

Discovery of the February Eta Draconids (FED, IAU#427): the dust trail of a potentially hazardous long-period comet

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Abstract. A previously unknown shower was detected on February 4, 2011, during routine low-light-level video triangulations with NASA's Cameras for Allsky Meteor Surveillance (CAMS) project in California between 2h20m and 14h20 m UT. During that time interval, six meteors radiated from a compact geocentric radiant at R.A. = 239.92 +/- 0.50 deg, Decl. = 62.49 +/- 0.22 deg, with speed $V_g = 35.58 \pm 0.34$ km/s. The times of arrival for the meteors were 6h25m, 7h59m, 10h49m, 11h18m, 12h14m UT and 13h33m UT, suggesting that the outburst peaked around 11h UT (solar longitude 315.1 deg) and had a duration of at least 7 hours. The shower was not detected on the days prior to or after Feb. 4. The meteors were in a narrow magnitude range, with peak visual magnitude of +2.1, +1.9, +2.6, +2.1, +2.3 and +2.4, respectively, moving from 103.6 +/- 1.4 to 95.7 +/- 1.5 km altitude. The mean meteoroid orbital elements derived from the radiant and speed are: $q = 0.971 \pm 0.001$ AU, $1/a = -0.004 \pm 0.025$ 1/AU, $i = 55.20 \pm 0.34$ deg, $w = 194.09 \pm 0.35$ deg, Node = 315.07 +/- 0.10 deg (one standard deviation). The orbital period of this shower is $P > 53$ y (three standard deviations), so that the meteoroids are likely the dust trail of a potentially hazardous long-period comet, which remains to be discovered.

1. Introduction

When a long-period comet is in an orbit that passes close to Earth's orbit, its dust trail from a prior orbit can occasionally shower the Earth [1]. Comets that have orbits taking between 200 and about 10,000 years to complete, can have dense enough dust trails to be detected in this manner. Such comets originated in the Oort cloud and were initially on orbits taking a longer 100,000 years to complete. Hence, (nearly) all such comets were in the inner solar system in an earlier orbit. During the most recent passage by the Sun, a dust cloud was released, grains of which are now returning at different times depending on the orbital period of each meteoroid. If the comet passes close enough to Earth's orbit, the continuous stream of returning dust wanders in and out of Earth's orbit when the meteoroids are directed to do so by the gravity of the planets [2,3]. When they do, the Earth is literally showered by meteoroids and a brief 1-h meteor shower can be observed. Recent examples are the 1995 alpha Monocerotids [3] and the 2007 Aurigid outburst [4,5].

Such meteor showers are extremely rare. They happen only about once or twice every sixty years, when the thin meteoroid stream is exactly in Earth's path at the time when Earth arrives at that spot. Because they are so rare, many of these showers remain to be discovered. Here, we report that one such shower, previously unknown, just showed up on February 4, 2011.

2. The Cameras for Allsky Meteor Surveillance (CAMS) network

The shower was detected during routine observations with a new NASA-sponsored network of low-light video cameras called the Cameras for Allsky Meteor Surveillance (CAMS) project. The project website is at: <http://cams.seti.org>. Goal of the project is to verify the 300+ meteor showers in the IAU Working List of Meteor Showers that remain unestablished. The project

consists of three stations, each equipped with twenty Watec Wat-902H2 Ultimate / Pentax 12 mm f1.2 cameras, which have a small $20^\circ \times 30^\circ$ field of view. The stations are located at Fremont Peak Observatory south of San Juan Bautista in California, at Lick Observatory, and in Mountain View. The first two-station observations with the Fremont Peak and Mountain View stations were made on October 21, 2010. At the time of the observations reported here, the Lick Observatory station was not yet in operation.

The video data is compressed in a distortion-free (Four-Frame) format, modified from [6] and written to hard disk during the night. In the morning, all files are examined with MeteorScan [7] to find the meteors. Those files are later collected and re-processed to obtain the astrometry of the meteor tracks and the photometry of the meteor light curves at 60 Hz. Once all data are in one place, an interactive coincidence program searches for meteors and calculates the trajectory in the Earth's atmosphere and the orbit in space. The system and reduction procedures are described in detail in a recent paper submitted to Icarus [8].

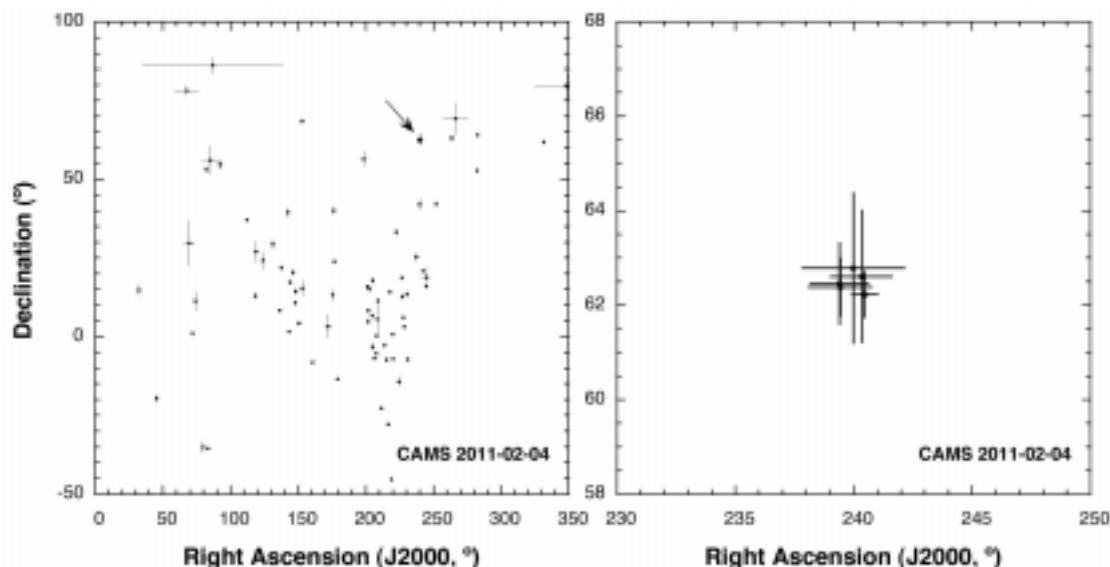


Figure 1 - Geocentric radiant positions of meteors observed in the CAMS network on February 4, 2011. Results for five meteors (marked by arrow) are shown enlarged in the right diagram.

3. The February eta Draconids

During routine data processing, we discovered among the 80 meteoroid orbits measured in the night of February 4, 2011 (UT), a cluster of five orbits very tightly together near the star eta Draconis (Fig. 1). On further inspection, all meteors had a similar speed of about 35.6 km/s. This resulted in a nearly parabolic orbit, in prograde motion. The orbital elements of these meteors are summarized in Table 1. Running the coincidence software again with looser constraints (radiant error in Declination $2\text{-}3^\circ$) produced a sixth meteor (Table 1).

Table 1. Meteoroid physical parameters, trajectory, and orbital elements. mV is the visual magnitude, F the light curve parameter (position of peak relative to distance from begin to end point), Hb and He are beginning and end altitude, RAg and Decg are the geocentric Right Ascension and Declination, Vg is the geocentric speed. Orbital elements are in J2000.

Time	mV	F	Hb	He	RAg	Decg	Vg
6:24:31	+2.3	0.68	105.1	94.6	239.43±1.32	62.38±0.60	35.67±0.28
7:59:25	+2.1	0.59	105.1	96.3	240.47±0.53	62.23±0.48	35.16±0.07
10:48:53	+2.6	0.62	102.7	97.0	239.40±1.22	62.46±0.85	35.90±0.34
11:17:46	+1.9	0.67	103.9	97.1	239.98±2.14	62.79±1.58	35.30±1.06
12:13:49	+2.1	0.40	103.1	95.7	240.33±1.28	62.61±1.39	35.87±0.61
13:32:19	+2.4	0.67	101.4	93.4	239.80±2.88	61.38±3.01	35.62±0.94

Time	Sol long	q (AU)	1/a (1/AU)	i(°)	ω(°)	Ω(°)
6:24:31	314.929	0.970±0.002	-0.002±0.030	55.39±0.44	194.42±1.05	314.923
7:59:25	314.995	0.972±0.001	+0.032±0.020	54.94±0.29	193.73±0.43	314.990
10:48:53	315.115	0.970±0.002	-0.022±0.043	55.54±0.64	194.41±0.88	315.111
11:17:46	315.135	0.971±0.003	+0.002±0.095	54.74±1.51	194.17±1.39	315.132
12:13:49	315.175	0.972±0.002	-0.032±0.072	55.37±1.07	193.73±0.84	315.175
13:32:19	315.229	0.971±0.004	+0.037±0.136	55.90±2.11	194.09±2.24	315.228

The calculated error bars (from Monte Carlo modeling of the uncertainties) are scaled with the presumed uncertainty in astrometry (fraction of a pixel). We assumed that error was of order 0.4 pixels. In reality, the error bars appear to be over estimated. The standard deviation of the meteor radiants is 0.22° (1 sigma). The mean error bar was 0.98°, a factor of 4.5 larger. The deviation in right ascension is a factor of two higher at 0.50° because of the higher Declination. The calculated error is 1.3°, a factor of 2.6 higher. Possibly, the uncertainty in the astrometry was about 0.1-0.2 pixels and the quoted error bars are 3-sigma. This is the random error only, systematic errors may exist as well.

It is surprising to see that all confirmed shower members are in a narrow magnitude range of +1.9 to +2.6. This phenomenon was earlier observed for the alpha Monocerotid and Aurigid showers [3] and is thought to be due to the meteoroids of brighter size not being able to make it all the way to where the Earth encountered the dust [1].

It is interesting to note that most light curves look similar: fairly broad with a rounded flattened top. None show flares. This is quite different from other meteors observed that night. The shape of the light curves suggests that these are relatively sturdy meteoroids that don't crumble easily. Figure 2 shows the light curve in one of the interactive screens to determine whether a coincidence is an actual meteor. The other two screens used in the coincidence software show altitude versus distance along the track and latitude versus longitude of the calculated track. The result from each station are shown with different colors (shown here as light and dark gray).

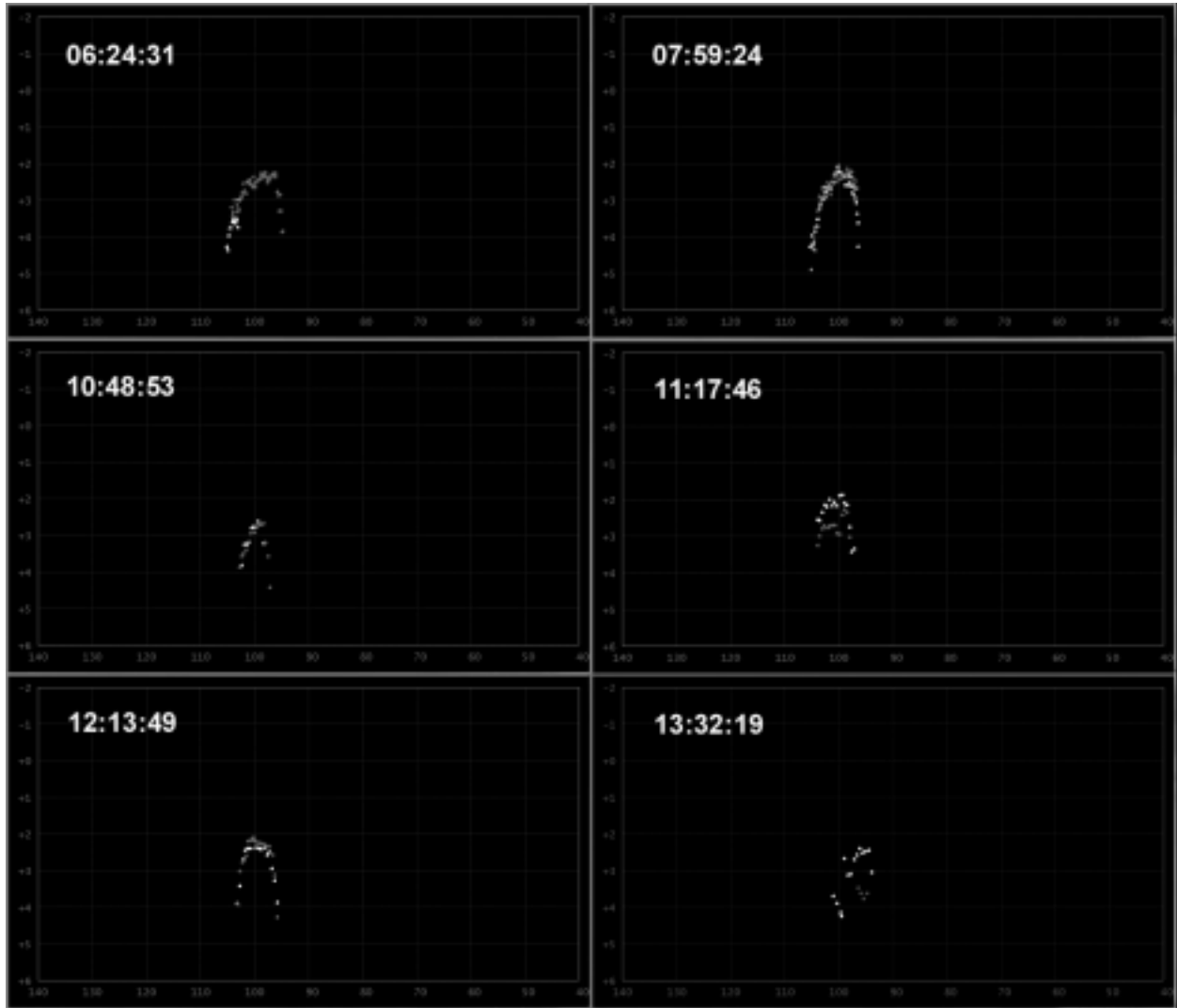


Figure 2 - Meteor light curves of shower members. Each graph shows brightness from bottom to top ranging from +6 to -2 visual magnitude, and altitude left to right ranging from 140 to 40 km.

A brief announcement of the discovery was submitted to the IAU Central Bureau of Telegrams, after checking in with the Meteor Data Center (Jopek Taduesz) to verify the proposed name: the February eta Draconids. The name was unique and the shower received #427 and code "FED".

4. Long-period comet dust trail?

The similarity of the orbits implies that the February eta Draconids are a dynamically young stream. The orbital period suggests a long-period comet, perhaps a Halley-type comet. If this indeed is a long-period comet dust trail, then the dust was ejected in the previous return to the

Sun. Such dust trails get perturbed enough on the way in that the orbital periods change dramatically and dust trail sections catch up on each other, spreading out into a more diffuse stream already after one orbit [1].

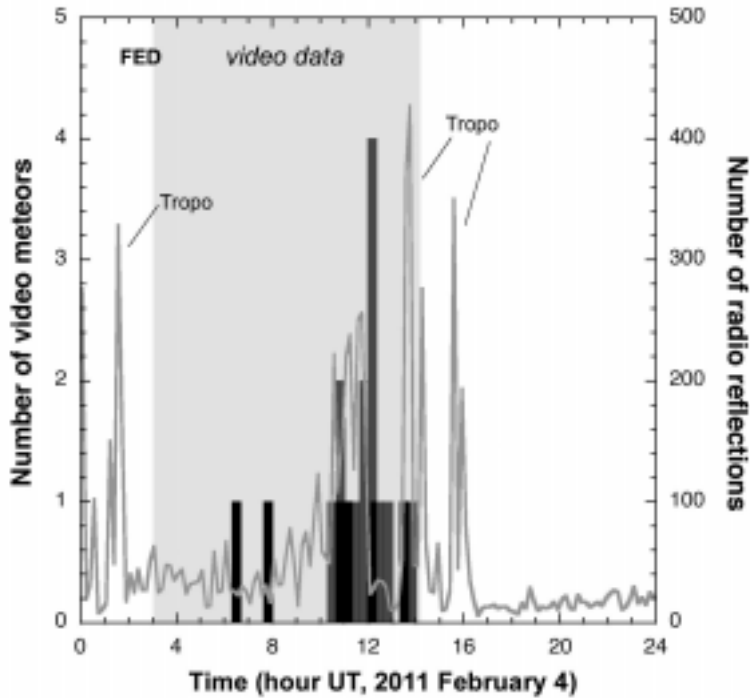


Figure 3 - Number of detected shower meteors as a function of time on February 4, 2011. The gray area is the timeframe for which video observations are available. Also shown is the count of radio reflections in observations by Ilkka Yrjölä of Kuusankoski, Finland (GlobalMSNet).

The shower was not detected in the days before and after February 4 (Feb 1-10 were all clear nights). The shower also doesn't appear to have been active in 2007-2009, because no shower members were detected in the SonotaCo database (2007-2009) compiled by Touru Kanamori, for a 3° solar longitude interval around the current event [9].

Surprising, however, is the long 7-h duration of the event. Other crossings of long-period comet dust trails were much shorter, of order 0.7-2 hours [3]. We examined the log file of astrometric tracks for all moving objects in all cameras that recorded that night (16 cameras at Fremont Peak Observatory and 16 cameras in Mountain View). We found an additional 11 meteors that were likely part of this shower. All these new trails cluster in the time period 10 - 13h UT. Hence, the two earlier meteors appear to have been outliers in the activity profile (Figure 3).

The time of detections was compared to the 10-minute count of radio reflections during that day, obtained by Ilkka Yrjölä of Kuusankoski Finland in routine observations for GlobalMSNet. A peak in reflection count is observed between 10 and 12h UT on February 4. Unfortunately,

during February, there was a lot of tropospheric propagation interference, as well as aurora. It is not certain that the measured peak was due to the meteor shower.

5. Conclusion.

A new meteor shower was discovered caused by the dust trail of a long period comet. The shower is now listed as #427 in the IAU Working List of Meteor Showers and is called the February eta Draconids (FED).

This is an important discovery, because it points to the presence of a potentially hazardous comet. If the dust trail can hit the Earth, so can the comet: the planetary perturbations do not depend on the mass of the object. Of course, an impact will occur only if the comet orbit is perturbed into Earth's path right at the time when Earth passes by the comet orbit on February 4. It is in principle possible to guard against such impacts by looking along the comet orbit to those spots where the comet would be in such a dangerous position. In that way, perhaps a few years of warning could be provided.

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