Short paper

Quadrantids 2014 – Multi-station meteor videography

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NEMETODE, a network of low-light video cameras in the British Isles, operated in conjunction with the BAA Meteor Section and other groups, monitors the activity of meteors, enabling the precision measurement of radiant positions and, from the best quality data, the altitudes and geocentric velocities of meteoroids and their solar system orbits. The results from multi-station observations of the 2014 Quadrantids meteor shower are presented and discussed.

Equipment and methods

William Stewart (WS) and Alex Pratt (ARP) employed the same equipment and methods as described in their paper on the 2012 Perseid meteor shower[1] and on the NEMETODE website.[2] David Anderson (DA, Low Craighead, Ayrshire, Scotland) operated his Watec camera with a 6mm f/0.75mm lens. In the Republic of Ireland Mike Foylan (MF, Rathmolyon, Co. Meath) ran two Watec 902DMS cameras with 8mm f/0.8 lenses, and Michael O'Connell (MOC, Monasterevin, Co. Kildare) used a Watec 902H and 12mm f/0.8 lens.

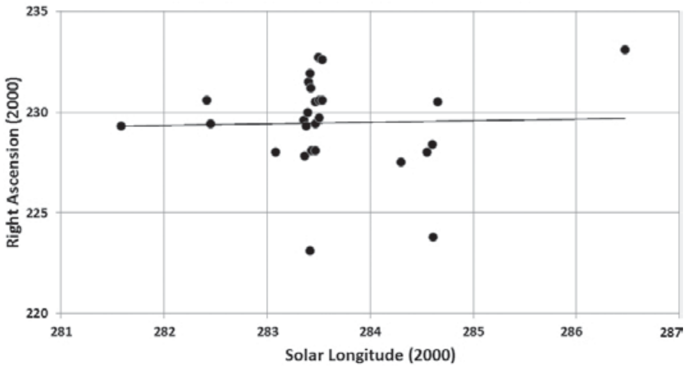

Figure 1. Quadrantids radiant drift in right ascension.

The Quadrantid meteor stream

The Quadrantids (IAU MDC 0010 QUA) are medium-speed meteors with geocentric velocities of 41 km/s, active from late December to mid-January. They produce low rates except for a ZHR of ~120 at maximum on January 3/4, solar longitude 283°.16 (2014),[3] during a brief FWHM (full width half maximum) period of about 14 hours.[4] It has been suggested that their parent body is the Amor near Earth object 196256 (2003 EH_1).[5,6]

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Table 1. Magnitude distribution of the Quadrantid meteors, 2014

Apparent magnitude	*−3*	*−2*	*−1*	*0*	*1*	*2*	*3*	*4*	*Sum*	*Mean*
Count	3	8	42	80	96	84	29	2	344	0.8

Table 2. The position of the Quadrantids radiant at maximum and its daily motion

	Solar long.(°)	*RA(°)*	*RA*	*dRA(°)*	*Dec(°)*	*dDec(°)*
		(All positions are for epoch 2000.0)				
NEMETODE	283.16	229.4	15h 18m	0.08	49.5	0.26
HBAA[7]	283.1	232	15h 28m		50	
IAU MDC[8]	283	231.5	15h 26m	0.78	48.5	−0.38
IMO[3]	283.16	230	15h 20m	0.6	49	−0.2
SonotaCo[9]	283.1	230.0	15h 20m	0.15	49.0	0.17

Table 3. Geocentric velocities of the Quadrantid meteors

	Vg (km/s)
NEMETODE	41.1
IAU MDC[8]	41.7
IMO[3]	41
SonotaCo[9]	40.0

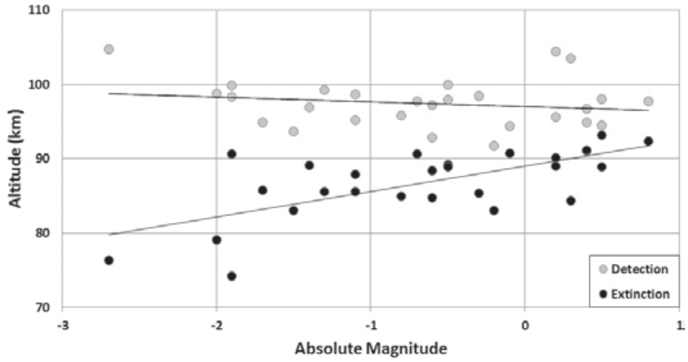

Figure 3. Detection and extinction altitudes of Quadrantid meteors.

Results

The first probable Quadrantid candidate was recorded on 2013 December 19/20 (Leeds NW) and the last on 2014 January 20/21 (Leeds NW). In total, 344 recordings were made of 312 individual Quadrantids by WS (160), ARP (101), MF (60), DA (21) and MOC (2).

The magnitude distribution of the events (measured by *UFO Analyser*) is given in Table 1.

Multi-station Quadrantids

UFO Orbit supports three built-in Quality Assurance criteria:

Q1 – minimum criterion for radiant computation;

Q2 – standard criterion for radiant and velocity computation;

Q3 – criterion for high precision computation.

(When analysing captures, Q1 includes level Q2 and Q3 data, Q2 includes level Q3 data.)

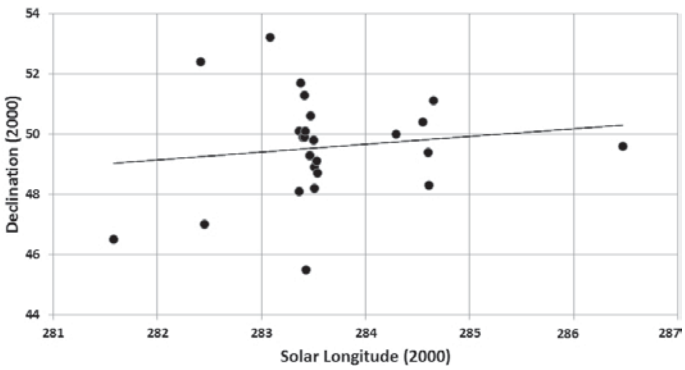

Figure 2. Quadrantids radiant drift in declination.

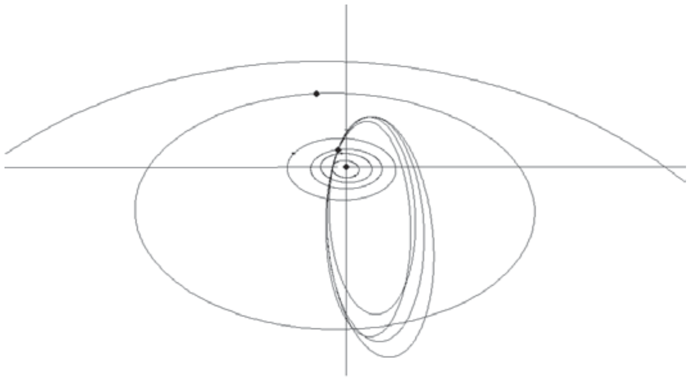

Figure 4. Solar system orbits of 4 Quadrantid meteors.

Between 2013 Dec 1/2 and 2014 Jan 4/5 a total of 25 Q1-level multi-station Quadrantids was recorded, with the addition of 2 Q0 events.

Radiant drift

UFO Orbit was used to derive the radiant point for each multi-station Quadrantid, corrected for zenith attraction. These were used to estimate the daily drift of the radiant in RA and Dec.

The method of least squares gave the linear fits:

$RA = 0.0812 * (\lambda_{solar}) + 206.44$ $\quad r = 0.03$

$Dec = 0.2599 * (\lambda_{solar}) - 24.128$ $\quad r = 0.136$

Table 4. Orbital elements of the Q3 Quadrantid meteors, IAU MDC shower data and 196256 (2003 EH1) (NASA JPL HORIZONS)[9]

	Solar long.	*Abs mag*	*Vg*	*a (AU)*	*q (AU)*	*e*	*p*	*Peri*	*Node*	*Incl*
	283.380920	−0.5	40.2	3.036	0.983	0.676	5.292	176.809	283.381	69.868
	283.414612	−0.5	40.1	2.877	0.978	0.660	4.881	170.364	283.415	69.902
	284.553711	−1.9	43.3	2.735	0.983	0.641	4.525	177.683	284.554	71.515
	284.654633	−2.0	40.5	3.192	0.982	0.692	5.705	175.647	284.655	70.161
Mean	284.0		41.0	2.960	0.981	0.667	5.101	175.126	284.001	70.362
Std. dev.			1.5	0.198	0.002	0.022	0.510	3.283	0.698	0.780
IAU MDC[8]	283		41.7	3.35	0.9746	0.709		168.14	283.0	72.4
196256 (2003 EH1)[10]				3.122	1.189	0.619	5.52	171.356	282.963	70.876

where λ_{solar}= the solar longitude and r= the correlation coefficient. These are shown in Figures 1 and 2.

The small datasets show very weak correlation, but if we assume that Quadrantid maximum occurred at solar longitude 283°.16,[3] its estimated RA is 229°.4 (15h 18m) and Dec 49°.5. The estimated daily motion in RA (dRA°) is 0°.08 and in Dec (dDec°) is 0°.26. These are presented in Table 2 for comparison with other sources.

Detection and extinction altitudes

UFO Orbit computed the start and end altitudes of 27 Quadrantid meteors and their absolute magnitudes (see Figure 3). Absolute magnitude is the magnitude the meteor would have if it was observed in the zenith, 100km above the observer.

The method of least squares gives the linear fits:

Detection altitude (km) = –0.6396 * (Absolute magnitude) + 97.042   r = 0.184

Extinction altitude (km) = 3.3962 * (Absolute magnitude) + 88.988   r = 0.674

Geocentric velocities

UFO Orbit computed the geocentric velocities (Vg) of 11 Q2 Quadrantids captured on 2014 Jan 3/4 and 4/5, which gave the following:

Mean	41.1 km/s
Standard deviation	1.8 km/s

These are compared with other sources in Table 3.

Orbits

UFO Orbit computed the orbital elements of 4 Q3 Quadrantids, captured on January 3/4 and 4/5. For each pair of observations it calculated two orbits and a Unified orbit; the latter are given in Table 4 and as a solar system diagram in Figure 4, showing their aphelia lying close to the orbit of Jupiter.

Conclusions

The team was fortunate to have some clear skies during the short duration of the Quadrantids' peak, because poor weather in January often precludes useful observations of this shower.

The meteors' detection and extinction altitudes are in good agreement with other workers (Betlem *et al*, 1998).[5] Our results from bright Quadrantids suggest that for every magnitude increase in brightness they penetrate about 3km deeper into the atmosphere. The Quadrantids are extinguished at higher altitudes than the Geminids,[11] even though they have similar geocentric velocities (Vg), suggesting that they consist of more fragile debris.

The estimates of radiant drift in RA and Dec are general approximations, due to the sparse data. During 2014 additional stations and cameras have been added to the network which have significantly improved our coverage of meteor activity from the British Isles, which should result in more comprehensive reports on the major showers in future.

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Erratum – 'Changes in the spectrum of Z Ursae Majoris...' *(D. Boyd)*

We regret there is an error in the above paper by David Boyd in the June *Journal*, **125**(3), 2015, p. 163. Equation 1 should read:

V= (mv × 0.8456) + 0.9350.

Apologies to readers and to the author. *Ed.*