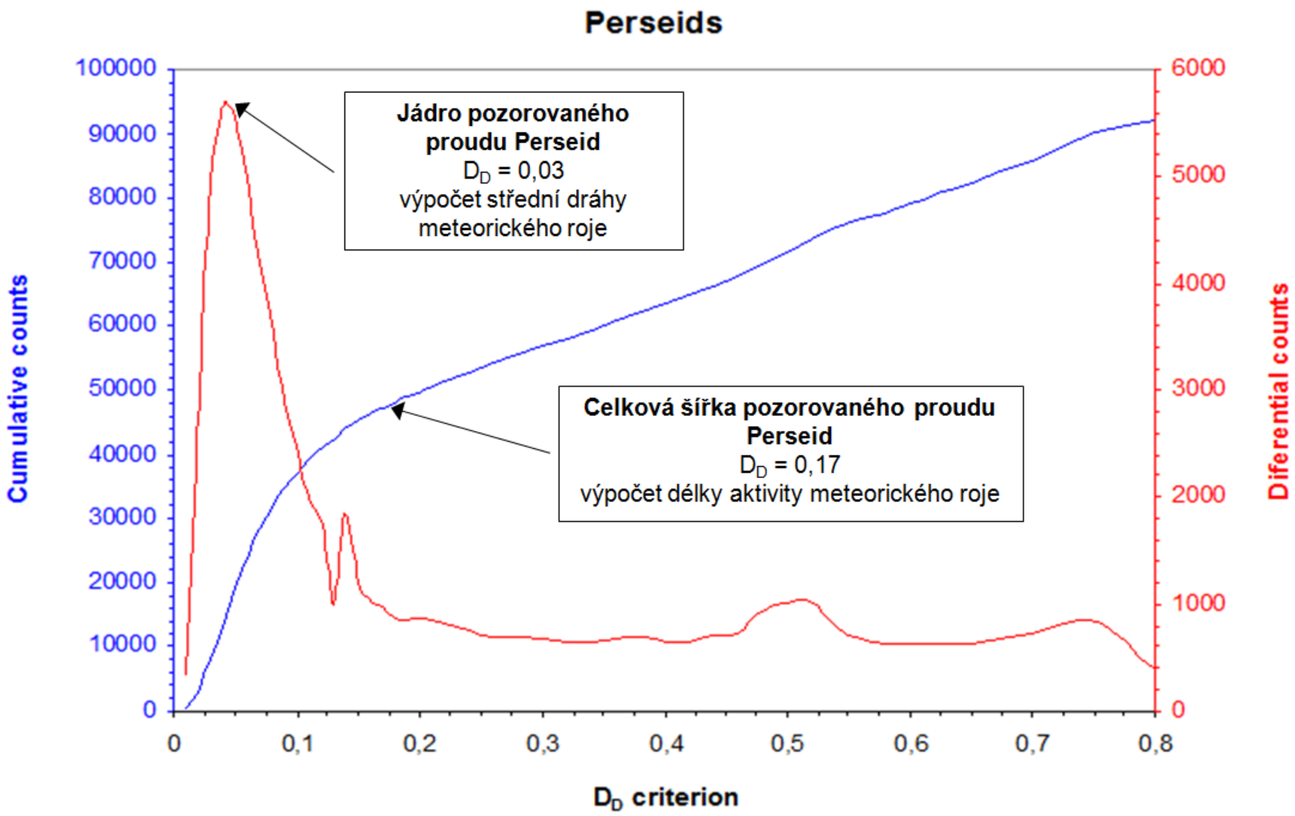
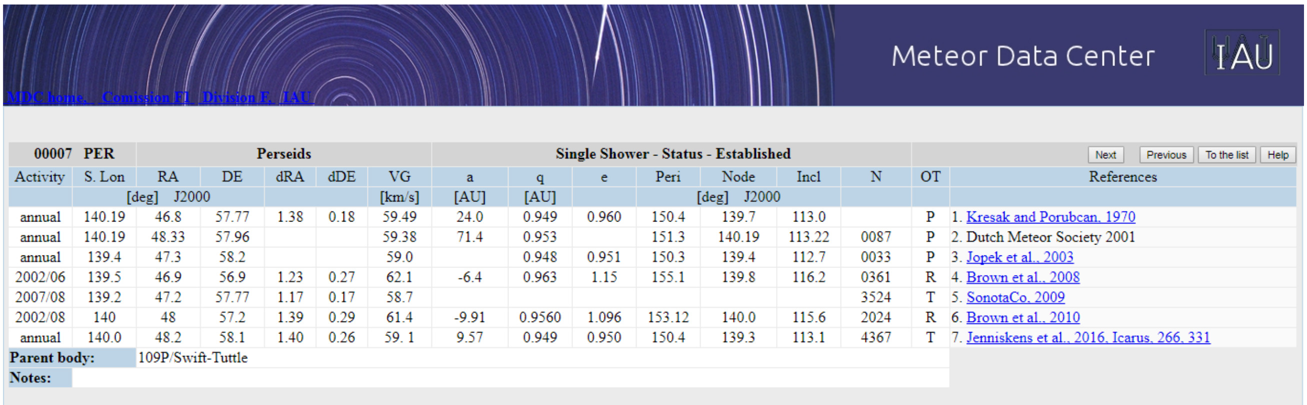


Figure 4 – Practical use of the "break-point" method for the Perseid meteor shower (007 PER). Values of the D_D criteron for the shower "core" and for its width (activity) are highlighted. Author: Jakub Koukal.


Meteor Data Center IAU

MDC home, Comission F1 Division F, IAU

00007 PER		Perseids					Single Shower - Status - Established								Next Previous To the list Help
Activity	S. Lon	RA	DE	dRA	dDE	VG	a	q	e	Peri	Node	Incl	N	OT	References
	[deg] J2000					[km/s]	[AU]	[AU]		[deg] J2000					
annual	140.19	46.8	57.77	1.38	0.18	59.49	24.0	0.949	0.960	150.4	139.7	113.0		P	1. Kresak and Porubcan, 1970
annual	140.19	48.33	57.96			59.38	71.4	0.953		151.3	140.19	113.22	0087	P	2. Dutch Meteor Society 2001
annual	139.4	47.3	58.2			59.0		0.948	0.951	150.3	139.4	112.7	0033	P	3. Jopek et al., 2003
2002/06	139.5	46.9	56.9	1.23	0.27	62.1	-6.4	0.963	1.15	155.1	139.8	116.2	0361	R	4. Brown et al., 2008
2007/08	139.2	47.2	57.77	1.17	0.17	58.7							3524	T	5. SonotaCo, 2009
2002/08	140	48	57.2	1.39	0.29	61.4	-9.91	0.9560	1.096	153.12	140.0	115.6	2024	R	6. Brown et al., 2010
annual	140.0	48.2	58.1	1.40	0.26	59. 1	9.57	0.949	0.950	150.4	139.3	113.1	4367	T	7. Jenniskens et al., 2016, Icarus, 266, 331
Parent body:		109P/Swift-Tuttle													
Notes:															

Figure 5 – Overview of mean orbits from individual sources for the Perseid meteor shower (007 PER), including listing of individual sources in the IAU MDC database. Author: IAU MDC.

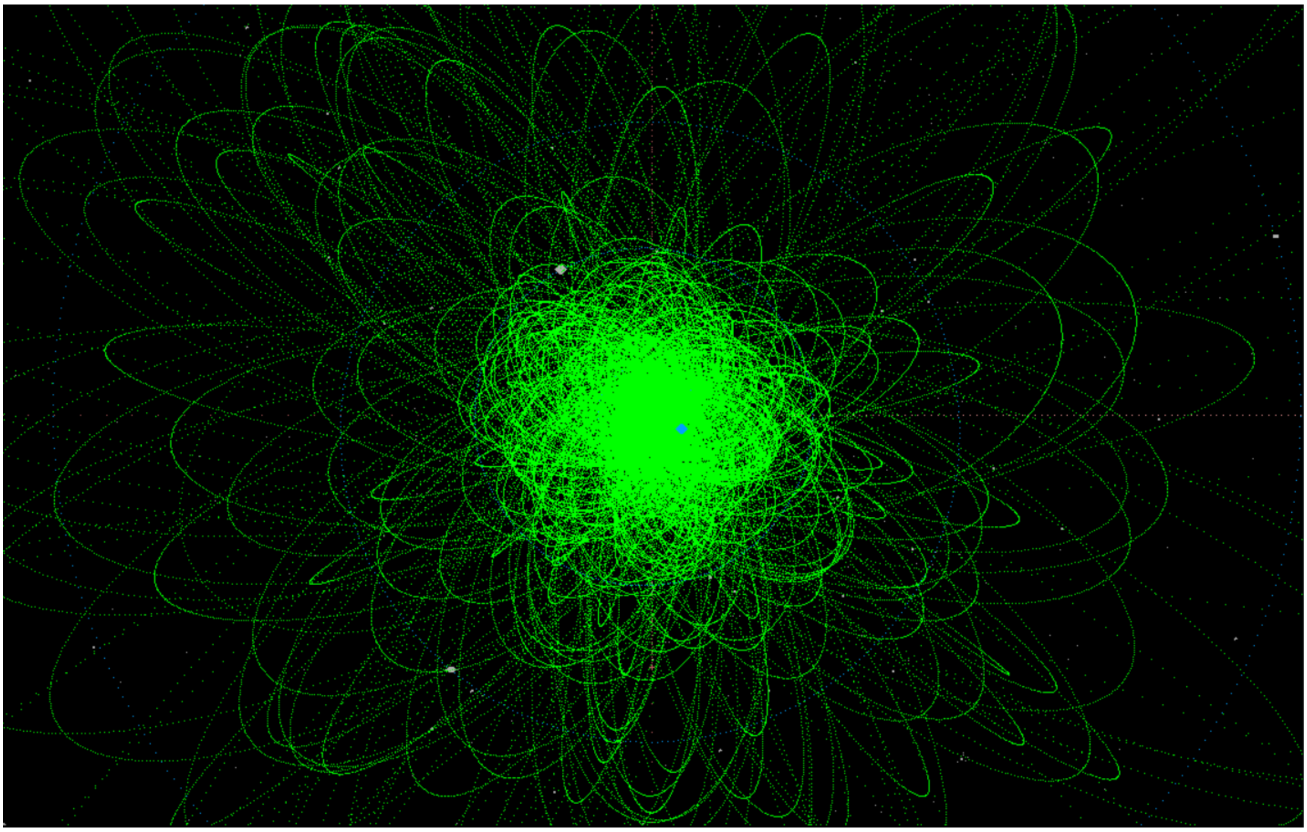


Figure 6 – Mean orbits of all 726 meteor showers in the IAU MDC database in side view of the center of the Solar System (the position of the planet Earth is marked in blue). Author: Jakub Koukal.

5 Meteor showers IAU MDC database

The IAU MDC meteor showers database (Jopek et al., 2014) contains all the information that is currently available for all classified meteor showers (e.g. see *Figure 5*). In addition to the data on the period of activity it also includes the orbital elements of the mean orbits of meteor showers (if known), the radiant position, its daily motion, geocentric velocity, and a source with a number of orbits that served to calculate the orbital elements of the meteor showers' mean orbits. The IAU MDC showers database currently contains 726 meteor showers (*Figure 6*), of which only 112 are established and 26 are in the unconfirmed (pro tempore) category, 545 meteor showers from this list have been discovered/added over the last 12 years.

For known and strong meteoric showers (e.g. Perseids, Geminids, Leonids, etc.), the amount of sources for calculating the mean orbit is considerable. A relatively large part of the meteor showers has, of course, a mean orbit defined by only one source while the number of orbits for the calculation is quite often relatively small; sometimes the calculation is made from less than 10 orbits. Anyway, the amount of meteor showers is currently higher than the total number of individual orbits of photographic meteors 30 years ago.

6 Division of known meteor showers

A typical and very complex case is the Taurid complex, or the 2P/Encke comet complex. This massive and complex system with a very long activity includes besides the southern (002 STA) and northern (017 NTA) Taurids many smaller showers (e.g. the northern and southern delta Piscids, northern and southern October delta Arietids, etc.), but also two powerful daily showers – beta Taurids and zeta Perseids which occur at the second intersection (node) of the orbit of the complex and the Earth's orbit. The division into sub meteor showers of the Taurid complex attempts to capture the variety and quantity of the parent bodies, like the 2P/Encke comet, which originated in the past from the collapse of the massive original cometary body. In addition, the overall situation will make the gravitational perturbation by planets difficult, especially Jupiter, also by the fact that this is the largest mass flow in the inner part of the solar system. The search for asteroids that can be associated with the complex or the search for the filaments of the complex has been devoted to and will probably be devoted to a number of scientific works in the future. For example (Porubčan et al., 2006) mentions 7 filaments in the complex and 9 associated NEO asteroids (2001 HB, 2003 SF, 2001 QJ96, 1999 RK45, 2003 QC10, 2003 WP21, 2004 TG10, 2003 UL3, 2003 WP21 a 2002 XM35) of which 4 (2003 QC10, 2004 TG10, 2003 UL3 and 2002 XM35) were evaluated in this paper as the most probable parent bodies for individual filaments found. Also (Spurný et al., 2017) talks about the newly discovered branch of the complex in connection with the increased activity of bright bolides of the complex in 2015. In this work, 3 asteroids are associated with the Taurid complex (2015 TX24, 2005 UR and 2005 TF50).

Table 1 gives an overview of the mean orbits of the new meteor showers from the IAU MDC catalog in relation to the major showers of the Taurids complex (002 STA and 017 NTA) including the orbital elements, and the Drummond criterion for the similarity of the orbits in relation to both major showers. Some new meteor showers are associated with previously mentioned asteroids (e.g. 630 TAR – 2005 TF50, 632 NET – 2004 TG10) however, for example the meteor shower s Taurids (628 STS) is associated directly with the 2P/Encke comet and due to the low value of the D_D criterion in relation to the southern Taurids mean orbit (D_D = 0.035), it will not be possible to reliably assign the individual meteors to the mean orbit of the s Taurids shower.

The core of the meteor shower usually falls within the range of $0.03 < D_D < 0.05$, the width of the activity of the meteor shower is usually between $0.15 < D_D < 0.20$, for scattered meteoric showers it may be even higher. And the Taurids complex is exactly this case, due to its development and gravitational perturbations from Jupiter. The same problem is visible for several other meteor showers, such as 630 TAR (0.020), 632 NET (0.028), 635 ATU (0.043), and 629 ATS (0.056), the mean orbits of which are very close to the mean orbit of the major shower 017 NTA. The same problem also occurs for the new showers 626 LCT (0.021) and 637 FTR (0.053) relative to the mean orbit of the second major shower 002 STA. The mean orbits of all these meteor showers, including southern and northern Taurids, are shown in *Figure 8*. Therefore, it would be more appropriate in these cases to talk about the branches or filaments of the two major showers of the complex and not about new meteor showers.

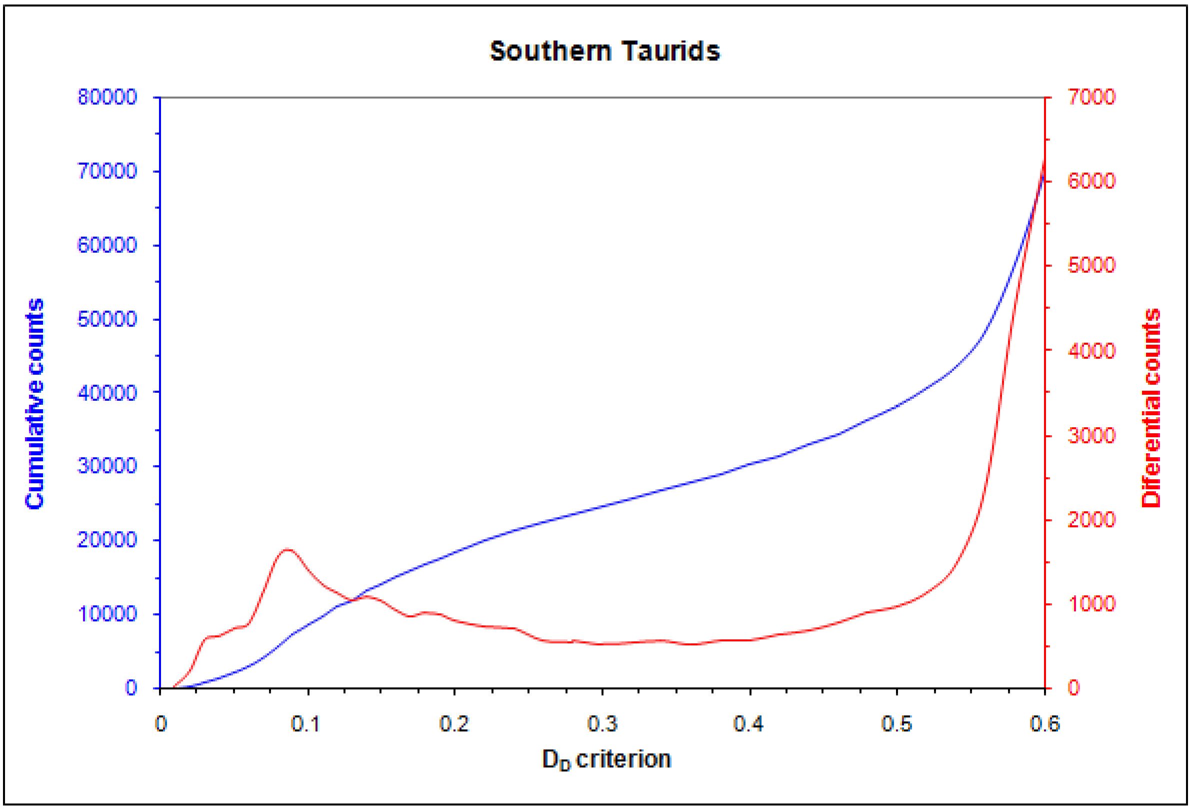


Figure 7 – Graph of differential and cumulative counts of the meteor shower 002 STA members for increasing value of D_D criterion („break-point“ method). The graph shows the complexity of the Taurids complex, the similarity of the meteor orbits and the position of other complex filaments, including the meteoric shower 017 NTA. Author: Jakub Koukal.

Table 1 – Overview of the mean orbits of new meteor showers from the IAU MDC catalog in relation to the major showers of the Taurids complex (002 STA and 017 NTA).The used orbital elements of the mean orbits are taken from (Jenniskens et al., 2016). The column "D_D" denotes the value of the Drummond criterion for the similarity of the orbits in relation to the main showers of the complex (STA, NTA), at the same time, the parent body is specified if known (Jenniskens et al., 2016). Author: Jakub Koukal.

IAU-Shower	Sol	*a*	*q*	*e*	*ω*	*Ω*	*i*	*R.A.*	*Dec.*	V_g	D_D	Parent body
17-NTA Northern Taurids	220	2.130	0.3550	0.829	294.60	220.60	3.00	48.9	+20.7	28.0	0.000	2P/Encke
630-TAR τ Arietids	220	1.932	0.3420	0.823	296.84	220.01	3.11	50.0	+21.1	28.0	0.020	2005 TF50
632-NET Nov.η Taurids	227	2.098	0.3571	0.830	294.20	227.01	2.72	56.1	+22.2	28.1	0.028	2004 TG10
635-ATU A1 Taurids	231	2.155	0.3664	0.830	292.86	231.02	2.76	59.7	+23.0	28.0	0.043	?
629-ATS A2 Taurids	233	2.191	0.3856	0.824	290.53	233.02	2.77	60.7	+23.3	27.5	0.056	2012 UR158
633-PTS ρ Taurids	240	2.223	0.4146	0.813	287.07	240.01	2.43	66.6	+24.1	26.7	0.095	?
634-TAT τ-Taurids	244	2.174	0.4366	0.799	284.79	244.01	2.46	69.8	+24.7	25.9	0.122	2003 UL3
2-STA Southern Taurids	216	1.950	0.3530	0.798	116.60	34.40	5.30	47.9	+12.8	26.6	0.000	2P/Encke
28-SOA Southern Oct. λ-Arietids	196	1.750	0.2860	0.834	124.60	15.40	5.70	32.0	+8.5	29.0	0.118	2P/Encke?
626-LCT λ-Cetids	216	1.899	0.3431	0.819	116.97	36.01	5.58	48.2	+13.0	27.9	0.021	2010 TU149
628-STS s Taurids	223	2.121	0.3577	0.831	114.09	43.01	5.51	53.8	+14.4	28.2	0.035	2P/Encke
637-FTR f Taurids	225	2.177	0.3876	0.822	110.46	45.01	5.01	54.1	+14.6	27.4	0.053	?
625-LTA λ-Taurids	231	2.104	0.4401	0.791	104.92	51.01	5.00	57.8	+14.8	25.6	0.112	?

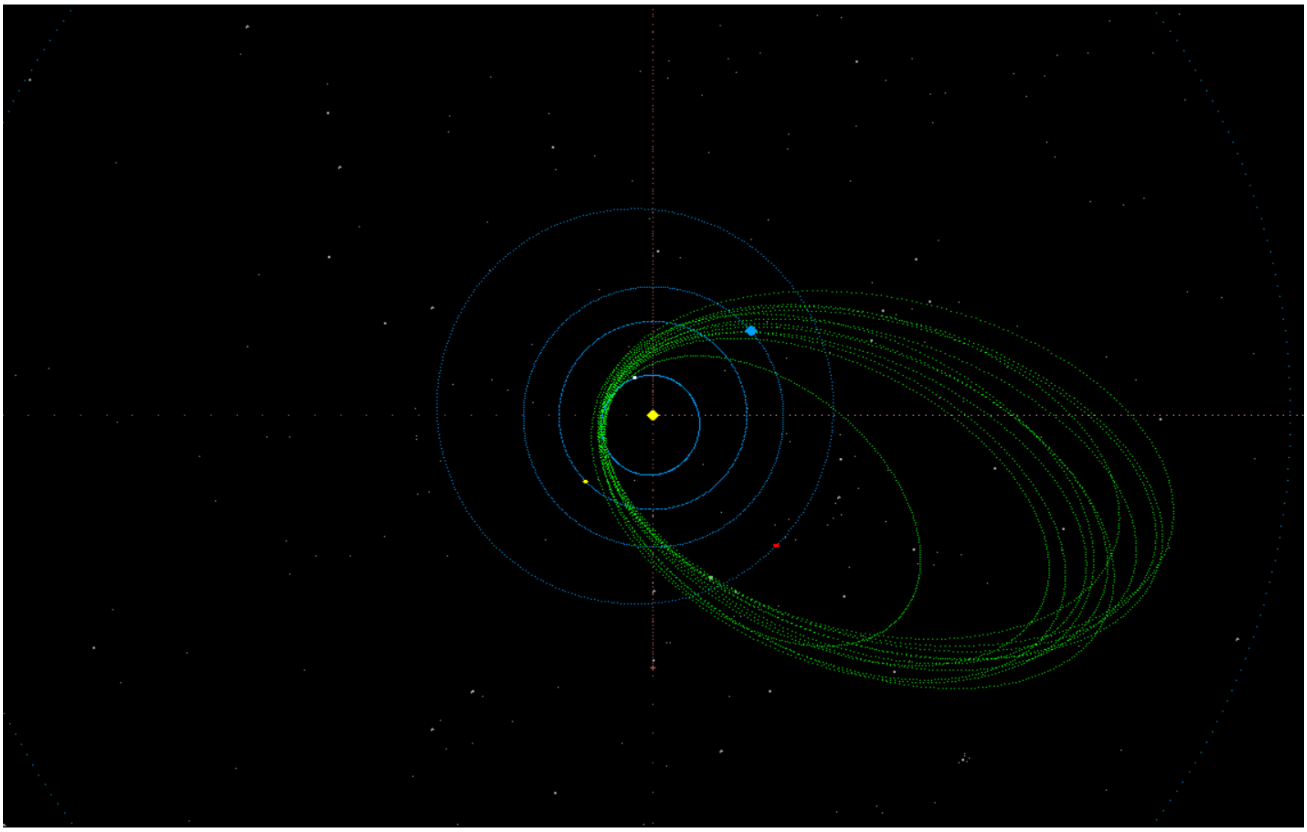


Figure 8 – The mean orbits of all 13 meteor showers listed in Table 1 whose orbital elements are very similar (D_D < 0.15) to the orbital elements of the main showers of the complex (002 STA and 017 NTA). Author: Jakub Koukal.

7 New meteor showers on a strong sporadic background

A typical representative of this group is the kappa Cepheids meteor shower (751 KCE, Šegon et al., 2015). For the mean orbit of the shower mentioned in the IAU MDC database, 17 meteors were used by source work. However, given the relatively high geocentric velocity (v_g = 33.7 km/s), the total area of individual meteor radiants is relatively large, the radiant dimension in the declination exceeds 10°. Using the Drummond criterion D_D on the EDMOND database, 29 orbits for D_D < 0.05, 441 orbits for D_D < 0.10 and even 1354 orbits for D_D < 0.15 could be found.

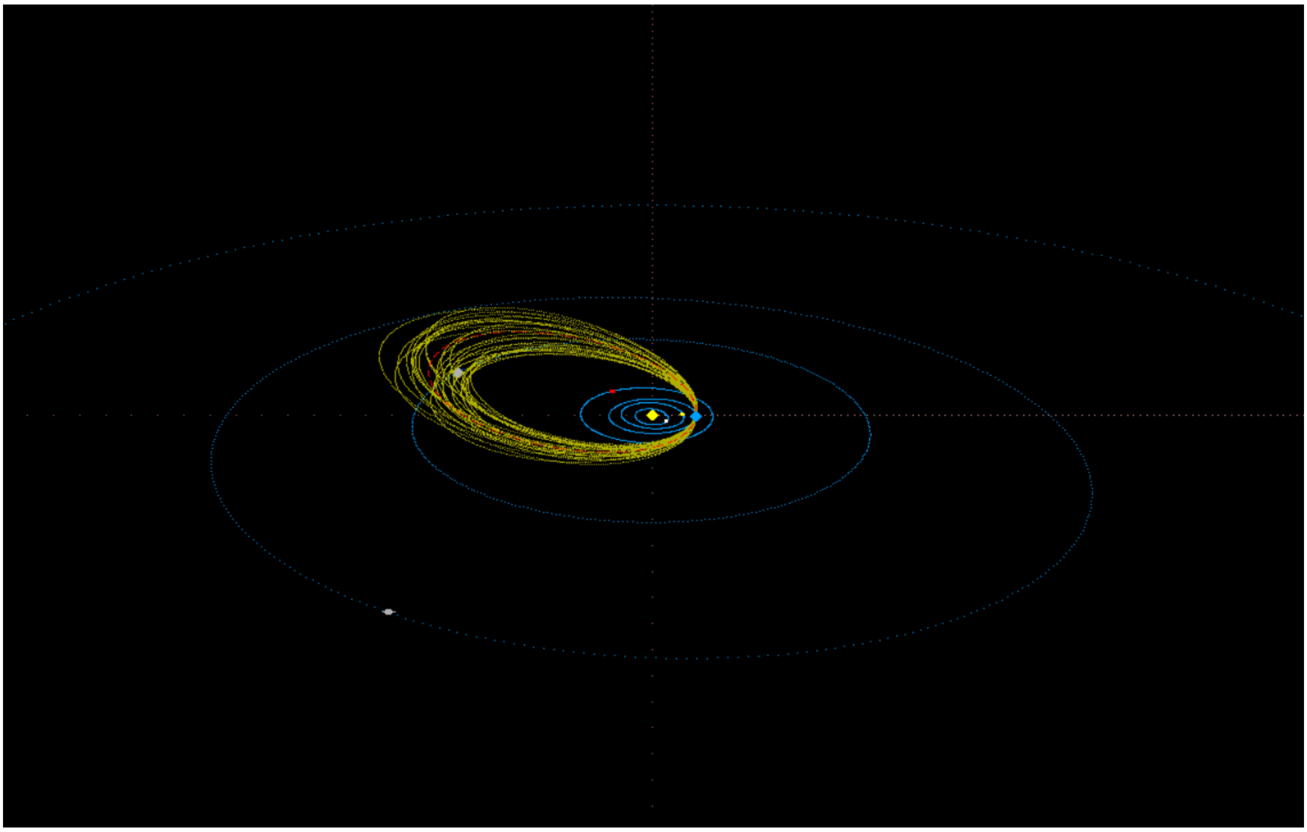


Figure 9 – The orbits of 29 meteors assigned to meteor shower 751 KCE with the D_D criterion value < 0.05. Author: Jakub Koukal.

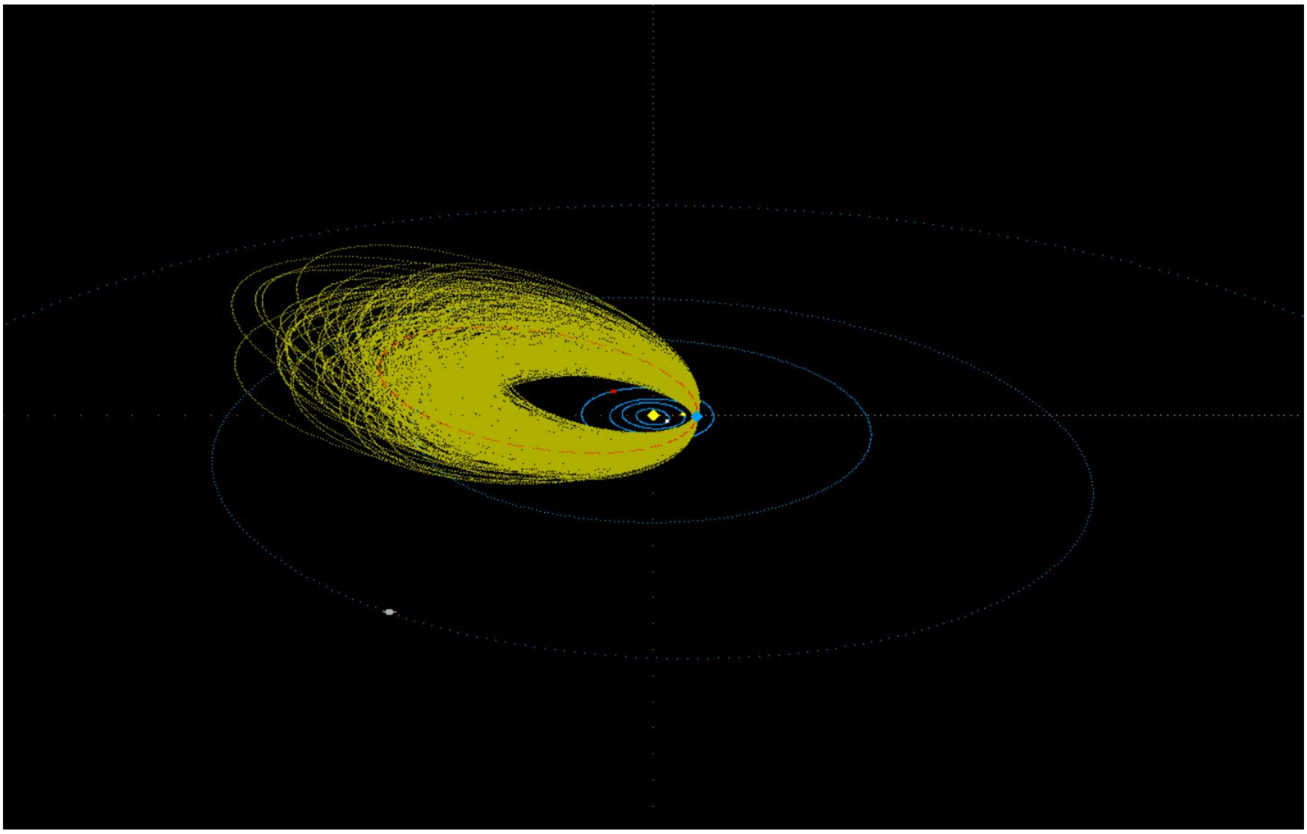


Figure 10 – The orbits of 441 meteors assigned to meteor shower 751 KCE with the D_D criterion value < 0.10. Author: Jakub Koukal.

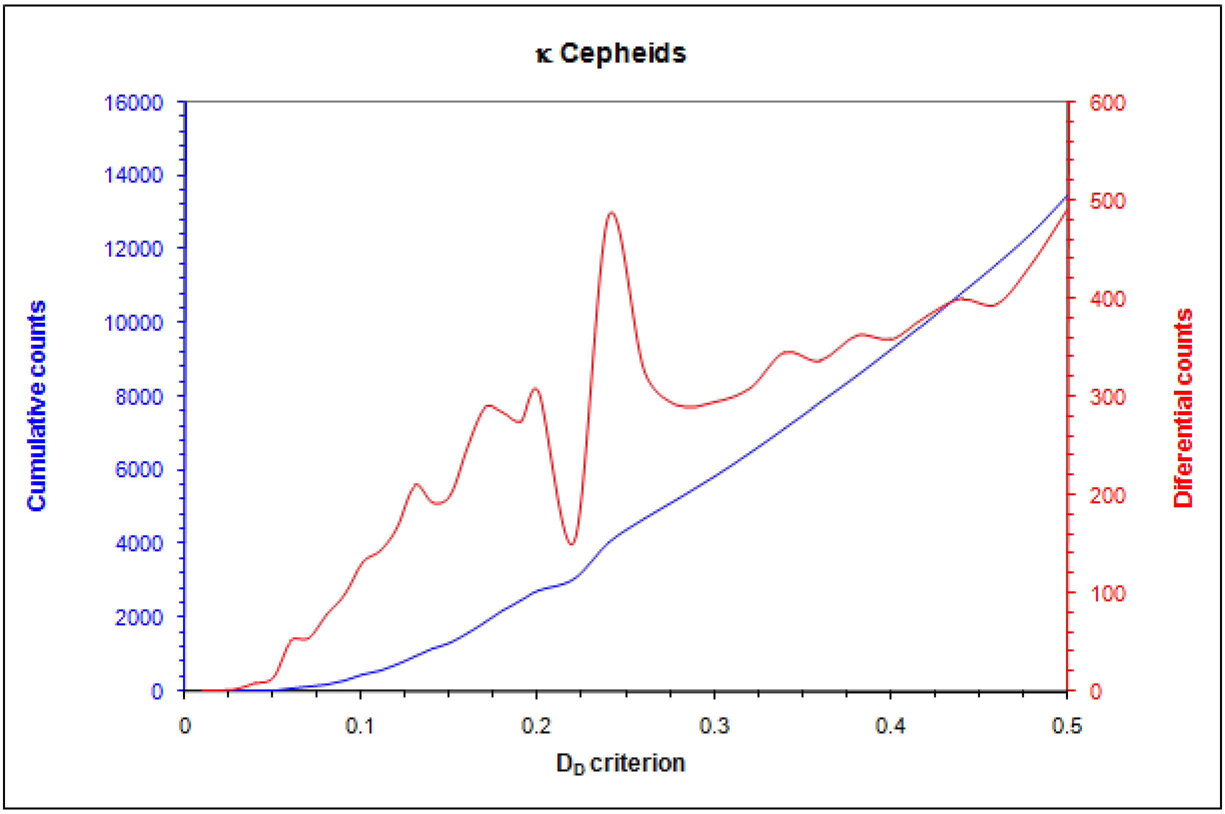


Figure 11 – Graph of differential and cumulative counts of numbers of 751 KCE shower members for increasing value of the D_D criterion („break-point" method). The graph shows a steep increase in cumulative counts of meteor shower numbers, as well as individual peaks in differential counts of meteor numbers corresponding to nearby meteor showers, or other areas with a higher sporadic background density. Author: Jakub Koukal.

The graph of the differential and cumulative counts of numbers of 751 KCE shower members is shown in *Figure 11* and shows a steep increase in cumulative meteor counts assigned to the mean orbit of the shower with increasing value of the D_D criterion. Because of this, it seems that in the case of the meteor shower kappa Cepheids, these meteors are only randomly selected orbits from the sporadic background, or the densification of the sporadic background at the position of the supposed shower. The existence of this meteor shower is therefore highly controversial.

8 Double meteor showers on a strong sporadic background

In this case, it is a combination of the problem of the Taurids complex and the problem of the kappa Cepheids. The IAU MDC database already has a meteor shower (in this case phi Draconids – 45 PDF) and the newly discovered shower (psi Draconids – 754 POD) has a mean orbit very similar to the original shower. In addition, both are located in the area of the toroidal complex, which contains a large number of sporadic meteors, and the existence of any meteor shower here is very difficult to prove. Basically, the number of meteor showers found in this area depends only on the criteria selected for the selection and results in a certain number of mean orbits of "showers" of very similar orbits, which are only rotated in the length of the perihelion. The mean orbit of the shower 754 POD has a Drummond criterion $D_D = 0.048$ in relation to the mean orbit of shower 45 PDF. This shows again (as with the Taurids) the problem of assigning individual meteors to both showers within the considered width of showers activity; the mean orbits of both meteor showers are shown in *Figure 12*.

For the mean orbit of the shower mentioned in the IAU MDC database, 31 meteors were used by the source work (Šegon et al., 2015). Using the Drummond D_D criterion, EDMOND found 77 orbits for $D_D < 0.05$, 493 for $D_D < 0.10$, and even 1038 for $D_D < 0.15$. The graph of the differential and cumulative counts of the 754 POD shower meteors (as well as the shower 45 PDF) is shown in *Figure 13* and shows a steep increase in the cumulative counts of meteors assigned to the mean orbit of the shower with the increasing value of the D_D criterion. Because of this, it seems that in the case of meteor shower psi Draconids these are only randomly chosen orbits from a sporadic background, eventually the concentration of the sporadic background at the position of the supposed swarm. The existence of this meteor swarm is therefore highly controversial. The same, of course, applies to shower 45 PDF (Jenniskens et al., 2006), which has a very similar mean orbit and it is rotated only in the length of perihelion.

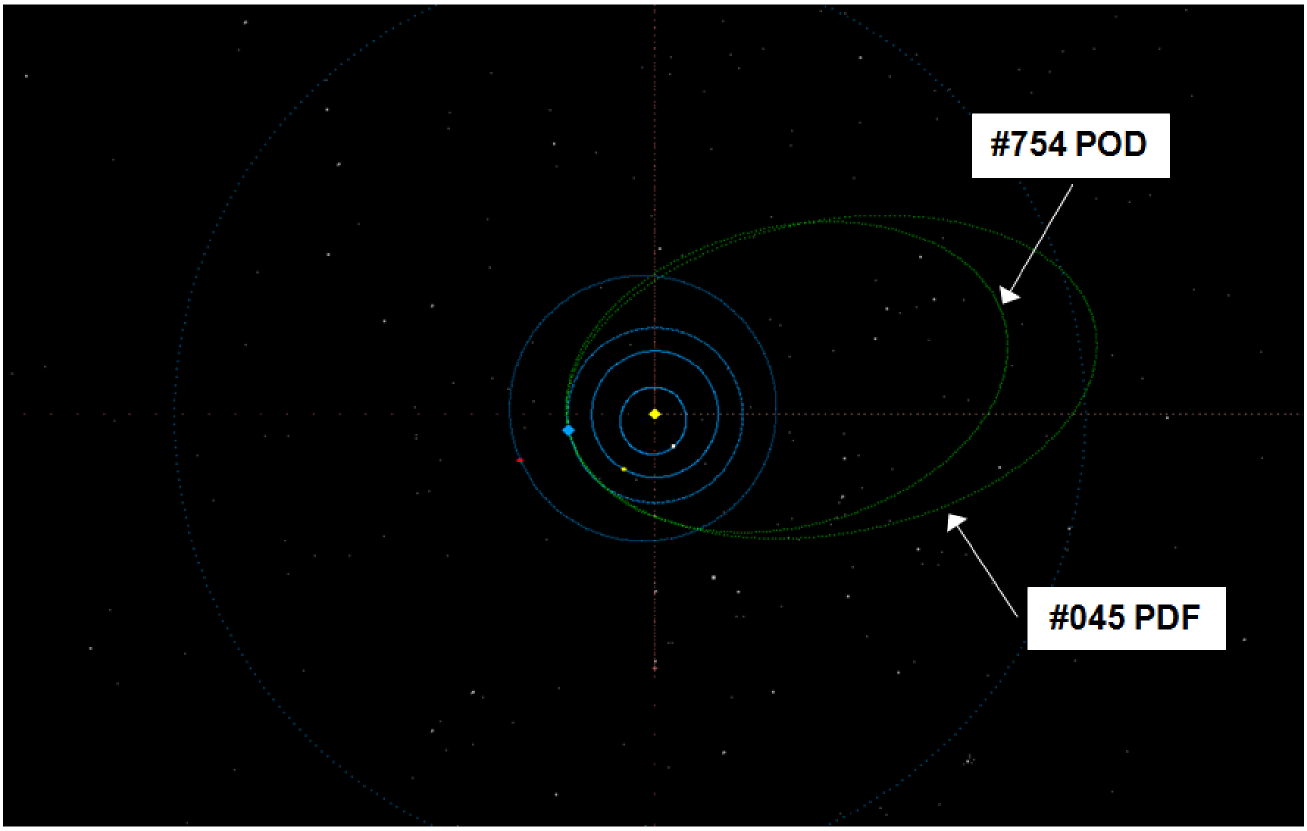


Figure 12 – Mean orbits of meteor showers phi Draconids (45 PDF) and psi Draconids (754 POD). Author: Jakub Koukal.

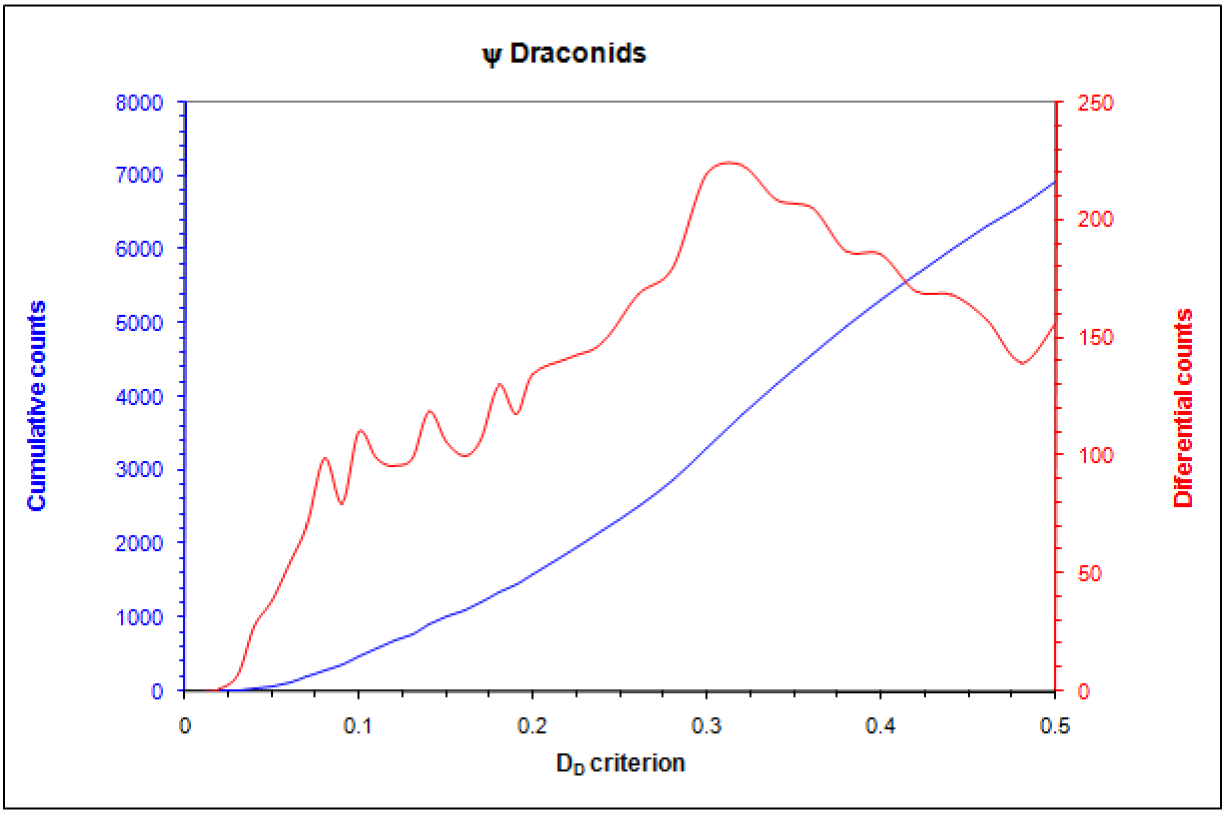


Figure 13 – Graph of differential and cumulative counts of numbers of 754 POD shower members for increasing value of the D_D criterion („break-point" method). The graph shows a steep increase in cumulative counts of meteor shower numbers, as well as individual peaks in differential counts of meteor numbers corresponding to nearby meteor showers, or other areas with a higher sporadic background density. Author: Jakub Koukal.

9 Conclusions

Although this article could be construed as being critical, it was not thus intended. The author, on the contrary, very much values the work of all the above mentioned and only points out the problems that arise within the massive development of this domain of astronomy science. However, due to the above mentioned problems, the revision of the IAU MDC catalog appears to be necessary. The minimum (and first step) should be the "clustering" of all meteors in the databases without affecting the mean orbits of the already known meteor showers. Also, where possible, the dynamic development of individual orbits in the past (reverse orbit integration) should be considered. With the increasing number of orbits recorded, of course, the need for analyzes is increasing, and the current methodology, even with the use of new procedures (Welch, 2001), fails to solve all the problems arising from the huge amount of data.

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Alpha Monocerotids 2017

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17 orbits of the annual component of the Alpha Monocerotids (246 AMO) were captured by CAMS networks between 21 and 24 November, 10 of them in the United Arab Emirates on 21 November between 21h to 24h UT.

1 Introduction

The Alpha Monocerotids (AMO-246) are a poorly known meteor stream which must be related to a so far unknown long periodic comet. This shower caught attention because of short outbursts of activity in 1925, 1935, 1985 and 1995, the 1995 outburst being predicted and well observed by different observers in Europe.

The shower analyses of over 110000 orbits obtained by the CAMS project between October 2010 and March 2013 did not reveal any single orbit for this shower (Jenniskens et al., 2016). The IAU meteor shower list has the orbit of the Alpha Monocerotids based on as few as 10 orbits obtained during the 1995 outburst (Jenniskens et al., 1997). Any additional data about this shower would be very welcome.

2 1995 AMO outburst

Peter Jenniskens had predicted a possible outburst for this shower on 1995 November 22 (Jenniskens, 1995). The outburst did effectively occur on November 22, at 1^h29^m UT corresponding to solar longitude 239.32° (epoch 2000.0). The annual component of this shower is believed to display a zenithal hourly rate of 5 per hour at best; nevertheless CAMS did not manage to capture any single AMO orbit in the years 2010, 2011 or 2012.

3 2017 observations

No outburst was expected, a possible next outburst may occur in 2043, although there is also a small chance in 2019 (Jenniskens, 2006). However, with more network capacity there is always hope to catch some more orbits for the annual component of this stream. Hence it wasn't a complete surprise that the CAMS networks captured some Alpha Monocerotids during 2017.

Up to today, as many as 17 Alpha Monocerotid orbits have been identified from data by the different CAMS networks in 2017. Most of these orbits were obtained by CAMS in the United Arab Emirates.

Table 1 – Radiant position, beginning and ending height and the orbit for the annual component of the AMOs as well as for the 1995 dust trail (Jenniskens et al., 1997). The CAMS BeNeLux AMO orbit was obtained on 23 November at $5^h48^m52^s$ UT by CAMS 382 and CAMS 399.

	Annual component	Outburst 1995	CAMS BeNeLux 2017
RA	117.53±0.05	117.10±0.13	119.3±0.1
Decl	+1.18 ± 0.05	+0.83±0.16	+0.1±0.1
V_{inf}	63.6±0.4	64.0±0.2	61.6 km/s (V_g)
H_b	97.5 km		110.10±0.05 km
H_e	84.1 km		98.80±0.05 km
q	0.485	0.488±0.019	0.487±0.003
i	138.18	134.13±0.34	133.5±0.2
ω	91.25	90.66±0.78	92.571
Ω	59.425	59.322±0.4	60.886

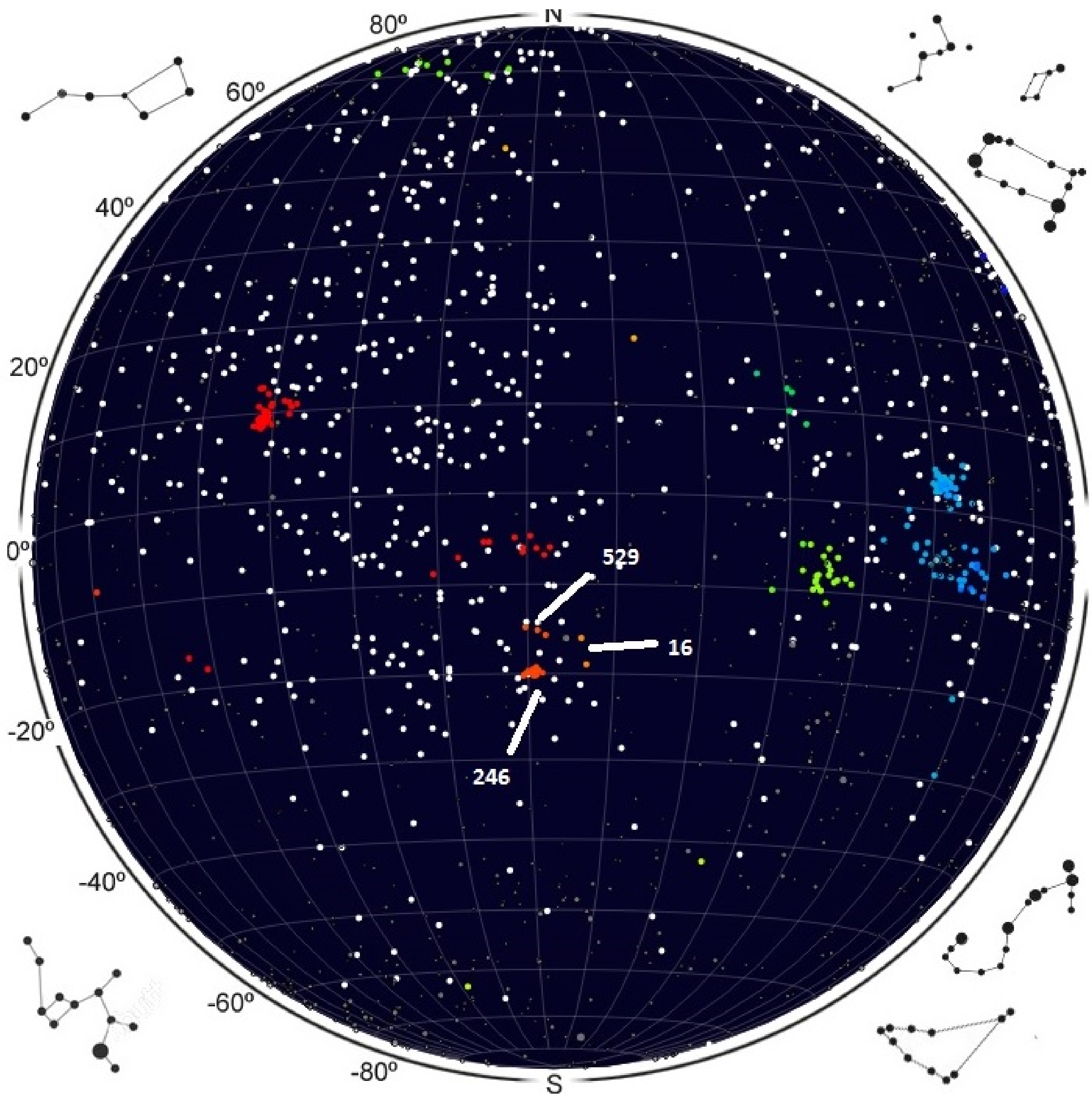

Figure 1 – The radiant map shows the 13 AMO radiant positions (marked with 246) from all CAMS networks around 22 November. Two other minor showers were detected nearby the Alpha Monocerotids radiant: 529 (eta Hydrids) and 16 (sigma Hydrusids).

The first AMO was recorded by the United Arab Emirates CAMS network on 21 November ($\lambda_{\odot}$ = 238.679°) and the second by the Lowell Observatory CAMS network in Arizona at $\lambda_{\odot}$ = 239.053°. The CAMS BeNeLux network had totally overcast sky during this night. The next night, 21–22 November, 10 AMO orbits were obtained around $\lambda_{\odot} \sim$239.57° by the United Arab Emirates CAMS network on a total of 127 orbits obtained that night by this network (see *Figure 1*). The CAMS BeNeLux network had totally overcast sky during this night. The CAMS network in California got 2 AMO orbits at $\lambda_{\odot} \sim$ 240.035° on a total of 247 orbits and the CAMS BeNeLuX network got 1 AMO orbit at $\lambda_{\odot}$ = 240.895°on a total of 320 orbits for that night. CAMS California got an AMO at $\lambda_{\odot}$ = 240.991° and the last AMO was for the Lowell Observatory CAMS network in Arizona at $\lambda_{\odot}$ = 241.146°. The weather circumstances were less favorable except for the United Arab Emirates.

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The Southern Delta Aquariids (SDA) in 2017

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In 2017, extensive analysis could be done on observations of the Southern Delta Aquariids (SDA). The results were compared with those from 2008 (Johannink et al., 2008a; Johannink et al., 2008b) and 2011 (Johannink et al., 2011a; Johannink et al., 2011b). Overall, we can conclude that the population index r and the ZHR showed the same trend in 2017 as in 2008 and 2011. The ZHR of the SDA rises rapidly between $\lambda_{\odot}$ 122°-125° followed by a plateau in activity between $\lambda_{\odot}$ 125°-127° (ZHR 20-25). This is followed by a slow decline in ZHR after $\lambda_{\odot}$ 128°.

1 Introduction

From the Netherlands, the southern delta Aquariids are a hard-to-see meteor shower. With a radiant that does not exceed a height of 23 degrees, we see only a fraction of the actual activity of the meteor shower. This is already very different about 1000 km to the south in the Haute Provence, France. Hourly counts above 10 are possible. If you travel further south to Morocco or Crete, hourly counts around 20 are possible. For La Palma, the numbers are even higher, between 30-35 SDAs per hour. And under the top-conditions of Namibia, the maximum hourly rates are around 40. For many years it was assumed that the maximum ZHR was around 10–15, DMS observations from 2008 (Johannink et al., 2008a; Johannink et al., 2008b) and 2011 (Johannink et al., 2011a; Johannink et al., 2011b) from respectively La Palma and Namibia showed values with maximum ZHRs of around 20–30 during the period of 28 to 31 July. This means that this meteor shower can compete with the Orionids in good years (Rendtel, 2016).

With a New Moon on July 23, conditions were favorable in 2017 for a new analysis of the SDAs. However, this year's problem is that only Michel Vandeputte and the author were active in southern regions, instead of the entire group of observers from 2008 and 2011. A good comparison with 2008 and 2011 is somewhat more difficult. In this article the result of the calculations are presented.

2 The available data

As mentioned, there was too little DMS data this year, so it was decided to browse the IMO database[1]. It was checked whether a reliable perception coefficient C_p was available for all observers who had provided data to the IMO. In addition, observations were only used for locations that are more southerly than 44° in latitude. Furthermore, observations were only used with limiting magnitudes better than +5.9 and radiant heights above 25 degrees.

The observations of the following observers passed these tests: *Michel Vandeputte* (Provence, France), *Kai Gaarder* (Norway, but observations made in Morocco), *Javor Kac* (Slovenia), *Terrence Ross* (Texas, US), *Paul Jones* (Florida , US), *Robert Lunsford* (California, US) and the author from Crete, Greece. The C_p is known for all these people, only a new C_p has been calculated for *Terrence Ross*.

After this entire process, 813 SDAs remained for the final analysis. This number of course contrasts sharply with the results from 2008 (1889 SDAs) and 2011 (3465 SDAs). In spite of this, an attempt was made to make a good analysis and to make a comparison with the data from 2008 and 2011.

3 Population index r for the SDA 2017

From the observations of *Koen Miskotte* in 2017, a mean magnitude gradient could be made on the basis of 323 SDAs. This resulted in *Table 1*. It is striking that as the period expires, the share of bright SDAs increases. See also *Figure 1*.

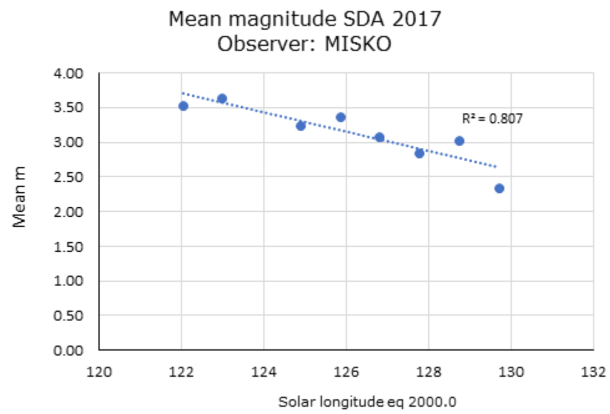

Figure 1 – Mean magnitude for the SDA 2017 based on observations of MISKO (323 SDAs).

The *r* value of the SDA, determined from all data from all above-mentioned observers, could best be determined from the distributions between magnitudes +1 and +5 and

[1] http://www.imo.net/members/imo_live_shower?shower=SDA&year=2017

Tabel 1 – Magnitude distributions for the SDA 2017 from MISKO.

$\lambda_{\odot}$	Night	Obs	-3	-2	-1	0	+1	+2	+3	+4	+5	Lm	Tot.	m
122.041	24–25/7	MISKO	0	0	0	0	0	3	6	4	4	6.55	17	3.53
122.984	25–26/7	MISKO	0	0	0	0	0	3	6	9	4	6.37	22	3.64
124.888	27–28/7	MISKO	0	1	0	0	2	4	12	12	5	6.68	36	3.25
125.844	28–29/7	MISKO	0	0	0	2	4	7	18	26	10	6.69	67	3.37
126.800	29–30/7	MISKO	0	0	0	1	5	12	16	18	6	6.71	58	3.09
127.757	30–31/7	MISKO	1	0	1	4	3	16	15	16	9	6.70	65	2.85
128.723	31–01/8	MISKO	0	0	0	3	2	6	12	10	5	6.65	38	3.03
129.697	01–02/8	MISKO	0	0	3	2	1	3	4	4	3	6.64	20	2.35

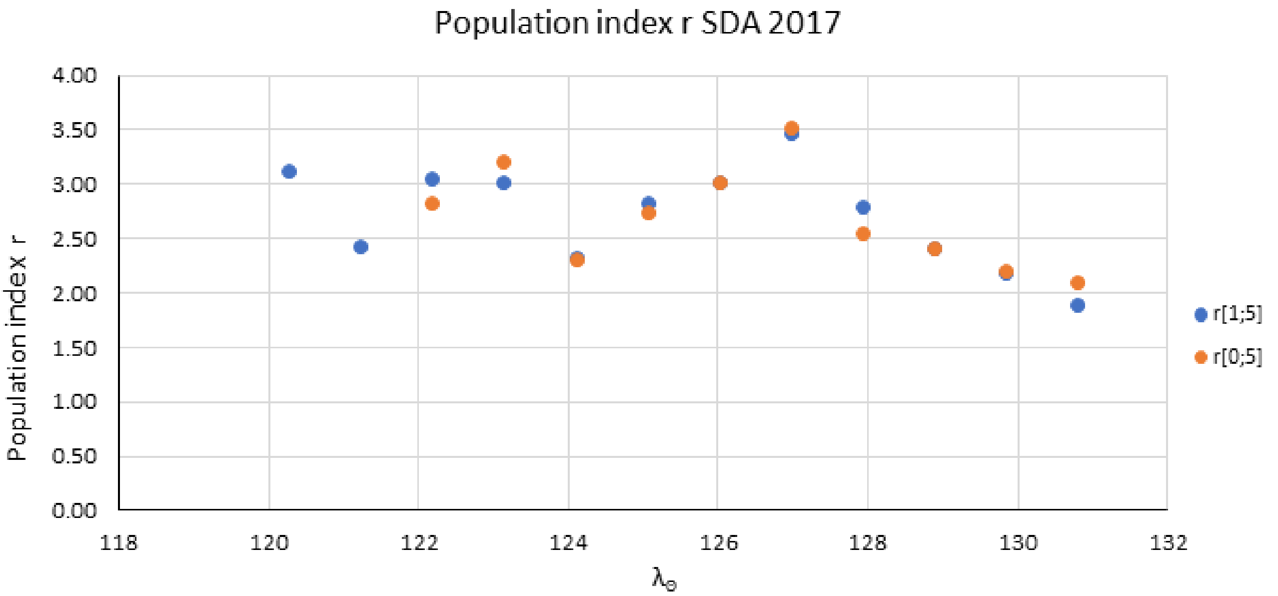

Figure 2 – Population index *r* for the Southern delta Aquariids in 2017. This is based on $r_{[1;5]}$ and $r_{[0;5]}$. With the exception of the data point from the night 29–30 July ($\lambda_{\odot}$ = 127°), the *r* value seems to confirm the impressions of Figure 1.

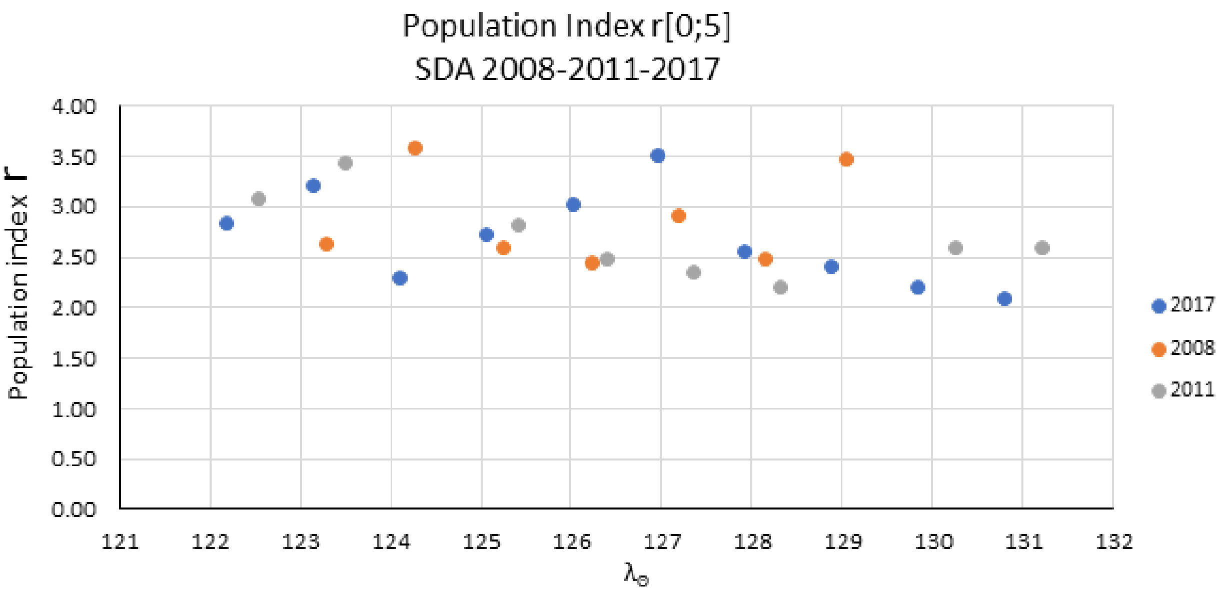

Figure 3 – Comparison of population index $r_{[0-5]}$ between the years 2008, 2011 and 2017.

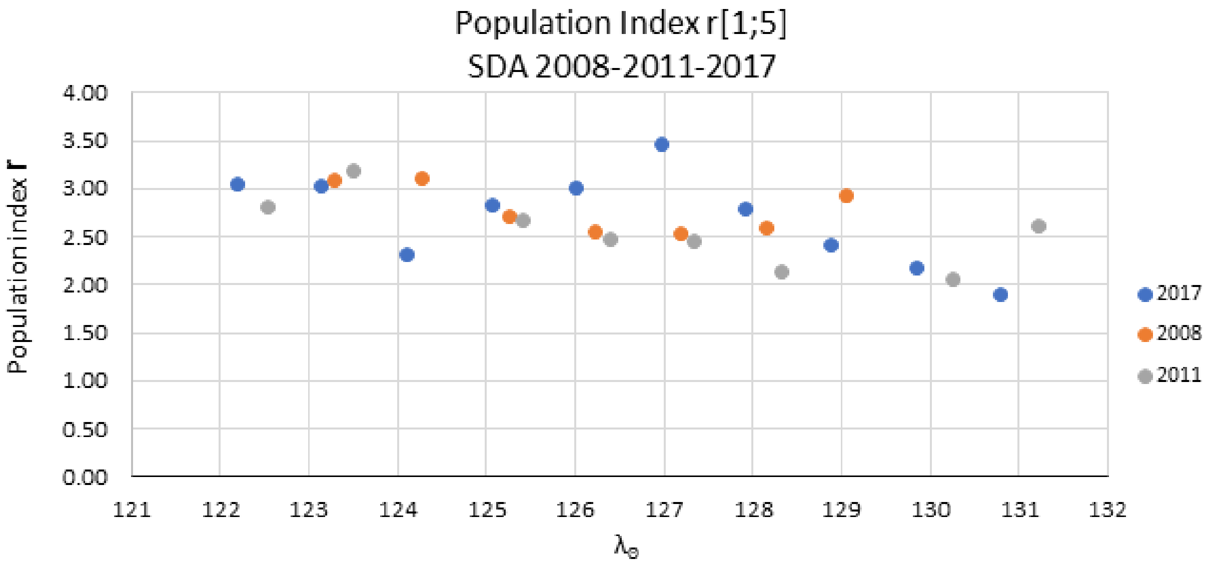

Figure 4 – Comparison of population index $r_{[1;\,5]}$ between the years 2008, 2011 and 2017.

Table 2 – Population index *r* for the SDA 2017 [0;5] and [1;5].

$\lambda_\odot$	Date	$r_{[1;5]}$	n SDA	$r_{[0;5]}$	n SDA
120.270	22/23-7	3.12	14	~	~
121.225	23/24-7	2.44	17	~	~
122.180	24/25-7	3.06	32	31	32
123.136	25/26-7	3.03	54	3.22	55
124.092	26/27-7	2.33	39	2.31	41
125.048	27/28-7	2.84	140	2.74	146
126.004	28/29-7	3.02	172	3.03	177
126.960	29/30-7	3.47	101	3.52	103
127.916	30/31-7	2.79	150	2.56	161
128.873	31/01-8	2.42	76	2.41	81
129.829	01/02-8	2.19	31	2.21	33
130.786	02/03-8	1.90	21	2.10	22

between magnitude 0 and +5. There were too few SDAs of –1 and –2. From this data *Table 2* and *Figure 2* could be distilled.

Subsequently, the value found for 2017 was compared with the *r* values for 2008 and 2011. In the analysis of 2008 and 2011 the *r* values were used $r_{[-2;+5]}$. As a result of the much smaller dataset for 2017, we have now limited ourselves to $r_{[0;+5]}$ and $r_{[+1;+5]}$. *Figures 3 and 4* are the result. The *r* values for 2008 and 2011 $r_{[0;+5]}$ and $r_{[+1;+5]}$ were still available.

What stands out here is that 2017 seems to follow the years 2008 and 2011 reasonably well: from a high value of *r* (more weak meteors) to a lower value *r* (more bright meteors). Exceptions are points from the nights 29–30 July 2017 and 31 July – 1 August 2008.

An explanation of the higher *r* value in the night 29–30 July 2017 compared to 2008 and 2011 lies in the fact that there were few SDAs of 0 and +1 that night. The numbers of SDAs are therefore not a problem here.

The higher *r* value from the night 31 July – 1 August 2008 compared to 2017 (in 2011 no observations were done in this night) is probably caused by a low number of SDAs as a result of a shorter observation period and by heavy Calima dust above La Palma.

In addition, there are also sometimes considerable differences in the period before $\lambda_\odot$ = 124°, this is due to the fact that the *r* values for the period for $\lambda_\odot$ = 124° are based on (too) few SDAs. A single bright SDA can make a big difference in the *r* value.

So broadly speaking, the *r* value found from 2017 determined in the period $\lambda_\odot$ 124°–131° reasonably follows the line from 2008 and 2011. The two mentioned exceptions aside.

In the ZHR calculations we used *r* = 2.70, the average. This average value is close to the values found for 2008 (2.71) and 2011 (2.81).

4 The zenithal hourly rate ZHR

The ZHR was then calculated with the mean *r* value. The result can be found in *Figure 5*.

Figure 5 shows that the activity of the SDAs increases rapidly after July 25 and decreases less rapidly after the maximum. We also saw this effect in the years 2008 and 2011. See also *Figure 6* for the comparison with the years 2008 and 2011.

It is striking that the graphs can be compared well with each other. The development is almost the same. The graph for 2008 is the highest with a ZHR that reaches up to 30. 2017 and 2011 are close together in terms of

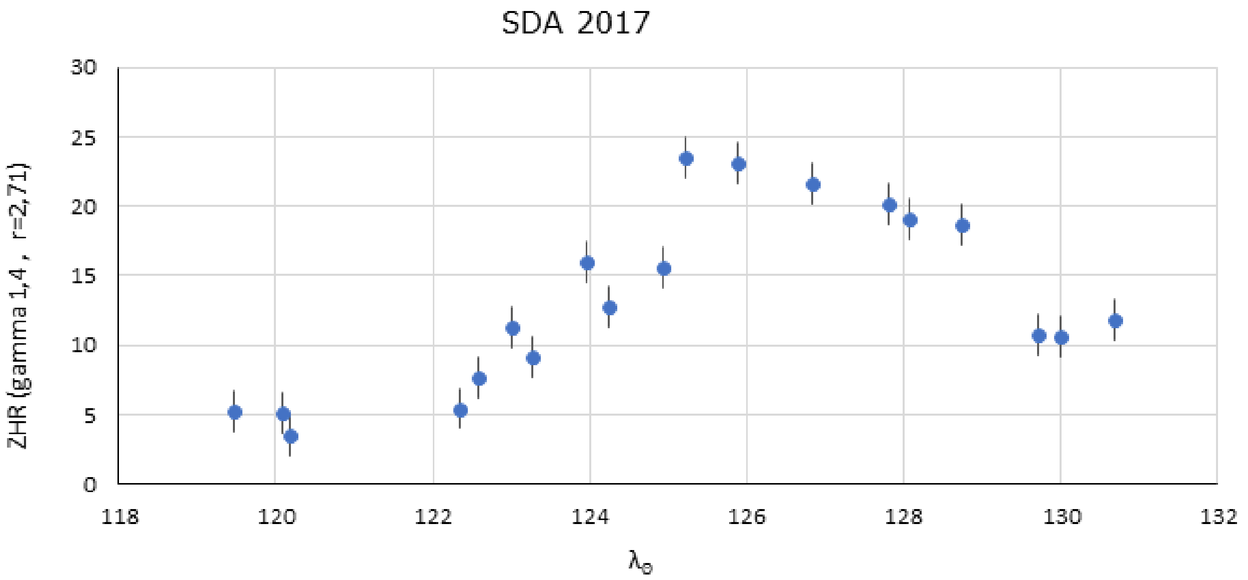

Figure 5 – ZHR graph Southern delta Aquariids 2017. The period shown runs from July 22 to August 3, 2017. This graph is based on 813 SDAs.

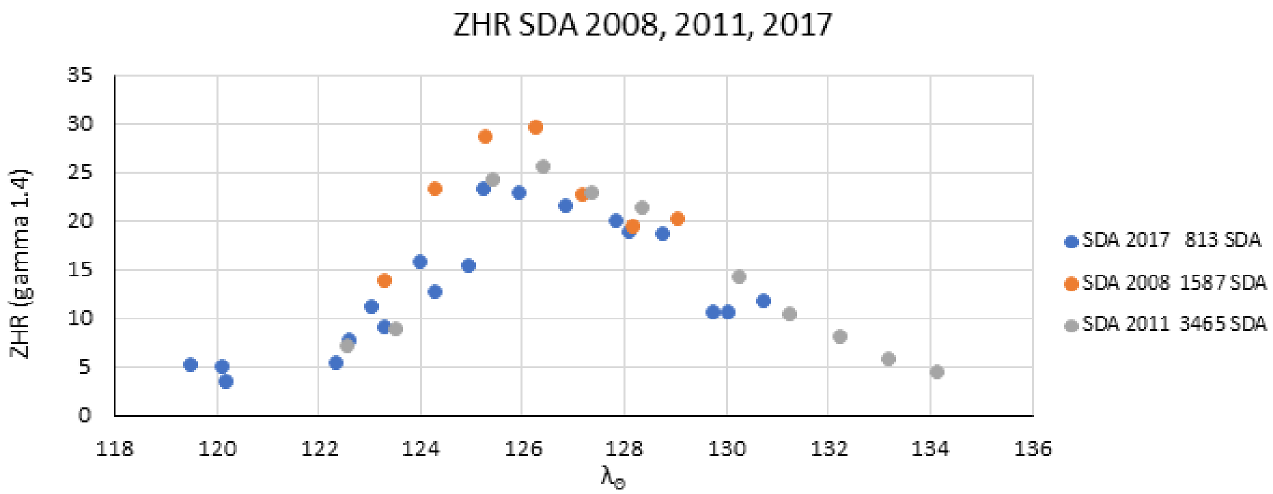

Figure 6 – The ZHR graph of the Southern delta Aquariids from 2017 compared to the ZHR graphs from 2008 and 2011.

maximum activity: around 25. The rapid increase in ZHR after July 25, 2017 ($\lambda_\odot$ = 122°) and the slow decrease after $\lambda_\odot$ = 127° is also visible in 2008 and 2011.

The curve from 2017 is on average the lowest in the series 2008, 2011 and 2017. Whether this is a real effect cannot be said, because the differences are small. The observations were carried out under different circumstances (locations) and slightly different r values were used in 2008 and 2011. In 2008 and 2011 all were known DMS observers, in 2017 we also used data from active IMO observers. But thanks to the C_p, I do not expect that there is a problem here.

It would also be nice to set up another expedition to La Palma or Namibia to once again accurately determine the curve of the SDAs and see if we can confirm the results from 2008, 2011 and 2017.

5 Conclusion and recommendations

The Southern delta Aquariids showed a similar trend in 2017 as in 2008 and 2011. The ZHR seems to be slightly lower, but perhaps the cause can be found in the reduction method (in particular the population index determination) and / or the observing locations. The observation sites in 2017 were in fact more to the north than the much better locations from 2008 and 2011. All in all, the SDAs are a nice meteor shower that is certainly worth to observe visually. Useful visual data can only be obtained south of 44° latitude, the further to the south, the better.

It would be nice if more observers could supply data for this meteor shower, with at least 15 hours between 00^h and 04^h local time in the period at the end of July and August in order to be able to make a good C_p determination.

Acknowledgment

A word of thanks to Carl Johannink and Michel Vandeputte for the critical reading of this article and their useful comments. Also a word of thanks for the great efforts of all visual observers. Also thanks to Paul Roggemans for checking my English.

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October Camelopardalids activity recorded by CAMS

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CAMS BeNeLux collected 15 meteors belonging to a minor stream called the October Camelopardalids, (281 OCT) during routine CAMS observations on October 5, 2017. Radiant positions and orbital elements are in good agreement with previously reported results.

1 Introduction

The weather in the first week of October 2017 was very unstable, so it is no surprise that our network could collect no more than 380 orbits during the few clear spells. Fortunately, October 5–6 was the best night for observing in this week. During this night 18 of the 21 stations had at least longer clear periods. They collected 99 orbits in this single night.

2 History

In the course of the last century, observers noticed meteor activity from a region near the northern celestial pole, for instance in 1902, 1942 and 1976.

On October 5, 2005 some video-observers in Finland (Moilanen, Yrjölä and Lyytinen) and Germany (Molau) captured several bright meteors from a radiant near the border of the constellations Draco and Camelopardalis. Moilanen captured 19 meteors in the period 17^h06^m – 22^h41^m UT. Twelve of them shared the same radiant. Most of these meteors appeared between 17^h and 20^h UT (Jenniskens et al., 2005).

The mean radiant of these twelve meteors was calculated at RA = 164.1 ± 2.0 degrees and Dec = 78.9 ± 0.5 degrees with a geocentric velocity of v_g = 46.9 ± 2.6 km/s. The mean orbital elements are summarized in *Table 1*.

According to Jenniskens et al. (2005), this stream is debris from a yet unknown long periodic comet, although because of the uncertainty on the semi major axis a Halley type comet cannot be excluded as possible option.

Esko Lyytinen forecasted higher activity for this stream at 14^h45^m UT of October 5 2016. Indeed, CAMS California captured 9 meteors that could be matched with this stream between 08^h45^m and 13^h15^m UT. CAMS UAE could add three more candidates between 14^h48^m and 19^h15^m UT. Finally, CAMS BeNeLux added four more candidates until 22^h00^m UT.

The orbital elements for these meteors are also listed in *Table 1*.

For 2017, Esko Lyytinen forecasted enhanced activity at October 5th, 20^h47^m UT, although possibly at a lower level than in 2016, due to a greater distance between the dust trail and the Earth this year.

3 Processing the 2017 data

While processing the data of October 5–6, a cluster of radiants became visible near RA = 170 degrees and Dec. = 74 degrees.

A total of 15 meteors showed orbital elements in good agreement with the now so called October Camelopardalids (281 OCT). Six of these OCTs appeared between 18^h and 19^h UT. The other nine members appeared between 19^h and 24^h UT.

Figure 1 shows the radiant positions of all captured simultaneous meteors during the night of October 5–6. The OCTs are marked with a red colored square in this plot. They appear as a striking compact radiant.

The D-criterion for 13 out of these 15 OCTs is < 0.05. OCTs with the highest and lowest declination in this plot have a D_d in the interval 0.08 – 0.09, just below the limit of Drummond's D-criterion (Drummond, 1981).

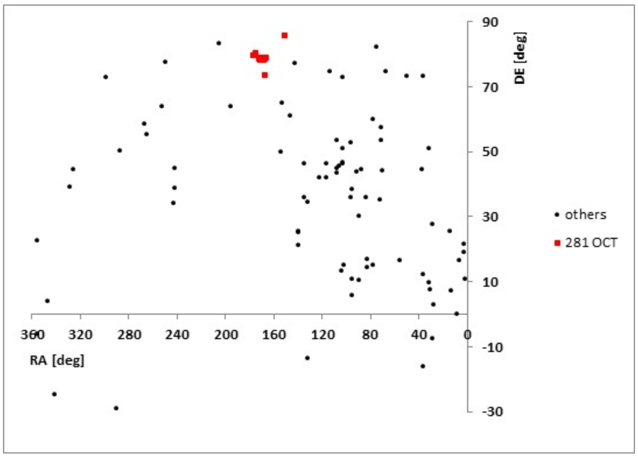

Figure 1 – Radiantplot for 2017 October 5; red squares mark the 281 OCT meteor radiants.

Figure 2 shows a plot of the orbital elements PI, length of perihelion, against *i*, the inclination. Again a striking compact picture appears. The OCTs with D_d > 0.05 are the ones with the lowest and highest value of PI.

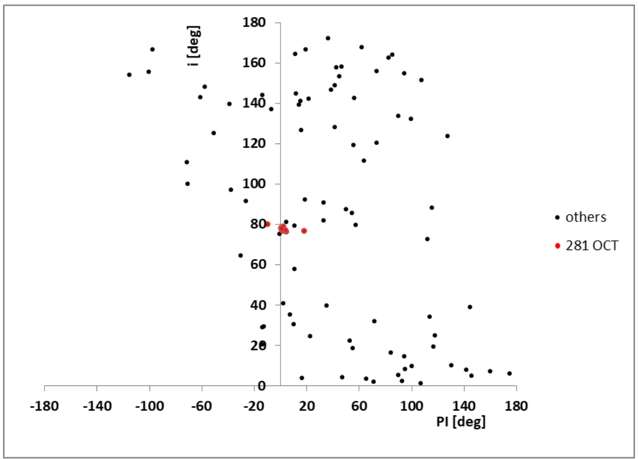

Figure 2 – Plot of the length of perihelion PI against inclination i for 2017 October 5; 281 OCTs are marked in red.

Table 1 shows the mean orbital elements of OCTs in Jenniskens et al. (2005)[1] and our data in 2017.

Table 1 – The orbital elements of the 281 OCT meteors.

	Jenniskens et al. (2005)	Jenniskens[2]	2017 CAMS BeNeLux
q (UA)	0.993±0.001	0.990±0.005	0.991±0.006
e	-	0.93±0.08	0.948±0.05
i (°)	78.3±0.5	77.1±1.0	77.6±2.3
ω (°)	170.5±1.0	168.2±2.5	169.4±4.1
Ω (°)	192.59±0.04	192.41±0.15	192.35±0.25

4 Conclusion

Until 2016 we could not find any member of this stream in the CAMS BeNeLux data. In 2016 and 2017 this stream is clearly visible in our data.

In 2017 the highest activity seems to have occurred between 18^h and 19^h UT, more than one hour earlier than predicted. However, we should keep in mind that our network cannot start collecting data before 17:30 UT (eastern parts of the Netherlands) around this time in October. Higher activity before 18^h UT cannot be excluded and may have been missed by our network.

Acknowledgments

Thanks to *Reinder Bouma* for his critical comments on this article.

We thank all CAMS stations for their quick processing of all data:

Hans Betlem (Leiden, CAMS 371, 372 and 373), *Felix Bettonvil* (Utrecht, CAMS 376 and 377) , *Jean-Marie Biets* (Wilderen, CAMS 380, 381 and 382), *Bart Dessoy* (Zoersel, CAMS 397, 398, 804, 805 and 806), *BISA / Hervé Lamy* (Dourbes / Ukkel, CAMS 394 and 395/ 393), *Martin Breukers* (Hengelo, CAMS 320, 321, 322, 323, 324, 325, 326 and 327), *Franky Dubois* (Langemark, CAMS 386), *Jean-Paul Dumoulin/ Christian Wanlin* (Grapfontaine OCA, CAMS 814 and 815), *Luc Gobin* (Mechelen, CAMS 390, 391, 807 and 808), *Robert Haas* (Alphen aan de Rijn, CAMS 360, 361, 362, 363, 364, 365, 367 and 368; Texel, 810, 811 and 812), *Robert Haas / Edwin van Dijk* (Burlage, CAMS 801 and 802), *Klaas Jobse* (Oostkapelle, CAMS 330, 331, 332, 333, 334, 337, 338 and 339) , *Carl Johannink* (Gronau, CAMS 311, 312, 313, 314, 315, 316, 317 and 318), *Koen Miskotte* (Ermelo, CAMS 351, 352, 353 and 354), *Piet Neels* (Ooltgensplaat, CAMS 340, 341, 342, 343, 344, 345, 349 and 840; Terschelling, 841, 842, 843 and 844), *Steve Rau* (Zillebeke, CAMS 385 and 387), *Paul Roggemans* (Mechelen, CAMS 383, 384, 388, 389, 399 and 809), *Hans Schremmer* (Niederkruechten, CAMS 803) and *Erwin van Ballegoij* (CAMS 347 and 348).

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[2] https://www.seti.org/seti-institute/news/october-5-outburst-october-camelopardalids

Leonid fireball above the BeNeLux 2017 November 19, 02h29m UT

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A brilliant Leonid fireball of magnitude -8 occurred right above the center of the CAMS BeNeLux network on 2017 November 19, 02h29m09s UT. It was captured by 7 CAMS cameras and several all-sky stations. The impressive event was also captured on color video by Klaas Jobse with the Astronomy!Projects Oostkapelle.

1 Introduction

November 2017 is a typical autumn month with general overcast sky with frequent rain. Looking at the weather during the day time gave very little or no hope for the night. That is a great pity as the CAMS network now has over 13 hours with the Sun more than 8° under the horizon while the overall meteor activity is at its best during the autumn months. Any complete clear night results in over 500 orbits for the CAMS network around this time. Unfortunately, weather is just 'normal' this year without any periods with exceptional stable clear sky. Luckily the long nights offer very often some gaps between the clouds, here and there clear sky occurs for a short time in these nights. This is enough to collect nice numbers of orbits, with every now and then a surprise.

2 Leonid fireball

In the morning of November 2017, *Paul Roggemans* was among the first few to notice that a bright flash occurred on one of his cameras (384). Camera 388 displayed the culprit: a beautiful fireball. Camera 388 points about above the center of the BeNeLux, hence it was very likely that more CAMS and all-sky stations had this fireball too. Soon the very first reports appeared on the social media and mailing lists. *Klaas Jobse* reported that he captured this fireball with his color video camera[3]. The persistent train could be monitored for 20 minutes on this recording.

It turned out that at least 7 cameras of the CAMS network and several all-sky cameras had registered this fireball. *Paul Sutherland* photographed this fireball from England.

Figure 1 – The video recording by Klaas Jobse at Oostkapelle, the Netherlands.

Figure 2 – Leonid fireball of 2017 November 19, $02^h29^m09^s$ UT, photographed by Paul Sutherland, Walmer, Kent, England.

[3] https://vimeo.com/243502557

Figure 3 – The same fireball recorded with the all-sky camera of Koen Miskotte at Ermelo, the Netherlands.

Figure 4 – Leonid fireball 2017 November 19 at $02^h29^m09^s$ UT captured by CAMS 813 operated by Robert Haas at Texel, the Netherlands.

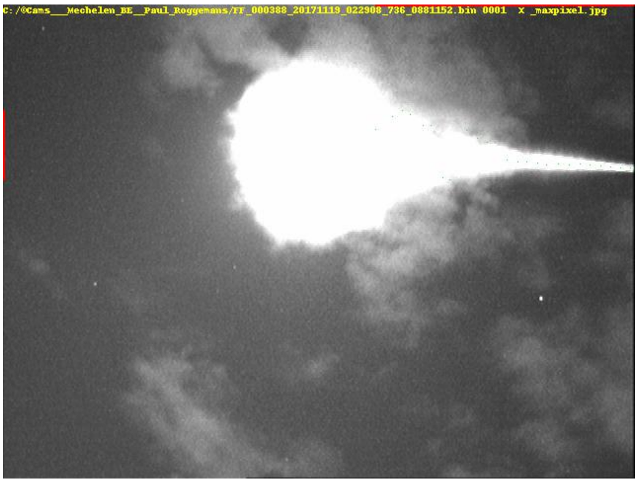

Figure 5 – Leonid fireball 2017 November 19 at $02^h29^m09^s$ UT captured by CAMS 388 operated by Paul Roggemans at Mechelen, Belgium. Thin clouds made the fireball even more dramatic.

Figure 6 – Leonid fireball 2017 November 19 at $02^h29^m09^s$ UT captured by CAMS 382 operated by Jean-Marie Biets at Wilderen, Belgium.

Figure 7 – Leonid fireball 2017 November 19 at $02^h29^m09^s$ UT captured by CAMS 337 operated by Klaas Jobse at Oostkapelle, the Netherlands.

Figure 8 – Leonid fireball 2017 November 19 at $02^h29^m09^s$ UT captured by CAMS 802 operated by Robert Haas at Burlage, Germany.

Figure 9 – Leonid fireball 2017 November 19 at $02^h29^m09^s$ UT captured by CAMS 323 operated by Martin Breukers at Hengelo, the Netherlands.

Figure 10 – Leonid fireball 2017 November 19 at $02^h29^m09^s$ UT captured by CAMS 324 operated by Martin Breukers at Hengelo, the Netherlands.

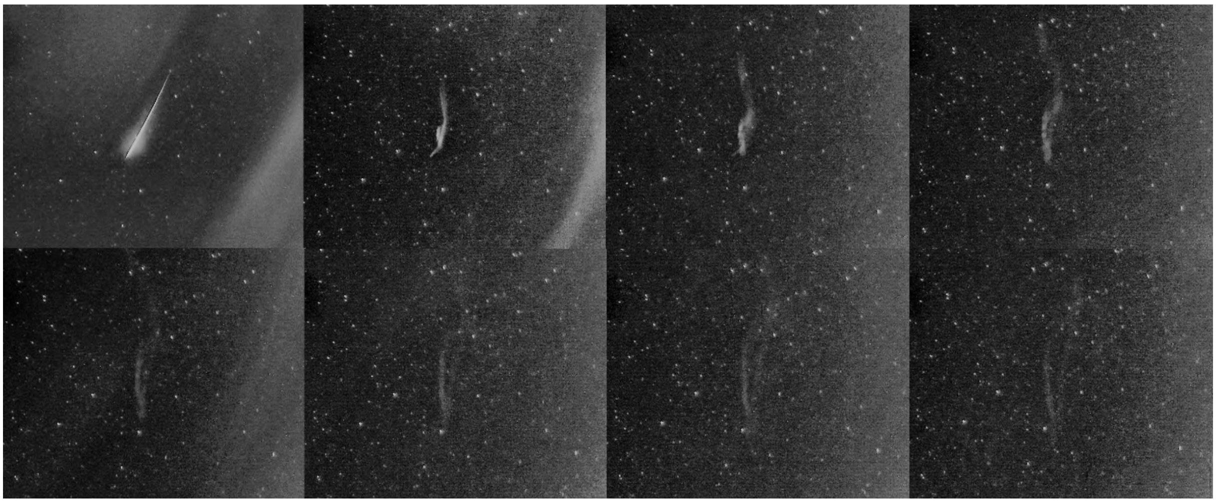

Figure 11 – Klaas Jobse (Oostkapelle, the Netherlands) made this series of pictures of the persistent trail during the first 12 minutes after the appearance of this fireball. Photo with Canon 1300D and 4.5 mm sigma all-sky, exposure 90 seconds.

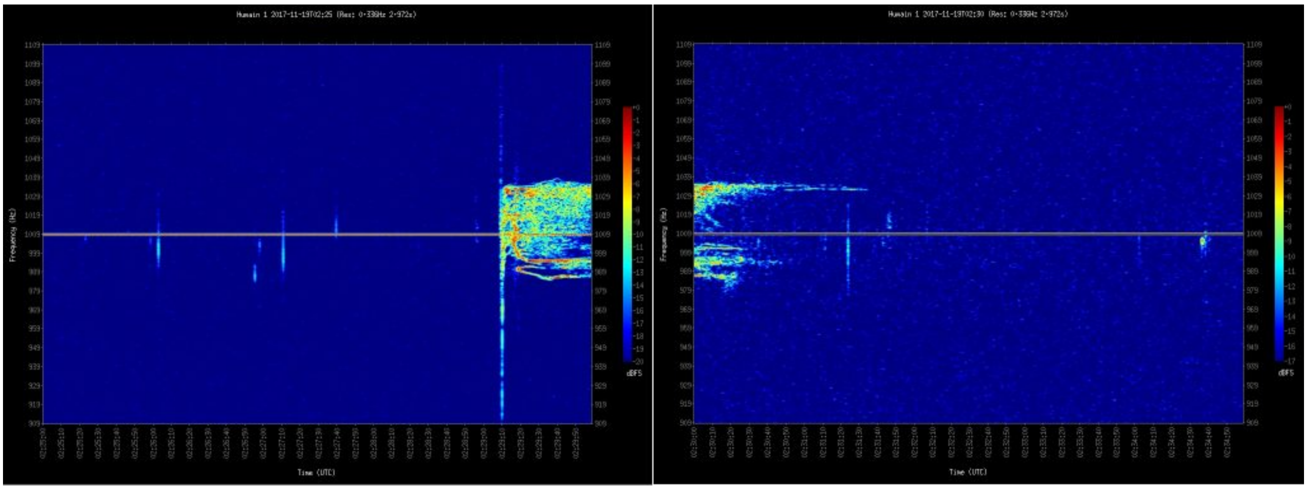

Figure 12 – Spectrogram of the BRAMS station in Humain (Belgium).

3 Radio echos from this fireball

Hervé Lamy reports that this fireball was also detected by all BRAMS stations. *Figures 12 and 13* display the data from Humain and Uccle. Note that the meteor echo was so long that it is split on 2 consecutive spectrograms.

Enrico Stomeo reported that the fireball was also detected by radio from Venice, Italy. The persistent signal was recorded during 6.4 seconds in the Venice Planetarium radio station at $02^h29^m24^s$ UTC (*Figure 14*).

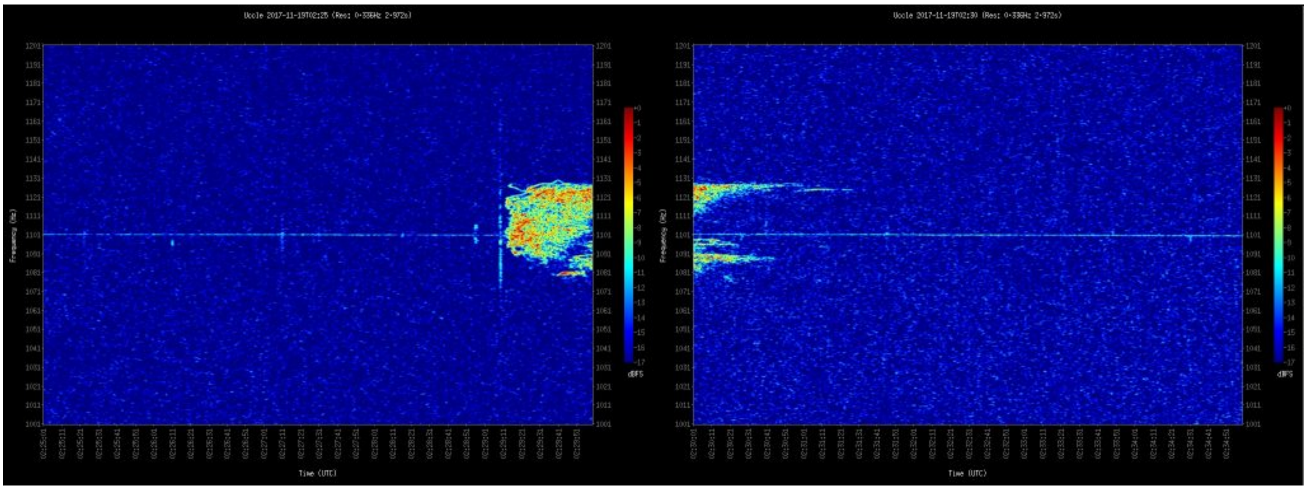

Figure 13 – Spectrogram of the BRAMS station in Humain (Belgium).

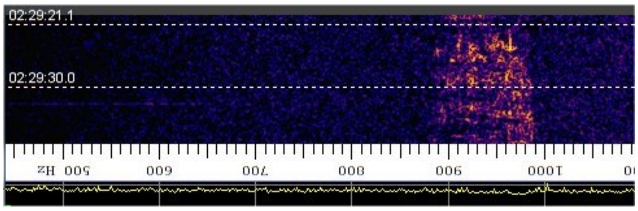

Figure 14 – The spectrogram recorded at the planetarium in Venice.

4 Radiant and orbit computation

The detection info from the different CAMS stations arrived during Sunday 19 November. The computation of the trajectory of this bright event proved to be a real challenge. Many CAMS sites got only a part of the fireball. These registrations were first put apart.

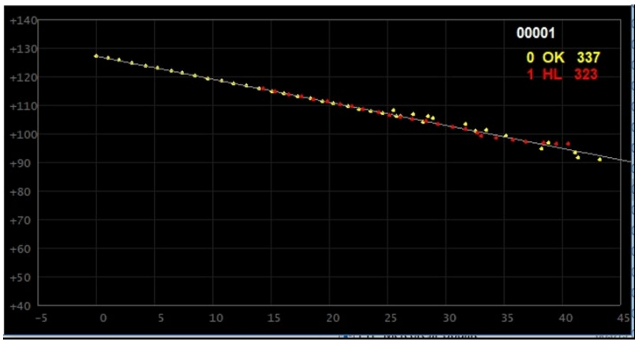

Figure 15 – The height profile of the Leonid fireball 2017 November 19 at $02^h29^m09^s$ UT.

With the remaining data an attempt was made to get an idea of the radiant position and the orbit using the *Coincidence* routine of CAMS. Only few combinations resulted in a good solution, the 337 of *Klaas Jobse* (Oostkapelle), the 323 of *Martin Breukers* (Hengelo) and the 813 of *Robert Haas* (Texel). The reason why only few captures proved suitable for computations is that this fireball was too bright for the CAMS program to track the actual path. *Figure 15* shows the height profile of this Leonid for the stations Oostkapelle (CAMS 337) and Hengelo (CAMS 323).

Figure 15 shows that the measured points display some scatter from a given point and deviate from the straight line. The points for Hengelo (red) are ending at a higher elevation. *Figure 9* with the picture of CAMS 323 explains this: the meteor disappears at the edge of the camera field.

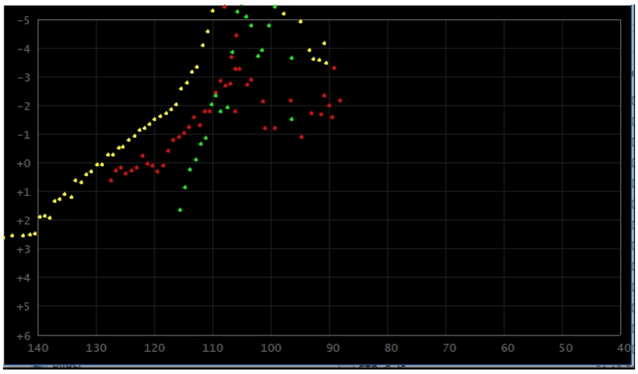

Figure 16 – Luminosity profile profile of the Leonid fireball 2017 November 19 at $02^h29^m09^s$ UT, Texel (yellow), Oostkapelle (red) and Hengelo (green).

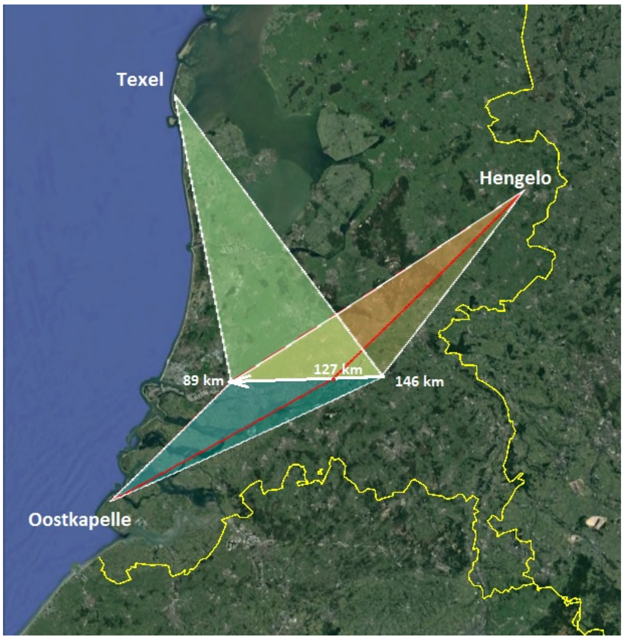

Figure 17 – The Trajectory of the Leonid fireball above the BeNeLux.

The luminosity profile in *Figure 16*, based on the data from all three stations, Texel, Oostkapelle and Hengelo shows an even more scattered picture.

Tables 1, 2 and 3 list the results of the different computations for each combination of two of the three stations as well as the combination of all three stations:

- Oostkapelle (331) – Hengelo (323)
- Texel (813) – Hengelo (323)
- Texel (813) – Oostkapelle (337)
- Oostkapelle (331) – Hengelo (323) – Texel (813)

The differences obtained in geocentric velocity for these four options indeed affects the orbital elements, q and e, (hence also the semi-major axis a) and ω. *Table 3* shows that the ablation height of this meteor is remarkable high, according to the computations between 125 and 145 km, something that has been found before with bright Leonids (Betlem et al., 2000; Spurny et al., 2000).

The end height is almost identical in all four calculations: 89 km. This is in good agreement with the end heights found from 12 bright Leonid fireballs in 1998. These 12 bright Leonids had ending heights between 73 and 103 km (average 87.6 km) (Betlem et al., 2000; Spurny et al., 2000).

Table 1 – Geocentric radiant position and geocentric velocity for the Leonid fireball of November 19, $02^h26^m09^s$ UT.

RA_g (°)	Dec_g(°)	v_g km/s	Cameras
154.93±0.07	20.91±0.08	69.73±0.03	337 & 323
155.25±0.03	21.33±0.03	70.21±0.02	813 & 323
154.78±0.06	21.05±0.07	71.23±0.17	813 & 337
154.87±0.01	21.06±0.01	71.23±0.01	813, 337, 323

Table 2 – Orbital elements for the Leonid fireball of November 19, $02^h26^m09^s$ UT.

q (AU)	e	i	ω	Cameras
0.98386±0.00027	0.8168±0.003	162.88±0.136	171.839±0.252	337 & 323
0.98354±0.00011	0.8671±0.002	162.13±0.056	171.69±0.094	813 & 323
0.98498±0.00014	0.9532±0.016	163.02±0.138	173.213±0.151	813 & 337
0.98471±0.00002	0.9536±0.000	162.96±0.01	172.951±0.022	813, 337, 323

Table 3 – Trajectory data, beginning and ending height, geographic position for the Leonid fireball of November 19, $02^h26^m09^s$ UT.

Lat_{Beg} (°)	$Long_{Beg}$ (°)	H_{Beg} (km)	H_{Max} (km)	Lat_{End} (°)	$Long_{End}$ (°)	H_{End} (km)	Cameras
51.7848±0.0002	5.1971±0.0004	127.2±0.02	97.7	51.8951±0.0003	4.5418±0.0005	89.49±0.04	337 & 323
51.7362±0.0004	5.5125±0.0002	145.38±0.02	97.6	51.8931±0.0002	4.5477±0.0004	89.46±0.05	813 & 323
51.7299±0.0002	5.5163±0.0006	146±0.05	103.8	51.8948±0.0004	4.5475±0.0022	89.52±0.11	813 & 337
51.7305±0.0001	5.5154±0	145.9±0.01	97.6	51.8949±0	4.5439±0	89.4±0.01	813, 337, 323

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PMN-Portuguese Meteor Network and OLA-Observatório do Lago Alqueva agreement

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The PMN-Portuguese Meteor Network has two new video meteor detecting systems at OLA- Observartório do Lago Alqueva, situated at the South East Portuguese territory with a pristine night sky and more than 290 clear nights each year.

1 Introduction

The PMN-Portuguese Meteor Network installed two new video meteor detection systems at OLA-Observatório do Lago Alqueva (*Figure 1*). This private observatory is located near Monsaraz, a small historical village, at South East Portuguese territory, near the Spanish border and Europe's greatest artificial lake Alqueva.

Figure 1 – Wide view of OLA-Observatório do Lago Alqueva main building.

2 OLA-Observatório do Lago Alqueva

This new observatory was build inside an unpolluted sky reserve known as Reserva Dark Sky® Alqueva[4], the first starlight tourism destination in the world.

Figure 2 – OLA- Observatório do Lago Alqueva entrance.

With these two new systems PMN-Portuguese Meteor Network[5] has now sixteen working systems at eight different locations (*Figure 3*).

Figure 3 – LUZ e ORADA systems attached to a concrete bases.

Now it is possible to have a new level of accurate meteor data, if meteor detections are simultaneously recorded at two or more different and distant systems. *Figures 4 and 5* obtained with UFO2-Maps free software, being the first data obtained at OLA show the improvement that PMN will give to the development of Meteor Science.

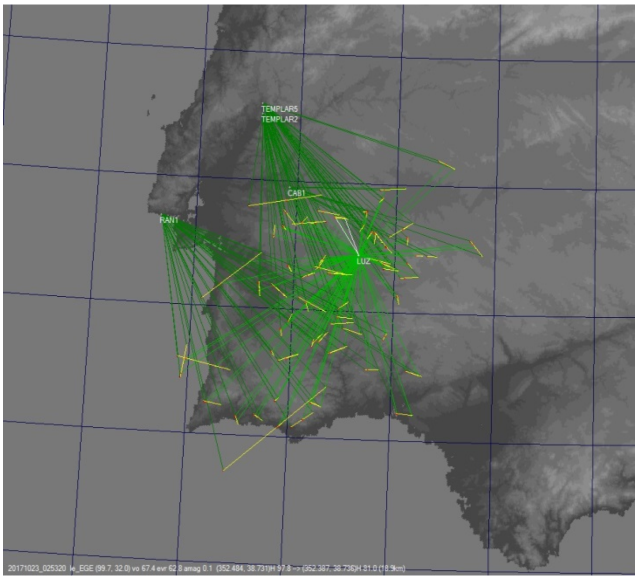

Figure 4 – The system LUZ is pointed towards South.

The OLA- Observatório do Lago Alqueva is now very well equipped with several modern designed telescopes and robotic facilities. The main building has an auditorium, a dome with several facilities and several platforms with electric energy and internet access points.

[4] https://www.facebook.com/observatoriolagoalqueva/

[5] https://www.facebook.com/groups/656819951153819/

Since its inauguration OLA has organized several successful meetings, events, observational sessions, astronomical courses, conferences as well as the Astrofesta 2017, the Portuguese annual astro party. OLA is now installing a faster internet connection, to allow remote command of the PMN video meteor systems, and doing the same with the OLA telescopes and dome at the same time.

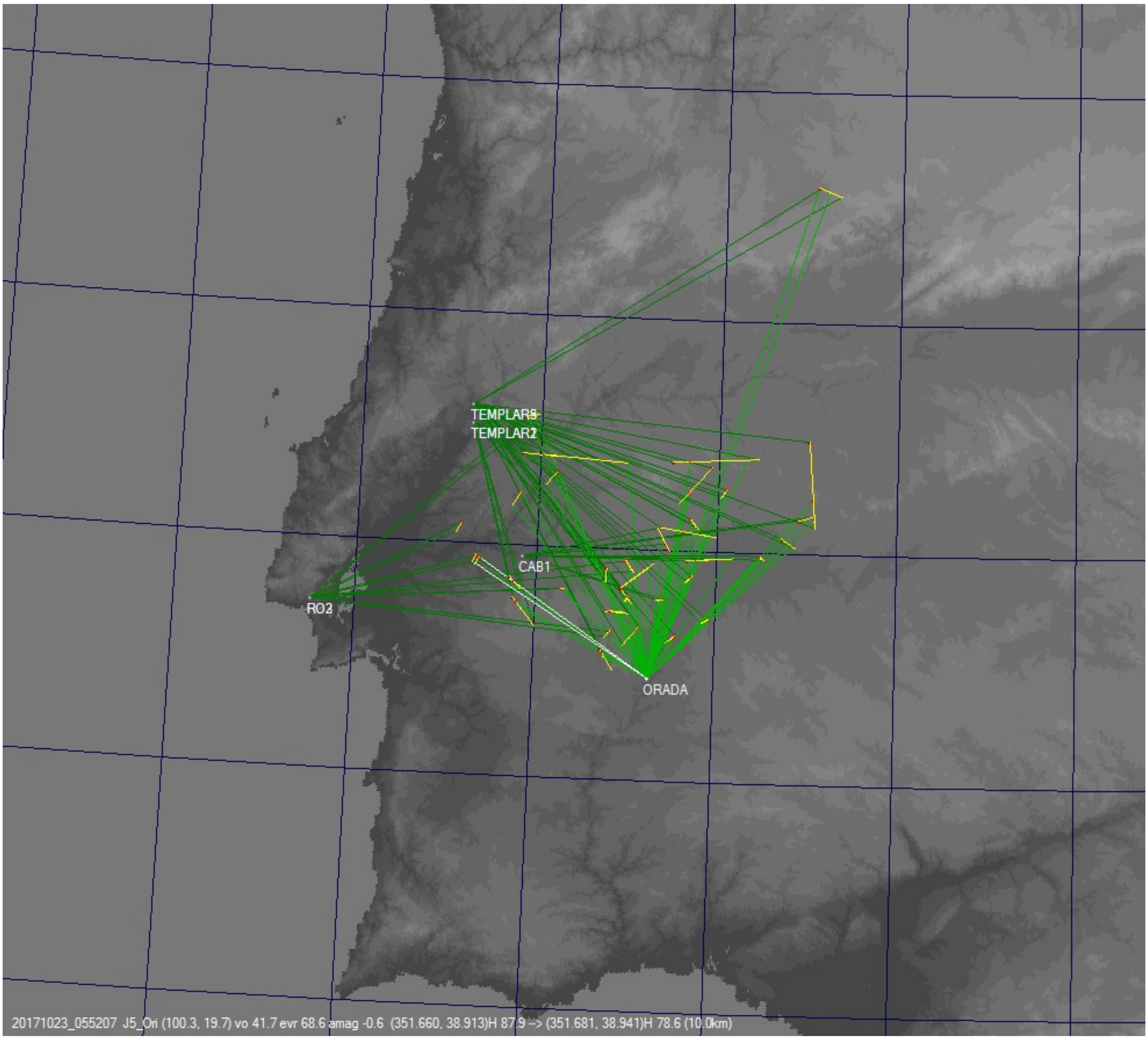

Figure 5 – The system ORADA is pointed towards North.

Leonids 2017 from Norway – A bright surprise!

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I am very pleased to have been able to observe near maximum activity of the Leonids, and clearly witnessed the unequal mass distribution during these hours. A lot of bright Leonids were seen, followed by a short period of high activity of fainter meteors, before a sharp drop in activity. The Leonids is undoubtedly a shower to watch closely, with its many variations in activity level and magnitude distribution. I already look forward to observing the next years' display, hopefully under a dark and clear sky, filled with bright meteors!

1 Introduction

After missing the maximum nights of the Orionids due to bad weather, I hoped for better luck in the maximum night of the Leonids. November weather is generally very bad in Norway, but the weather forecast gave hope for a clearing in the morning hours on November 17. The IMO calendar had indicated two possible maximum times, in the early afternoon hours of November 16 and 17 respectively, both with ZHR around 10. Being hours away from these timings, my best hopes were hourly rates between 5 and 10 meteors. These expectations were met, but the Leonids were also in for a bright surprise!

2 Preparations

I went to bed early on November 16, trying to get some sleep before observations started. The alarm was set for 00:00 UT on November 17, about the time of the clearing predicted by the weather forecast. After 5 good hours of sleep, a quick look out of the window at midnight, showed nothing but grey clouds. I decided to try to get one more hour of sleep, and sat the alarm for 01:00. The next weather check was more encouraging, with no clouds visible through the window, and Vega shining bright in the northern sky! After a quick "breakfast", I assembled my observation gear and went out to my observation site, on a field behind the barn at my home place. The first Leonid was seen while setting up my camping bed and camera equipment, a nice 1 Mag. in Leo, with a characteristic short smoke train. I was finally ready for the 2017 maximum of the Leonids!

3 Observations

I started observations at 01:45 UT, in the same minute as a 0 Mag. Leonid streaked from Leo, up into Gemini between Castor and Pollux. The following 15 minutes gave two more Leonids of Mag. 2 and 3, before a 0 Mag, slow moving, yellow/red sporadic, appeared in Ursa Major at 02:06. Another couple of bright Leonids showed up at 02:11. First a 1 Mag in Ursa Major, followed rapidly by a –1 Mag in the outskirts of my observation field in the southern sky. The Sporadics also showed up with another 0 Mag. meteor this first hour, before another couple of bright Leonids of Mag 0 and –1, streaked the sky at 02:24. The first hour of observation, was rounded off by another 0 Mag. Leonid at 02:42.

I was very satisfied with the activity and brightness of the meteors the first hour, and did not know the Leonids had saved the best for the next! At 03:05 an impressing, fast moving, yellow –2 Mag. Leonid lighted up the sky in Ursa Minor, followed by a –1 Mag. in Ursa Major only two minutes later! And best of all, was that both meteors were right in my camera field in the north-eastern sky! The great climax came 03:21, when a –3 Mag. burst in flames in Ursa Major, moving from Mizar in a north-western direction. An impressive smoke train could later be followed on 25 exposures each 20 seconds, on my camera.

4 Observational data for November 17

01:45 – 02:50

T_{eff}: 1.050 – F: 1.00 – RA: 150 – Dec: +55 – Lm: 6.15

- Leo: -1(2), 0(3), 1, 2, 3(2), 4. A total of 10 meteors
- Spo: 0(2), 1(2), 2, 3(2), 4, 5(2), 6. A total of 11 meteors.

02:50 – 03:55

T_{eff}: 1.050 – F: 1:00 – RA: 150 – Dec: +55 – Lm: 6.15

- Leo: -3, -2, -1, 2(3), 3(3), 4, 5. A total of 11 meteors.
- Spo: 2(2), 3(2), 4(2), 5(2), 6. A total of 9 meteors.

03:55 – 05:15

T_{eff}: 1.333 – F: 1.00 – RA: 150 – Dec: +55 – Lm: 6.13

- Leo: -2, 2(2), 3(2), 4(7), 5(3). A total of 15 meteors.
- Spo: 0, 2, 3(3), 4, 5(2). A total of 8 meteors.

The whole observing session can also be found with IMO[6]

[6] http://www.imo.net/members/imo_vmdb/view?session_id=75521

Figure 1 – A –3 Mag Leonid in Ursa Major on November 17 at 03:21 UT. Nikon D3100, with Samyang 16mm F2.0 lens. 20 seconds exposure, with ISO 1600 settings.

Figure 2 – The meteor that ended the bright Leonid show. A –2 Magnitude Leonid on November 17 at 04:08 UT. Photo taken with a Nikon D3100 camera, with a Samyang 16mm F2.0 lens. 20 seconds exposure time, with ISO 1600 settings.

As we see, the bright Leonids were more abundant in the two first periods, before the fainter ones shows up in the last period. These hour+ long periods however, camouflages the variations in activity level. Most noticeable is the "burst" of activity in faint meteors between 04:09 and 04:30, with 10 Leonids with an average magnitude of 3.8 observed. Thereafter the decline in activity level between 04:30 and 05:15, with only 2 Leonids observed.

5 Post-maximum observations

After two nights with massive clouds, sky was again clear the night between November 19 and November 20. However, the sky was a bit bright and hazy, with an Lm on 6.11. I started observations at 00:30 UT, and the first hour yielded four Leonids in the magnitude range between +3 and +5. The next hour only two Leonids were observed, under a slightly brighter sky with Lm 5.99. This night's best shower was undoubtedly the Taurids, with a beautiful –1 Mag. Southern Taurid as the highlight. Also, a nice, possible 0 Mag. Alpha Monocerotid was observed. Details of the observation can be found with IMO[7].

[7] http://www.imo.net/members/imo_vmdb/view?session_id=75541

Ancient City Astronomy Club 2017 Leonid Observations

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A summary is given of the visual observations of the 2017 Leonid observations in Florida.

1 Introduction

I am finally getting caught enough to report on the detailed observational results from last week's ACAC 2017 Leonid Meteor Shower maximum observations from North Florida. A big thanks to fellow ACAC members Neal and Nancy Brown for joining me on the main nights.

2 Nov., 14/15, 2017

Here are my results:

Observed for radiants:

- LEO: Leonids
- STA: South Taurids
- NTA: North Taurids
- NOO: November Orionids
- AND: Andromedids
- SPO: sporadics

Observer: Paul Jones, location: north bank of Matanzas Inlet, Florida, 15 miles south of St. Augustine, Florida, Lat: 29.75 N, Long:81.24W, LM: 6.5, sky conditions: clear, Facing: SE.

0330 – 0430 EST (0830 – 0930 UT)
T_{eff}: 1 hour, clear, no breaks.

- 5 LEO: -1(1), +1(1), +2(1), +4(1), +5(1)
- 1 NOO: +3(1)
- 2 NTA: +2(2)
- 8 SPO: +2(2), +3(2), +4(3), +5(1)
- 16 total meteors

2 of the 5 LEOs, 2 of the SPOs left visible trains, most common colors were gold and yellow in the brighter LEOs.

3 Nov., 15/16, 2017

Observer: Paul Jones, Location: north bank of Matanzas Inlet, Florida, 15 miles south of St. Augustine, Florida, Lat: 29.75 N, Long:81.24W, LM: 6.5, sky conditions: clear, Facing: SE.

0500 – 0545 EST (1000 – 1045 UT)
T_{eff}: .75 hour, clear, no breaks

- 9 ORI: 0(1),+1(2), +2(2), +3(2), +4(1), +5(1)
- 1 NTA: +2(1)
- 9 SPO: +1(1), +2(1), +3(3), +4(2), +5(2)
- 19 total meteors

4 of the 9 LEOs, 1 NTAs and 3 SPOs left visible trains, most common colors were gold and yellow in the brighter LEOs and SPOs.

4 Nov., 16/17, 2017

Observer: Paul Jones, Location: north bank of Matanzas Inlet, Florida, 15 miles south of St. Augustine, Florida, Lat: 29.75 N, Long:81.24W, LM: 6.5, sky conditions: clear, Facing: SE.

0230 – 0330 EST (0730 – 0830 UT)
T_{eff}: 1 hour, 20% clear, no breaks

- 7 LEO: 0(1), +2(3), +3(1), +4(2)
- 1 STA: +3(1)
- 1 NTA: +2(1)
- 1 NOO: +3(1)
- 6 SPO: +2(1), +3(3), +4(3)
- 16 total meteors

4 of the 7 LEOs, left visible trains, most common colors were gold and yellow in the brighter ORIs and SPOs.

0330 – 0430 EST (0830 – 0930 UT)
T_{eff}: 1 hour, clear, no breaks

- 12 LEO: -2(1), 0(1), +1(3), +2(3), +3(2), +4(2)
- 2 NTA: +2(1), +3(1)
- 9 SPO: +1(2), +2(3), +3(2), +4(2)
- 23 total meteors

5 of the 12 LEOs, left visible trains, most common colors were gold and yellow in the brighter LEOs and SPOs.

0430 – 0530 EST (0930 – 1030 UT)
T_{eff}: 1 hour, clear, no breaks

- 14 LEO: -1(2), 0(1), +1(2), +2(2), +3(5), +5(2)
- 2 NTA: +2(2)
- 10 SPO: -1(1), +1(1) +2(1), +3(2), +4(3), +5(2)
- 26 total meteors

6 of the 14 LEOs, and 3 of the SPOs left visible trains, most common colors were gold and yellow in the brighter LEOs and SPOs.

5 Nov., 17/18, 2017

Observer: Paul Jones, Location: Deep Creek Conservation Area, 2 miles east of Hastings, Florida, Lat: 29.69 N, Long:81.44W, LM: 6.2, sky conditions: 15% clouds & fog interference, Facing: W.

0345 – 0445 EST (0845 – 0945 UT)
T_{eff}: 1 hour, no breaks

- 9 LEO: -3(1), 0(1), +2(5), +3(1), +4(1)
- 1 NTA: +3(1)
- 7 SPO: +2(1), +3(3), +4(3)
- 17 total meteors

4 of the 9 LEOs, left visible trains, most common colors were gold and yellow in the brighter LEOs.

0445 – 0545 EST (0945 – 1045 UT)
T_{eff}: 1 hour, no breaks

- 13 LEO: -1(1), 0(1), +1(2), +2(3), +3(3), +4(2), +5(1)
- 1 NOO: +2(1)
- 8 SPO: 0(1), +2(2), +3(1), +4(2), +5(1)
- 22 total meteors

5 of the 13 LEOs and 1 SPO, left visible trains, most common colors were gold and yellow in the brighter LEOs.

6 Conclusion

Overall, the LEOs appeared to have a very normal year for them, with a mixture of nice, bright ones and short faint ones. The sky conditions were not optimal for the max this year, as although mostly clear, the fog and very high humidity each night cut into the transparency quite a bit, especially low in the sky in all directions.

After the horrendous year for weather we have had here in North Florida it was simply a blessing to see anything of the LEOs at all. 2017 Geminids next up!

Geminids 2017 – Pre-maximum night from Norway

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A report on the Geminid observation in the night of 12-13 December in Norway is presented.

1 Introduction

For a long time, I had been looking forward to the 2017 return of the Geminids. In 2015, I was impressed by the activity and the many bright meteors of fireball class. Also in 2016, I witnessed many bright meteors under a moonlit sky during the maximum. This year, observing conditions would be near perfect, and the only thing that could ruin the show, was bad weather. The weather forecast was quite depressing, except for one night. On the evening of December 12, the sky was clear, and I was excited to check out the activity more than a day before the expected maximum.

2 Preparations

I chose an observing site on an icebound lake, some 20 minutes driving from home. This place is far from any sources of light, and the horizon is nearly perfect. The temperature was very cold, about –14 degrees Celsius, so I was prepared for a freezing night. Despite the cold, it was a fantastic natural experience to lay down on the sunbed and listen to the sounds of the forest. The cracking of the ice sounded like a symphony from all around the lake, and sometimes from right under my sunbed! This made my heart jump a couple of times, but I knew the ice was thick enough. Anyway, it helped me not to fall asleep! Also, the screams of a nearby fox contributed to my alertness, and I was more than ready for what the Geminids would bring of further excitement.

3 Observations

The observation started 20:45 UT, but I soon became aware of some unexpected clouds coming in from the west. These clouds lasted for about an hour, and affected the Geminid rates the first hour. I chose to count Geminids in 20 minutes periods, and in the three first periods rates were 3, 3 and 7. The next hour the clouds disappeared, and the LM also improved somewhat. The 20 minutes rates for this hour was 8, 9 and 12. The last hour before a short break, yielded 20 minutes rates of 14, before a sharp fall to 4 and 7. The meteors these first three hours were quite weak, with only one Geminid of –1 magnitude, and two of 0 magnitude.

After 3 hours of observation in –14 degrees, I had to take a break to get some food, and change battery on my camera. After this my fingers were so frozen that I had serious problems to handle my cassette recorder and the remote control on my camera. After some minutes warming my fingers against my body, they were functional again, and observations could continue. I started observations again 00:05, and the next hour gave 20 minutes rates of 10, 12 and 14. Activity culminated between 01:05 and 01:25 UT, when 16 Geminids were seen, followed by 9 and 12 in the next two periods. There were also a lack of very bright meteors during these two hours, but 5 Geminids reached magnitude 0. After 5 hours of observations, I had to drive home to get two hours of sleep before going to work. The next night was unfortunately clouded, but I was happy to at least have seen some of the activity of this year's Geminids.

4 Observational data 12–13 December

20:45 – 21:05: T_{eff}: 0,333. F: 1,17. Lm: 6,11.

ANT: 0, DLM: 0, MON: 0, NOO: 0, SPO: 0, GEM: 3(2, 5(2)

21:05 – 21:25: T_{eff}: 0,333. F: 1,11. Lm: 6,11.

ANT: 1(5), DLM: 0, MON: 0, NOO: 0, SPO: 1(5), GEM: 3(0, 1, 2)

21:25 – 21:45: T_{eff}: 0,333. F: 1,05. Lm: 6,23.

ANT: 0, DLM: 0, MON: 2(4, 5), NOO: 2(3(2), SPO: 3(1, 3, 4), GEM: 7(-1, 1, 3(2), 4(2), 5)

21:45 – 22:10: T_{eff}: 0,383. F: 1,00. Lm: 6,23

ANT: 0, DLM: 1(5), MON: 0, NOO: 0, SPO: 1(5), GEM: 8(2, 3(4), 4, 5, 6

22:10 – 22:30: T_{eff}: 0,333. F: 1,00. Lm: 6,30

ANT: 0, DLM: 0, MON: 0, NOO: 0, SPO: 1(4), GEM: 9(1(2), 2, 3, 4(3), 5(2)

22:30 – 22:50: T_{eff}: 0,333. F: 1,00, Lm: 6,30

ANT: 0, DLM: 0, MON: 0, NOO: 1(3), SPO: 3(0, 2, 3), GEM: 12(1, 2(2), 3(3), 4(4), 5(2)

22:50 – 23:10: T_{eff}: 0,333. F: 1,00. Lm: 6,30

ANT: 0, DLM: 0, MON: 0, NOO: 0, SPO: 2(1, 6), GEM: 14(0, 1(2), 3(4), 4(2), 5(3), 6(2)

23:10 – 23:30: T_{eff}: 0,333. F: 1,00. Lm: 6,23

ANT: 1(3), DLM: 0, MON: 0, NOO: 0, SPO: 1(1), GEM: 4(2, 3, 5, 6)

23:30 – 23:50: T_{eff}: 0,333. F: 1,00. Lm: 6,23.

ANT: 0, DLM: 0, MON: 2(2, 4), NOO: 0, SPO: 2(2, 4), GEM: 7(1(2), 2, 3, 4(3)

00:05 – 00:25: T_{eff}: 0,333. F: 1,00. Lm: 6,30

ANT: 0, DLM: 0, MON: 0, NOO: 0, SPO: 1(4), GEM: 10(1, 2(3), 3(2), 4, 5(2), 6

00:25 – 00:45: T_{eff}: 0,333. F: 1,00. Lm: 6,30

ANT: 0, DLM: 0, MON: 0, NOO: 0, SPO: 1(4), GEM: 12(0, 1(2), 2(4), 3(3), 4, 5

00:45 – 01:05: T_{eff}: 0,333. F: 1,00. Lm: 6,30

ANT: 2(2, 3), DLM: 0, MON: 0, NOO: 0, SPO: 3(2(2), 3, GEM: 14(0, 1(2), 2(2), 3, 4(3), 5(4), 6

01:05 – 01:25: T_{eff}: 0,333. F: 1,00. Lm: 6,30

ANT: 0, DLM: 0, MON: 1(3), NOO: 1(3), SPO: 0, GEM: 16: 0(3), 1(3), 2(2), 3(3), 4(4), 5

01:25 – 01:45: T_{eff}: 0,333, F: 1,00. Lm: 6,30

ANT: 0, DLM: 0, MON: 0, NOO: 0, SPO: 3(3(3), GEM: 9(1(2), 2, 3(2), 4(3), 6

01:45 – 02:05: T_{eff}: 0,333. F: 1,00. Lm: 6, 30

ANT: 1(5), DLM: 1(4), MON: 0, NOO: 0, SPO: 3(2(2), 5, GEM: 12:(1, 2(4), 3(4), 4(2), 5

Mind blowing 2017 Geminid maximum from Matanzas Inlet – there are no words!

Paul Jones

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A summary is given of the visual observations of the 2017 Geminid observations in Florida.

1 Introduction

Well, I just woke up from what proved to be one of the most bizarre, surreal, unlikely, and totally amazing nights in my recent (or forever, really) meteor watching memory! It was a tale of sky high hopes, abject disappointment, divine intervention, insane perseverance and finally, ended up as one of the top ten meteor nights ever in my 44 years of this incredible hobby!!

After a day of gorgeous blue skies, I ventured down to Matanzas Inlet (MI) with only a few cirrus clouds way off in the west. By night fall, the clouds became more evident and soon took over almost the entire sky. I was heartsick. While waiting, I met a couple of folks who stopped by to check out the meteor shower. They didn't stay, but were planning to get back with us and join the ACAC!

After about 9:00 p.m., the skies cleared a bit and I was joined by several ACAC members for a brief period – Bill Spearow, Rod Paul, Julie Taylor and her daughter Claire, Dan and Sally Marks, ACAC good friend Leslie Goode from the SJC Library Bookmobile and Jeff Wellman one of our members from Jacksonville all came out with hopes to view.

However, every time it began to clear off, it clouded back over on us again. We did see a few nice GEMs through and around the clouds, but after a while, it appeared to be hopeless for fully clearing, so most folks left. Only Jeff and I remained, hanging in there until about 11:30 when it became totally overcast, so we decided to pack it in and take our crushed dreams home.

Just as I was about to pull out of the parking lot, a car pulled up. It turned out to be ACAC good friend Sara Clifton, who came out to join us after attending the Jacksonville Icemen hockey game up in Jax. I apologized to Sara saying we had given it a shot, but it looked hopeless and we were packing it up.

Very wisely as it turned out, Sara brushed aside my dire forecasts of continued clouds and hung in there after I left. Not long after I got home, I got a text from Lyle Guzman who was working the midnight shift at his job, telling me he had seen several nice GEMs and it was mostly clear where he was in the Molasses Junction area (several miles west of St. Augustine).

About that same time, I got a text from Sara who told me she had seen 85 meteors down at Matanzas Inlet in just the short time since I had left her and it was mostly clear and I should consider returning!! I jumped in the car immediately, and hauled butt back down to MI, setting a new land speed record getting there, too… ;o).

Upon my re-arrival at MI just before 1:15 a.m., I was blown away – the skies were spectacular and I saw over ten GEMs in just the three minutes it took me to get my chaise lounge set up!! I thanked Sara profusely and we settled back to see one of the most astounding displays of meteors I've witnessed since the 2001 and 2002 Leonid storms!

All told, in the first 60 minutes between 1:15 and 2:15 a.m. this morning, I counted 133 GEMs and 16 non-Geminids in four 15-minutes counting periods. GEMs were falling in clumps of four and five in quick succession, many of them in negative magnitudes. I had a –5 GEM fireball hardly five minutes into the watch and that was followed by several more GEM fireballs shooting around the sky in all directions. It was UNREAL!

Soon after my arrival, another car pulled into the lot and Sara and I met brand new ACAC friend Ashley Swain who set her alarm to come out after midnight to join us and she was VERY well rewarded for her wise decision!

The show continued unabated into my second hour (2:15 to 3:15 a.m.) with 122 more Gems counted and a few more GEM fireballs seen to boot. We had a stunning –6 GEM fireball fall into the eastern horizon, lighting up the sky in that direction with a gorgeous blue-green glow, followed several minutes later by a golden yellow, –4 GEM fireball, falling into and lighting up the western horizon! It was insane and hard to keep up with everything that was going on!

Sara topped the night by counting a total of 504 meteors between 11:30 p.m. and 3:15 a.m. I came in second with 327 total meteors between 1:15 a.m. and 3:45 a.m. plus about 50 more various casually seen meteors from earlier in the evening. I think Ashley was too stunned by it all to count, but she sure did enjoy the show! We must have had easily upwards to or even over 30 GEMs in negative magnitudes, with one –6, 2 –5s, several more –4s and a bunch of –3s. We must have seen at least ten instances of perfectly simultaneous pairs of GEMs and even a few sets of three!!!

Finally, after 3:30, the clouds began to return and the clear skies deteriorated, so the ladies left and I hung in there for another 45 minutes before finally packing it in, but not before seeing two more GEM fireballs and a bunch more bright ones!

I shall forever be indebted to Lyle and Sara for clueing me into seeing one of the most amazing events in many a year!

I am finally getting caught enough to report on the detailed observational results from the ACAC 2017 Geminid Meteor Shower maximum observations. A big thanks to Sara Clifton and Lyle Guzman for turning max night disappointment into amazing success! Here are my results:

Observed for radiants:

- GEM: Geminids
- ANT: Anthelions
- MON: December Monocerotids
- HYD: sigma Hydrids
- DLM: December Leonis Minorids
- DAD: December alpha Draconids

2 Dec., 11/12, 2017

Observer: Paul Jones, Location: north bank of Matanzas Inlet, Florida, 15 miles south of St. Augustine, Florida, Lat: 29.75 N, Long: 81.24W, LM: 6.5, sky conditions: clear, Facing: SE.

1200 – 1000 EST (0500 – 0600 UT)
T_{eff}: 1 hour, clear, no breaks

- 29 GEM: 0(1), +1(1), +2(5), +3(10), +4(9), +5(3)
- 1 MON: +4(1)
- 1 ANT: +2(1)
- 1 HYD: +3(1)
- 8 SPO: +2(2), +3(2), +4(3), +5(1)
- 40 total meteors

Only the one ANT left a visible train, most common colors were gold and yellow in the brighter GEMs.

0100 – 0200 EST (0600 – 0700 UT)
T_{eff}: 1 hour, clear, no breaks

- 18 GEM: -1(1), +2(4), +3(6), +4(4), +5(3)
- 1 MON: +4(1)
- 1 HYD: +3(1)
- 1 DLM: +4(1)
- 6 SPO: +1(2), +3(2), +4(1), +5(1)
- 27 total meteors

Only the –1 GEM left a visible train, most common colors were blue and yellow in the brighter GEMs.

3 Dec 12/13, 2017

Observer: Paul Jones, Location: north bank of Matanzas Inlet, Florida, 15 miles south of St. Augustine, Florida, Lat: 29.75 N, Long: 81.24W, LM: 6.8, sky conditions: clear, Facing: SE.

1200 – 0100 EST (0500 – 0600 UT), T_{eff}: 1 hour, clear, no breaks

- 53 GEM: -1(1), 0(5), +1(8), +2(15), +3(12), +4(9), +5(3)
- 2 ANT: +2(1), +3(1)
- 2 MON: +3(2)
- 1 HYD: +2(1)
- 1 DLM: +3(1)
- 9 SPO: +1(1), +2(1), +3(3), +4(2), +5(2)
- 68 total meteors

4 of the 53 GEMs, and 3 SPOs left visible trains, most common colors were blue and yellow in the brighter GEMs and SPOs.

0100 – 0200 EST (0600 – 0700 UT), T_{eff}: 1 hour, clear, no breaks

- 46 GEM: -1(2), 0(2), +1(6), +2(10), +3(13), +4(9), +5(4)
- 1 ANT: +2(1)
- 2 MON: +2(1), +3(1)
- 2 HYD: +2(1), +4(1)
- 1 DLM: +1(1)
- 1 DAD: +3(1)
- 10 SPO: +1(1), +2(2), +3(3), +4(2), +5(2)
- 63 total meteors

3 of the 46 GEMs, and 3 SPOs left visible trains, most common colors were blue and yellow in the brighter GEMs and SPOs.

0200 – 0300 EST (0700 – 0800 UT), T_{eff}: 1 hour, clear, no breaks

- 57 GEM: -1(3), 0(3), +1(7), +2(11), +3(17), +4(12), +5(4)
- 1 ANT: +2(1)
- 2 HYD: +2(1), +3(1)
- 2 DLM: +1(1), +2(1)
- 1 DAD: +3(1)
- 11 SPO: 0(1), +1(1), +2(1), +3(5), +4(2), +5(1)
- 74 total meteors

4 of the 57 GEMs, 1 DLM and 3 SPOs left visible trains, most common colors were blue and yellow in the brighter GEMs and SPOs.

4 Dec., 13/14, 2017

Observer: Paul Jones, Location: north bank of Matanzas Inlet, Florida, 15 miles south of St. Augustine, Florida, Lat: 29.75 N, Long: 81.24W, LM: 6.5, sky conditions: clear, Facing: South.

0115 – 0215 EST (0615 – 0715 UT), T_{eff}: 1 hour, clear, no breaks

- 133 GEM: -5(2), -4(2), -3(5), -2(6), -1(9), 0(11), +1(16), +2(24), +3(32), +4(18), +5(8)
- 1 ANT: +3(1)
- 2 DLM: +2(2)
- 2 HYD: +3(1), +4(1)
- 1 DAD: +1(1)
- 1 MON: +3(1)
- 9 SPO: +1(1), +2(2), +3(3), +4(3)
- 149 total meteors

15 minute subsets in UT (GEMs):

- 0615 – 0630: 28 GEMS
- 0630 – 0645: 32 GEMs
- 0645 – 0700: 38 GEMs
- 0700 – 0715: 35 GEMs

31 of the 133 GEMs left visible trains, most common colors were blue, blue/green, gold and yellow in the brighter GEMs.

0215 – 0315 EST (0715 – 0815 UT), T_{eff}: 1 hour, clear, no breaks

- 123 GEM: -6(1), -4(3), -3(4), -2(7), -1(6), 0(10), +1(13), +2(23), +3(31), +4(20), +5(5)
- 1 ANT: +3(1)
- 2 DLM: +2(2)
- 3 HYD: +2(1), +3(1), +4(1)
- 2 DAD: +1(1), +3(1)
- 1 MON: +3(1)
- 10 SPO: +1(1), +2(2), +3(4), +4(3)
- 142 total meteors

15 minute subsets in UT (GEMs):

- 0715 – 0730: 29 GEMS
- 0730 – 0745: 33 GEMs
- 0745 – 0800: 33 GEMs
- 0800 – 0815: 28 GEMs

29 of the 123 GEMs left visible trains, most common colors were blue, blue/green, gold and yellow in the brighter GEMs.

0315 – 0345 EST (0815 – 0845 UT), T_{eff}: .5 hour, 30% cirrus clouds, no breaks

- 33 GEM: -4(2), -3(1), -2(3), -1(2), 0(1), +1(5), +2(6), +3(8), +4(5)
- 1 HYD: +2(1)
- 4 SPO: +1(1), +2(1), +3(1), +4(1)
- 38 total meteors

15 minute subsets in UT (GEMs):

- 0815 – 0830: 19 GEMs
- 0830 – 0845: 14 GEMs

6 of the 33 GEMs, left visible trains, most common colors were blue, blue/green, gold and yellow in the brighter GEMs.

2017 Ursid Meteor Shower report from North Florida

Paul Jones

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A summary is given of the visual observations of the 2017 Ursid observations in Florida.

1 Introduction

I got yet another early Christmas gift this past Friday morning when the skies yet again somehow managed to clear out after midnight and I was able to get my best ever look at the obscure but quite intriguing Ursids (URS) from Matanzas Inlet (MI).

We used to joke about this shower in the early days of the ACAC as we had never seen much of anything in the way of activity from it, even though we tried. The jokes went something like: no matter how badly a meteor shower performed, at least it was bound to better than the Ursids.

We were still learning in those days, and it turns out we probably did not give the shower anywhere near its due. Also, we never tried observing it from MI either and we did not observe it at the right times. So, this year, armed with 40+ years of experience and a little help from Mother Nature, I was finally able to vindicate the shower a little bit, anyway.

I awoke at my usual 2:30 a.m. on Friday morning (without an alarm) and saw it was mostly clear. and MI was beckoning me. So, I arrived a bit before 3:30 a.m. and sure enough, the skies were stunning. The URS radiant is near the "bowl" of the Little Dipper in Ursa Minor and has the highest declination of all the meteor showers at +76 degrees (just 14 degrees from Polaris). This combined with the fact it occurs so close to Christmas makes it rarely observed at all. I call it the Winter Solstice Meteor Shower.

So, I faced a rare direction to view this shower: almost due north! The radiant was climbing up the NNE sky when I arrived and had barely reached an optimum elevation for viewing. Nonetheless, the shower didn't take long to be apparent. All told, in 1.75 hours, I counted 19 URS, 6 late GEMs and 25 others for 49 total meteors in a very nice session indeed! Here's my data:

Observed for radiants:

- URS: Ursids
- GEM: Geminids
- ANT: Anthelions
- MON: December Monocerotids
- HYD: sigma Hydrids
- DLM: December Leonis Minorids
- DAD: December alpha Draconids
- DSV: December sigma Virginids

2 Dec., 21/22, 2017

Observer: Paul Jones, Location: north bank of Matanzas Inlet, Florida, 15 miles south of St. Augustine, Florida, Lat: 29.75 N, Long: 81.24W, LM: 6.5, sky conditions: 10 – 25% clouds, Facing: NNE.

0330 – 0430 EST (0830 – 0930 UT), T_{eff}: 1 hour, clear, no breaks

- 10 URS: +1(1), +2(2), +3(3), +4(3), +5(1)
- 3 GEM: +2(1), +3(2)
- 1 DSV: +2(1)
- 1 HYD: +3(1)
- 1 DLM: +3(1)
- 11 SPO: -2(1), -1(1), +2(2), +3(2), +4(3), +5(2)
- 27 total meteors

3 URS and 3 SPO left visible trains, most common colors were gold and yellow in the brighter SPOs.

0430 – 0515 EST (0830 – 0915 UT), T_{eff}: .75 hour, 25% clouds no breaks

- 9 URS: +1(1), +2(3), +3(3), +4(2)
- 3 GEM: +2(2), +3(1)
- 1 HYD: +3(1)
- 9 SPO: +1(2), +2(1) +3(2), +4(2), +5(2)
- 22 total meteors

2 URS and 2 SPO left visible trains, most common colors were blue and yellow in the brighter SPOs.

Nineteen URS in almost two hours does not seem like a lot, but compared to what we used to see from them, this was a windfall… ;o). Some pesky cumulus clouds came in on me off the Atlantic which may have cut into the meteors somewhat. I will surely be on the lookout for them in coming years.

CEMeNt in the first half of 2017

Jakub Koukal

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The Central European Meteor Network (CEMeNt), is a platform for cross-border cooperation in the field of video meteor observations between the Czech Republic and Slovakia. The CEMeNt network activity in the first half of 2017 is the subject of the article. A total of 13890 meteors and 36 spectra were recorded on the CEMeNt network stations. The summary contains data taken by wide field systems (WF), spectrographs (SP) and narrow field systems (NFC).

1 Introduction

The Central European Meteor Network (CEMeNt), established in 2010, is a platform for cross-border cooperation in the field of video meteor observations between the Czech Republic and Slovakia. From the beginning, observation activities of the CEMeNt network have been coordinated with the Slovak Video Meteor Network (SVMN) and other similar networks in Central Europe (the Hungarian HMN network, the Polish PFN network, etc.). During seven years of operation, CEMeNt has undergone an extensive development. A total of 38 video systems work at 18 fixed stations in the Czech Republic and Slovakia, including 6 NFC cameras and 4 cameras for spectroscopic observations. A remote station of the CEMeNt network is a spectroscopic camera located at Teide Observatory (Canary Islands, Tenerife). All data acquired by stations in the CEMeNt network are available in the EDMOND open database (Kornoš et al., 2014a, 2014b).

2 Wide field systems (WF)

Video systems used in the CEMeNt network (Srba et al., 2016) are generally based on various types of sensitive CCTV cameras with CCD sensors (Sony Ex-View HAD, Sony Super HAD II, Sony Super HAD 960 H Effio) with a size of 1/3” or 1/2” with fast (~ f/1.0) varifocal lenses with PAL B image resolution (720 × 576 px). The software UFOTools (UFOCapture, UFOAnalyzer, UFOOrbit, UFORadiant), produced by SonotaCo (SonotaCo, 2009), is used for detection and analysis. Most of the stations have a field of view within the range of 60°–90° in horizontal direction.

Video systems are protected against weather using heated housings (usually used for security camera systems). These stations are able to work all year long without any weather restrictions. Most stations are fully autonomous and can be controlled by remote access from an external computer.

In the first half of 2017, a total of 10298 single station meteors were recorded at the CEMeNt stations, of which 2250 orbits were obtained (the so-called Q0 orbits, i.e. without application of qualitative criteria). The largest number of recorded orbits belong to the Quadrantid meteor shower. Blahová (SK) recorded the largest number of single station meteors. The statistical summary by month, or by individual stations is shown in *Tables 1–3* and *Figures 2–7*.

Table 1 – Numbers of single station meteors and orbits in the CEMeNt network in the first half of 2017. Author: Jakub Koukal.

Month	Single station meteors	Paired single station meteors	Number of orbits	Stations/ orbit ratio
January	3778	1763	747	2.36
February	1185	683	272	2.51
March	1398	820	321	2.55
April	908	463	197	2.35
May	1176	661	266	2.48
June	1853	1,053	447	2.36
Overall	10298	5443	2250	2.42

Table 2 – Numbers of single station meteors for individual stations in the CEMeNt network in the first half of 2017. Author: Jakub Koukal.

Station	Number of systems	Single station meteors
Blahová (SK)	4	1964
Karlovy Vary (CZ)	2	333
Vsetín (CZ)	1	324
Kroměříž (CZ)	2	816
Kostolné Kráčany (SK)	1	261
Maruška (CZ)	2	1204
Nýdek (CZ)	4	234
Ostrov (CZ)	1	63
Roztoky (SK)	1	528
Senec (SK)	3	1017
Těrlicko (CZ)	1	109
Valašské Meziřičí WF (CZ)	2	1547
Valašské Meziřičí SP (CZ)	4	463
Vartovka (SK)	1	281
Zvolenská Slatina (SK)	1	277
Zlín (CZ)	2	877

Table 3 – Numbers of orbits of individual meteor showers in the CEMeNt network in the first half of 2017. Author: Jakub Koukal.

IAU MDC	Meteor shower	Number of orbits
SPO	Sporadic	5551
QUA	Quadrantids	246
COM	Comae Berenicids	98
ETA	Eta Aquariids	69
LYR	April Lyrids	68
NBO	Nu Bootids	53
EVI	Eta Virginids	48
GUM	Gamma Ursae Minorids	40
TTB	22 Bootids	35

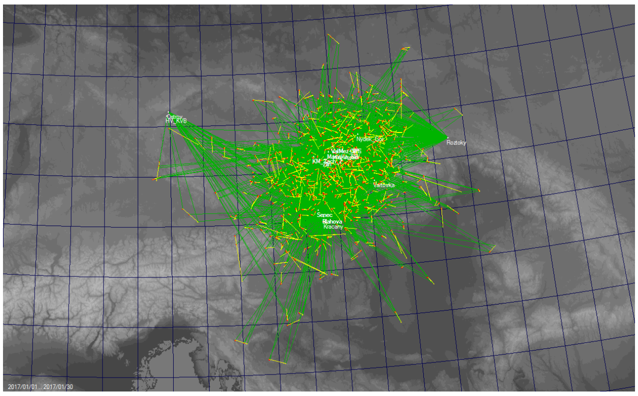

Figure 2 – 2D projection of multi station orbits in the CEMeNt network in January 2017. Author: Jakub Koukal.

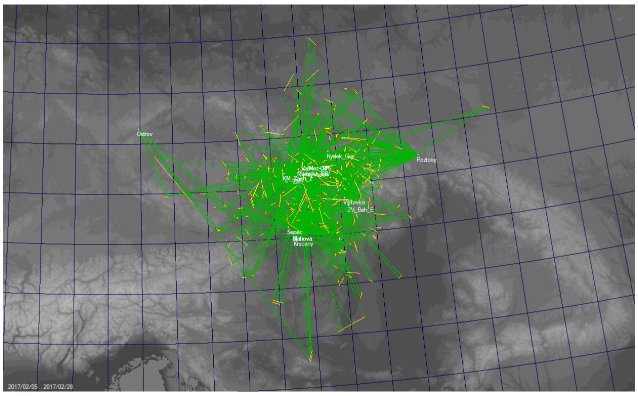

Figure 3 – 2D projection of multi station orbits in the CEMeNt network in February 2017. Author: Jakub Koukal.

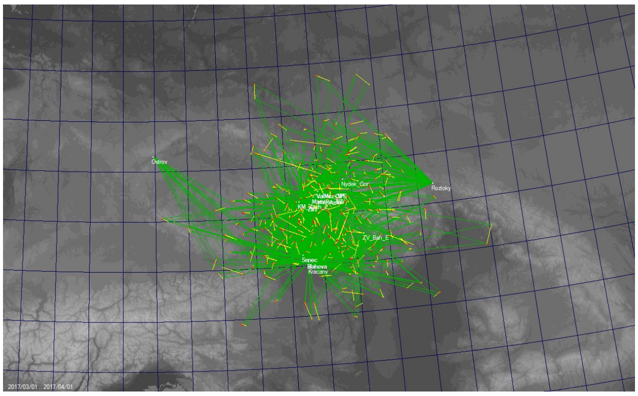

Figure 4 – 2D projection of multi station orbits in the CEMeNt network in March 2017. Author: Jakub Koukal.

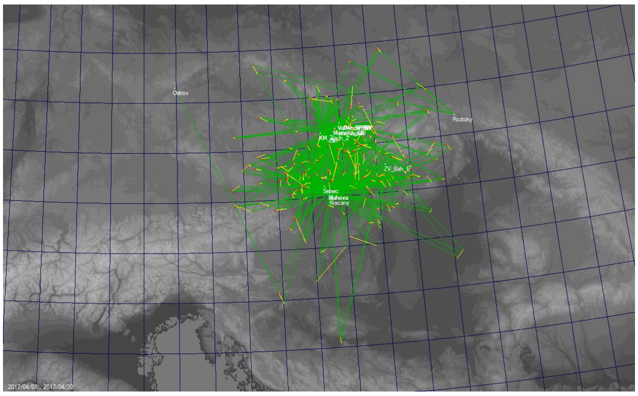

Figure 5 – 2D projection of multi station orbits in the CEMeNt network in April 2017. Author: Jakub Koukal.

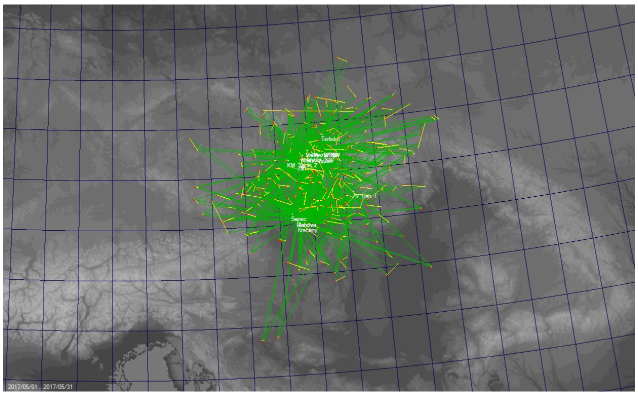

Figure 6 – 2D projection of multi station orbits in the CEMeNt network in May 2017. Author: Jakub Koukal.

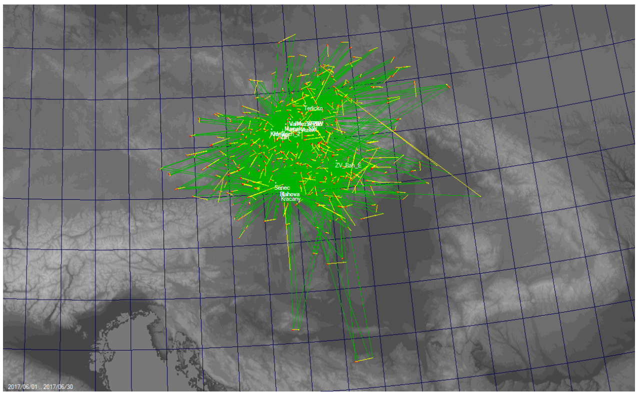

Figure 7 – 2D projection of multi station orbits in the CEMeNt network in June 2017. Author: Jakub Koukal.

3 Narrow Field Camera (NFC)

A new type of highly sensitive, specialized camera system with a narrow field of view was introduced in 2015. The system is called NFC (Narrow Field Camera), and 6 systems are currently in operation within the CEMeNt network (Koukal et al., 2015). The main part of the NFC system is the Meopta Meostigmat 1/50 (f/1.0) fast lens with focal length F = 50 mm. The Watec 902H2 Ultimate camera is used in the system as a sensor with a 1/2” CCD (Sony Ex-View HAD) chip. In combination with the Meostigmat lens, the system has a very narrow field of view with a width of ~ 7° in the horizontal direction, but at the same time the system can capture meteors up to a relative brightness of +7m, the limiting magnitude of the reference stars is +10.5m.

Table 4 – Numbers of single station meteors and orbits (NFC system) in the CEMeNt network in the first half of 2017. Author: Jakub Koukal.

Month	Single station meteors	Paired single station meteors	Number of orbits	Stations/ orbit ratio
January	539	122	61	2.00
February	331	148	74	2.00
March	454	170	85	2.00
April	308	120	60	2.00
May	423	152	76	2.00
June	456	76	38	2.00
Overall	2511	788	394	2.00

Table 5 – Numbers of single station meteors for individual stations (NFC system) in the CEMeNt network in the first half of 2017. Author: Jakub Koukal.

Station	Number of systems	Single station meteors
Blahová (SK)	1	638
Kroměříž (CZ)	1	321
Valašské Meziříčí (CZ)	1	471
Senec (SK)	1	411
Zákopčie (SK)	1	240
Kysucké Nové Mesto (SK)	1	430

Table 6 – Numbers of orbits of individual meteor showers (NFC system) in the CEMeNt network in the first half of 2017. Author: Jakub Koukal.

IAU MDC	Meteor shower	Number of orbits
SPO	Sporadic	1001
QUA	Quadrantids	9
MPS	May psi Scorpiids	8
FMV	February mu Virginids	8
KVI	Kappa Virginids	6

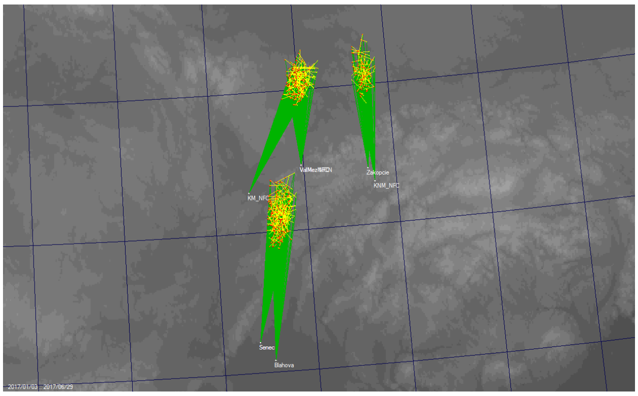

Figure 8 – 2D projection of multi station orbits (NFC system) in the CEMeNt network in May 2017. Author: Jakub Koukal.

In the first half of 2017, a total of 2511 single station meteors were recorded at the CEMeNt stations, of which 394 orbits were obtained (the so-called Q0 orbits, ie without application of qualitative criteria). The largest number of recorded orbits belong to the Quadrantid meteor shower, and Blahová (SK) recorded the largest number of single station meteors. The statistical summary by month, or by individual stations is shown in *Tables 4–6* and *Figure 8*.

4 Spectrographic systems (SP)

Since 2014, CEMeNt research also focuses on spectral observations of bright meteors (Koukal et al., 2016). Spectroscopic systems use the classical design of wide field systems with a diffraction grating added in front of the lens. The first, currently unused system used a classic CCTV camera (as well as wide field systems) with a diffraction grating (500 lines/mm) added in front of the lens. The resolution of the spectrum recorded by this system was ~ 33 Å/px. Systems installed in 2015 at the Valašské Meziříčí Observatory use QHY5LII-M cameras with 1/3”CMOS chip (Aptina MT9M034, 1280 × 960 px). The diffraction grating (1000 lines/mm) is placed in front of the Tamron M13VG308 (f / 1.0) fast megapixel varifocal lens. The field of view of the spectrographs within the range of 60°–70° in the horizontal direction, combined with the diffraction grating, allows the resolution of recorded spectra to be within the range of 8.0–8.5 Å/px. The software UFOTools (UFOCapture, UFOAnalyzer, UFOOrbit, UFORadiant), all developed by SonotaCo, is used for detection and analysis.

In the first half of 2017, 463 single station meteors and 9 spectra of bright meteors were recorded on the CEMeNt spectrographic systems. The statistical overview of the individual systems is shown in *Table 7*, samples of the recorded spectra are shown in *Figures 9–12*.

Table 7 – Numbers of single station meteors and recorded spectra for individual spectrographic systems in the CEMeNt network in the first half of 2017. Author: Jakub Koukal.

System designation	Camera type	Single station meteors	Spectra
SPSW V4	QHY5LII-M	79	0
SPSE V5	QHY5LII-M	49	1
SPNE V6	QHY5LII-M	93	1
SPNE *	QHY5LII-M	132	3
SPNW *	QHY5LII-M	62	2
SPNW V7	PG GS3-U3-32S4M-C	48	2
Overall		463	9

* Since March 2017, the cameras have been replaced by SPNW V7 and SPNE V6 in this azimuth.

In 2016 the high-resolution spectrograph was installed at the Teide Observatory (Tenerife, Canary Islands), the same system was installed at the Valašské Meziříčí Observatory in 2017. Systems use monochromatic cameras PointGrey Grasshoper3 GS3-U3-32S4M-C with 1/1.8” CMOS chip (Sony Pregius IMX252). The resolution of the installed sensor is 2048 × 1536 pixels, the frame rate is set at 15 fr/s. Spectrographs are equipped with fast lenses VS Technology (9 Mpx, f/1.4) with focal length F = 6 mm. The field of view of the spectrograph is 60 × 45°, a diffraction grating (1000 lines/mm) is used due to the resolution of the installed chip and the field of view, the resolution of the recorded spectrum is 4.8 Å/px. The software UFOTools, developed by SonotaCo (UFOCaptureHD, UFOAnalyzer, UFOOrbit, UFORadiant), is used for the detection and analysis.

Figure 9 – Spectrum of bright meteor 20170224_191117, SPNE spectrograph. Author: Valašské Meziříčí Observatory.

Figure 10 – Spectrum of bright meteor 20170227_023124, SPNW spectrograph. Author: Valašské Meziříčí Observatory.

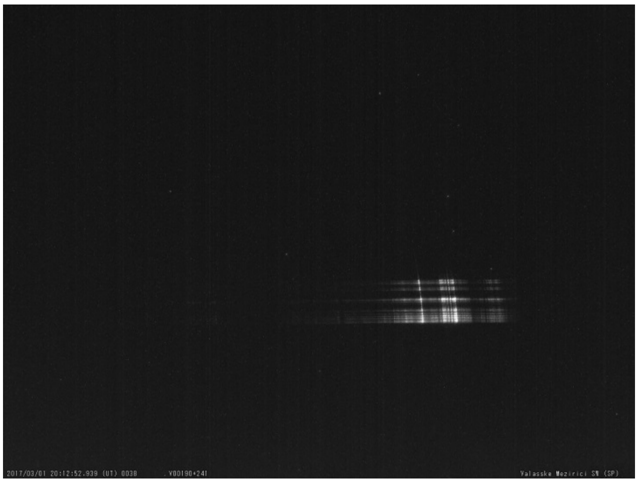

Figure 11 – Spectrum of bright meteor 20170301_201252, SPNE spectrograph. Author: Valašské Meziříčí Observatory.

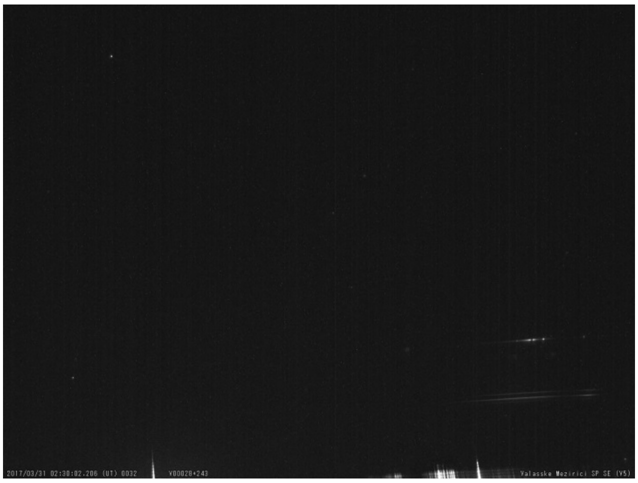

Figure 12 – Spectrum of bright meteor 20170331_023002, SPSE V5 spectrograph. Author: Valašské Meziříčí Observatory.

Figure 13 – Spectrum of bright meteor 20170127_000001, PGRACAM-TE spectrograph. Author: Valašské Meziříčí Observatory.

Figure 14 – Spectrum of bright meteor 20170314_013511, PGRACAM-TE spectrograph. Author: Valašské Meziříčí Observatory.

In the first half of 2017, 618 single station meteors and 27 spectra of bright meteors were recorded on the spectrographic systems at the Teide Observatory (PGRACAM-TE). The statistical summary by month is shown in *Table 8*, samples of the recorded spectra are shown in *Figures 13–16*.

Table 8 – Numbers of single station meteors and recorded spectra for individual months (spectrographic system PGRACAM-TE) in the first half of 2017. Author: Jakub Koukal.

Month	Single station meteors	Spectra
January	132	4
February	90	4
March	93	4
April	106	5
May	142	7
June	55	3
Overall	618	27

Figure 15 – Spectrum of bright meteor 20170414_042426, PGRACAM-TE spectrograph. Author: Valašské Meziříčí Observatory.

Figure 16 – Spectrum of bright meteor 20170502_230850, PGRACAM-TE spectrograph. Author: Valašské Meziříčí Observatory.

5 Spectrum analysis – fireball 20170301_201251

The projection of the beginning of the atmospheric path was located at the coordinates N49.474° E20.045°, the height of the fireball at this time was 79.2 ± 0.1 kilometers above the Earth's surface. The end of the projection of the atmospheric path was located at the coordinates N49.602° E20.089°, the height of the fireball at this time was 40.5 ± 0.1 km kilometers above the Earth's surface. It was a slow meteor, the geocentric velocity of the meteoroid before entering the gravitational field of the Earth was 9.26 ± 0.16 km/s (including the deceleration effect), the orbital elements of the meteoroid orbit were as follows:

a = 2.255 ± 0.055 AU
q = 0.9583 ± 0.0006 AU
e = 0.575 ± 0.010
i = 0.69 ± 0.04°
ω = 204.55 ± 0.07°
Ω = 341.2311°.

The fireball belonged to the sporadic meteors (SPO) with geocentric radiant RA = 115.7 ± 0.1°, Dec. = 24.1 ± 0.2°. The Tisserand´s parameter in relation to Jupiter T_J = 3.38 ± 0.06 shows the asteroid origin of the body in the inner part of the main asteroid belt. The meteoroid orbit in the Solar System is very similar to the orbit of asteroid 2016 DL1 (D_D = 0.022), which is probably the parent body of the fireball 20170301_201251.

In the calibrated aggregate spectrum of the fireball, the emission lines of the elements were identified in the following representation: iron (FeI), magnesium (MgI), sodium (NaI), manganese (MnI), aluminum (AlI), chromium (CrI), silicon (SiI) and relatively weak calcium lines (CaI). The ratio of the emission of elements belonging to the Earth's ionized atmosphere to magnesium (N2/MgI, NI/MgI and OI/MgI) is low, since this does not depend on the mass of the body but on its velocity. This means that the amount of emission of these elements is directly proportional to the weight of the body, but the rate coefficient increases with the velocity of the meteors. The ratio of relative intensities of OI-1/MgI-2 multiples is only 0.262, for meteor showers with high geocentric velocities (eg Leonid or Perseid), this ratio normally exceeds 3 and often reaches values close to number 6. The total ratio of relative intensities of MgI-2:NaI-1:FeI-15 is 0.204:0.224:0.572, due to the high iron content in the fireball spectrum, it consisted of chondritic material.

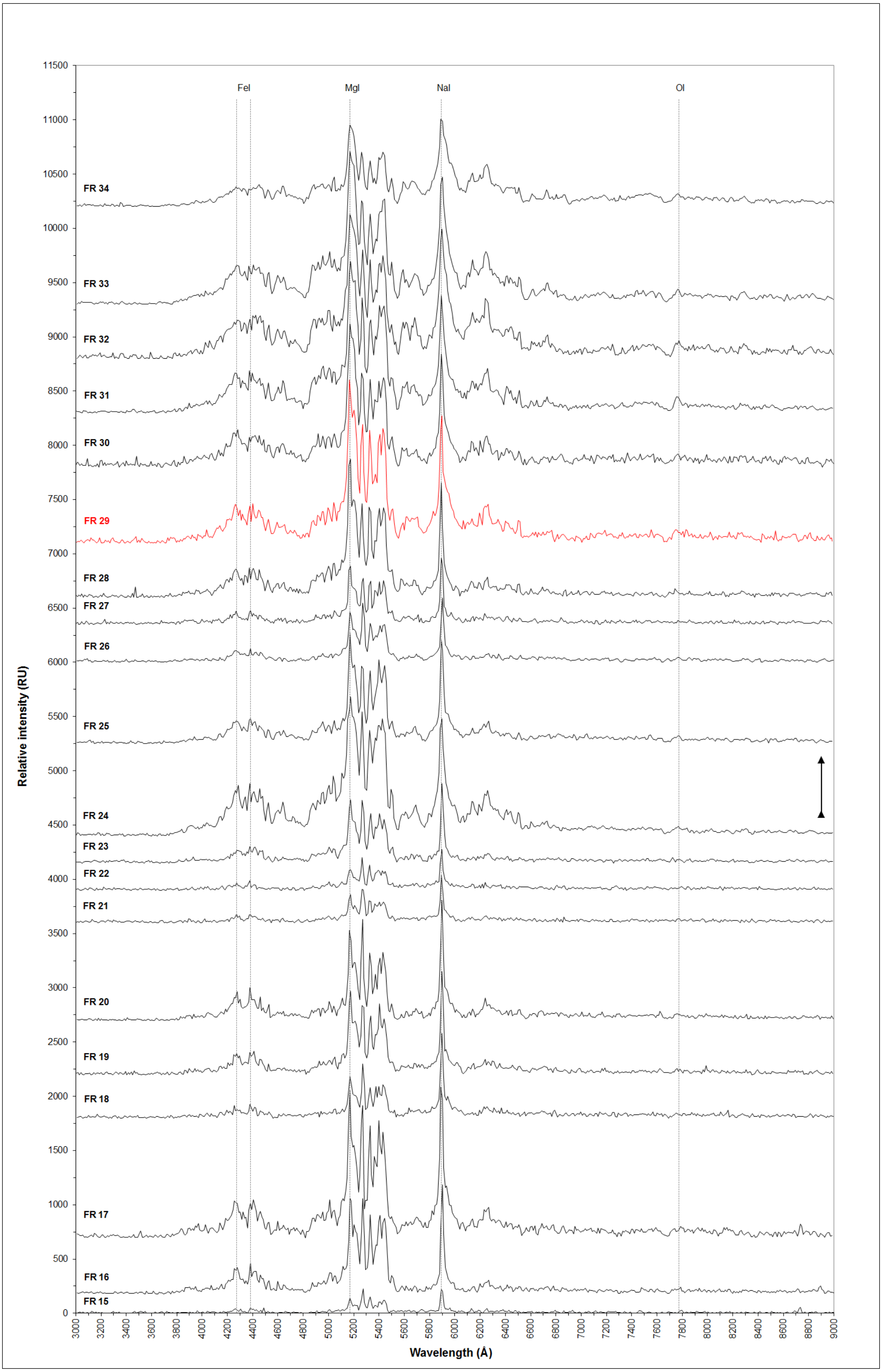

Figure 17 – The uncalibrated evolution of the fireball 20170301_201251 spectrum (3000-9000 Å) during the body flight through the Earth's atmosphere, depending on its height. Author: Jakub Koukal.

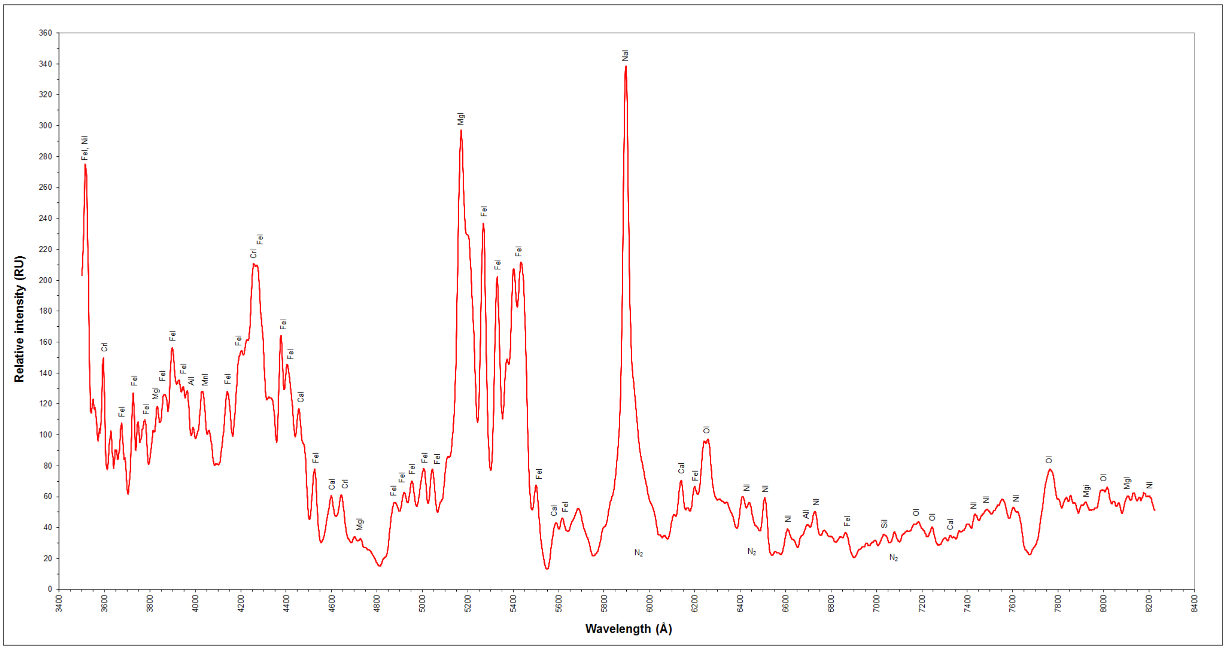

Figure 18 – Calibrated aggregate spectrum of the fireball 20170301_201251 (3500-8250 Å). Author: Jakub Koukal.

Acknowledgment

Acknowledgment belongs to all station owners, operators and observers for their long-term and precise work, which enabled the establishment and development of the CEMeNt network. Acknowledgment also belongs to all interested institutions in support of activities and network growth. The KOSOAP (Cooperating Network of Astronomic Observational Projects, in Czech: Kooperující síť v oblasti astronomických odborně-pozorovatelských programů) and RPKS (Evolvement of the Cross Border Network for Scientific Work and Education, in Czech: Rozvoj přeshraniční kooperující sítě pro odbornou práci a vzdělávání) projects were realized by the Valašské Meziříčí Observatory (CZ) and Kysucké Nové Město Observatory (SR) in cooperation with the Society for Interplanetary Matter. Projects were co-funded by the European Union (Cross-border Cooperation Program Slovak Republic – Czech Republic 2007-2013). The project for the purchase and operation of high-resolution spectrographs is partly subsidized by the Program for Regional Cooperation of the Academy of Sciences of the Czech Republic, Reg. No. R200401521, by the grant of APVV-0517-12 (FMFI UK) and by the internal grant of the J. Heyrovský Institute of Physical Chemistry No. 994316. In addition, companies DEZA, a. s. and CS CABOT, spol. s r. o., also contributed to the purchase of instrumentation at the Valašské Meziříčí Observatory.

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Fireball seen at Murmansk and Northern Finland

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A summary report is presented on the fireball of 2017 November 16 at 19h40m local time in Northern Finland.

Figure 1 – Fireball 2017 November 16 at 19^h40^m local time.

1 Fireball 2017 November 16

A bright fireball appeared and got registered by some dashboard cameras.

Residents of the Murmansk region and Finland watched the flight of a fireball in the night of November 16–17. The video recordings show a bright colored bolide. This phenomenon was observed in Murmansk, Olenegorsk, Nikel, Zapolyarny and Loparsky. The bolide also flew over northern Finland and Norway. The flash was recorded on a video camera in Lapland:

- https://www.youtube.com/watch?v=-igmFwUEwVQ
- https://www.youtube.com/watch?v=9THzuOyRUqQ
- https://www.youtube.com/watch?v=3N47VB8MrzU

Acknowledgment

With thanks to *Galina Ryabova* for reporting this event.

Fireball events recorded by the SMART Project

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An overview is presented of exceptional fireball events by the meteor observing stations operated by the SMART Project (University of Huelva) from Sevilla and Huelva during the period November – December 2017.

1 Meteorite fall on Nov. 16

This meteor event was recorded over the Atlantic Ocean on Nov. 16 at 0:06 universal time. The event was produced by a fragment from an asteroid that hit the atmosphere at about 54000 km/h. The fireball began at an altitude of around 90 km over the sea, and ended at a height of about 27 km. The analysis of its atmospheric path shows that this was a meteorite-producing event. The meteorite would have fallen into the sea. The event was recorded by the meteor observing stations operated by the SMART Project (University of Huelva) from Sevilla and Huelva[8].

2 Bright Leonid Fireball over Spain

At 6:11 local time (5:11 universal time) on 17 November, a brilliant fireball flew over the center of Spain. According to the preliminary analysis carried out by Professor José María Madiedo (University of Huelva), principal researcher of the smart project, the event is a Leonid that occurred as a result of the entry into the Earth's atmosphere of a fragment of comet Tempel-Tuttle at a speed of about 260000 miles per hour. The luminous phenomenon began at an altitude of about 139 km over the south of the province of Albacete, ending at an altitude of about 88 km. The event has been registered from the meteor shower stations operating under the smart project from the astronomical observatories of La Hita (Toledo), Calar Alto (Almeria), La Sagra (Granada), Huelva and Seville[9].

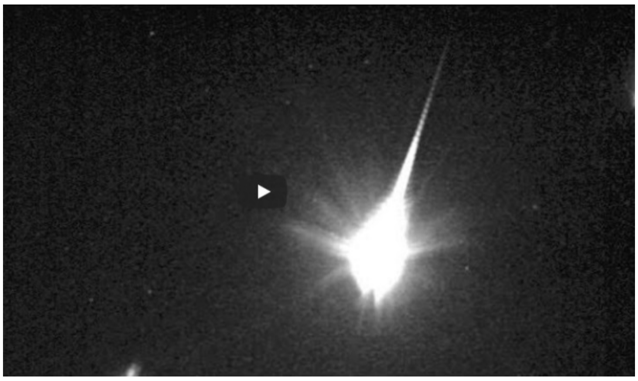

Figure 1 – The Leonids produced a brilliant fireball in the early morning of November 17.

3 Stunning Leonid meteor over Spain on Nov. 18

On Nov. 18, at 4:35 local time (3:35 universal time) a very bright (mag. –8) Leonid meteor was spotted over Spain. It was produced by a fragment from Comet Temple-Tuttle that hit the atmosphere at about 260000 km/h. The event begun at an altitude of around 133 km over the province of Jaen and ended at a height of about 83 km over the province of Cordoba. It was recorded in the framework of the SMART Project (University of Huelva) from the astronomical observatories of La Hita (Toledo), Calar Alto (Almería), La Sagra (Granada), Huelva and Sevilla.

The video shows this event as spotted from La Hita Astronomical Observatory (Toledo)[10].

4 Bright meteor event on 6 Dec. 2017 at 4:22 UT

This bright fireball was recorded on the night of Dec. 6 at 5:22 local time (4:22 universal time) over the Mediterranean Sea, between the coasts of Mallorca and Valencia. The event was produced by a meteoroid that hit the atmosphere at about 140000 km/h. It began at an altitude of around 100 km over the sea. It ended at a height of about 52 km. This meteor event has been recorded in the framework of the SMART project (University of Huelva) from the astronomical observatories of La Hita (Toledo) and Calar Alto (Almería)[11].

5 Bright Geminids over Spain

2017 December 14, at 2:24 UT

On Dec. 14, at 3:24 local time (2:24 universal time) this amazing Geminid meteor was spotted over Spain. The event was produced by a fragment from asteroid Phaeton that hit the atmosphere at about 122000 km/h. It began at an altitude of around 101 km over the province of Cordoba and ended at a height of about 43 km. It was recorded in the framework of the SMART Project (University of Huelva) from the astronomical observatories of La Hita

[8] https://youtu.be/q8GrHhBPO4o
[9] https://youtu.be/ASiKxZUXJFA
[10] https://youtu.be/NqfpsMBwyno
[11] https://youtu.be/CDpbhFHEFL8

(Toledo), Calar Alto (Almería), La Sagra (Granada), Huelva and Sevilla[12].

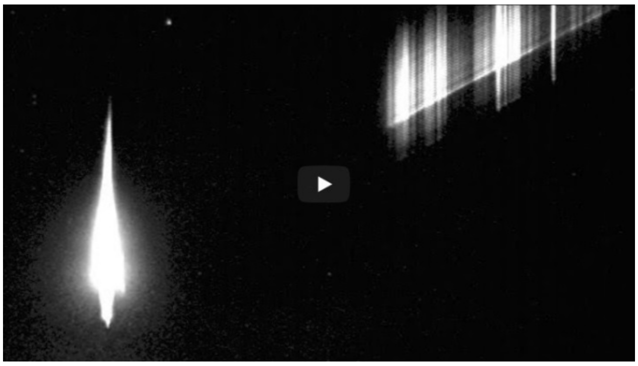

Figure 2 – Geminid fireball 2017 December 14, at 2:24 UT.

2017 December 14, at 3:48 UT

On Dec. 14, at 4:48 local time (3:48 universal time) this bright Geminid meteor was recorded over Spain. The event was produced by a fragment from Asteroid Phaeton that hit the atmosphere at about 122000 km/h. It began at an altitude of around 100 km over the province of Palencia and ended at a height of about 56 km over the province of Segovia. It was recorded in the framework of the SMART Project (University of Huelva) from the astronomical observatories of La Hita (Toledo) and Sevilla[13].

Figure 3 – 2017 December 14, at 3:48 UT.

6 Bright meteor event over Morocco December 14

This bright meteor event overflew Morocco on Dec. 14. It was spotted from several observatories in Spain at 3:45 universal time. The event is NOT a Geminid, despite it was recorded during the activity peak of this meteor shower. It began at an altitude of 114 km over Morocco and ended at a height of 61 km over the city of Melilla[14].

Figure 4 – Sporadic fireball 2017 December 14 3h45m UT.

7 Summary of the 2017 Geminids peak

Thanks to favorable weather conditions in Spain, the peak of the 2017 Geminids could be recorded from several meteor stations involved in the S.M.A.R.T Project (University of Huelva). This video shows a "meteor lapse" prepared with the meteor trails spotted from La Hita Astronomical Observatory (Toledo)[15].

Figure 5 – Stacked image of the 2017 Geminid display.

[12] https://youtu.be/97SlThVyaZo
[13] https://youtu.be/YRhzJcFREC8
[14] https://youtu.be/L7isldv5B44
[15] https://youtu.be/4QMROEslnSM

Fireball lighted up the southern parts of Norway

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On the 18th of December, at 16:37:07 UT, a bright fireball lighted up the southern parts of Norway. The event was registered by the cameras of the Norwegian Meteor Network on a quite cloudy sky.

1 Fireball 18th of December, at 16:37:07 UT

A better video of the event is taken by Tore Myhren from Lillehammer, and shows the fireball through some clouds near the horizon. The video can be found online[16].

These videos combined, shows that the meteor started at a height of 68.9 km, and exploded at a height of 26.8 km. The meteor was of sporadic origin, and had a radiant at RA: 331.3 degrees, and DEC: 62.,2 degrees. The velocity of the meteor is estimated to be around 17 km/s, but some uncertainty regarding this makes it difficult to obtain a certain estimate of the meteors mass. It is therefore uncertain whether anything from this event has reached the ground as meteorites. If any, the search for meteors will be very problematic, due to a difficult accessible, mountainous area. The automatic generated report from the Norwegian Meteor Network can be found on the website[17].

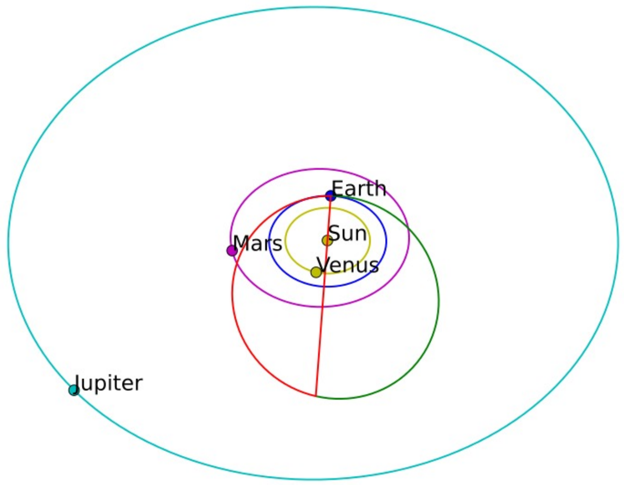

Figure 1 – The orbit calculated by the Norsk meteornettverk.

Some eyewitness reports, give a good impression on the brightness of the meteor:

Solveig Aga Hevrøy: "*Observed the sharp, bright light from Austevoll. It lighted up the whole of the inside of the car. Thought it was lightning.*"

Ørjan Solheim: "*Saw an insane powerful flash of light in Rosendal. The whole valley and the mountains lighted up. A lot of times stronger than lightning. Lasted longer and was smoother than lightning. Stopped the car and went out, but could hear no sound.*"

Rune Knutsen Taranger: "*Observed the light from Haugesund. Drove north, when the sky lighted up. It was rain and clouds, so I saw nothing else than a powerful flash in the sky*".

Ellen Marie Lyseng: "*Saw an enormous fireball over Valdres, with direction towards Hemsedal. It lighted up the whole valley for some seconds. Seemed almost like an explosion in the sky*."

[16] http://norskmeteornettverk.no/wordpress/?p=2865
[17] http://norskmeteornettverk.no/meteor/20171218/163707/

New Year's Eve Fireball over the UK

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On 2017 December 31 at 17h 33m UT, a very bright fireball has been observed over the United Kingdom.

UK finishes 2017 with a bang, a large fireball event spotted by over 300 members of public across the UK. The event occurred on December 31st 2017 around 17:34 UT and judging from the reports it was in green color with reported fragmentation.

UK Meteor Observation Network is already searching for a match on their cameras. We will update you as soon as we know more.

Image: IMO public reports map of the fireball event: 5538-2017

YouTube footage from dashcam:

- https://youtu.be/dXRtde0NePQ
- https://youtu.be/wJDNEVwT53I

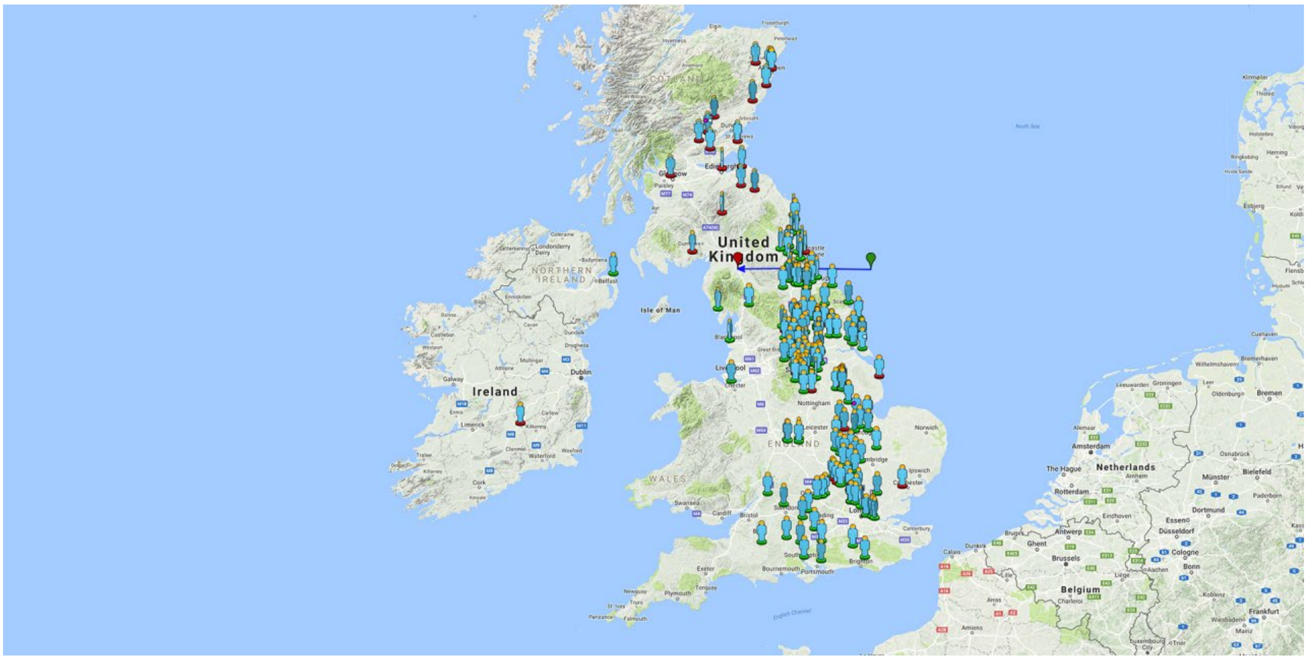

Figure 1 – Public reports of the fireball event of 2017 December 31 reported across the United Kingdom, with a very preliminary trajectory based on public reports. More precise data from cameras is searched to derive a more reliable trajectory.

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