Short paper

Perseids 2012 – Multi-station meteor videography

Alex R. Pratt, William Stewart & Leonard Entwisle

This paper describes a network of low-light video cameras operated from Cheshire and West Yorkshire that monitors the activity of meteor showers, enables the precision measurement of radiant positions and, from the best quality data, estimates the altitudes and geocentric velocities of meteors and their solar system orbits. The results from multi-station observations of the Perseid meteor shower in 2012 August are presented and discussed.

Equipment and methods

Alex R. Pratt (ARP) operates a Watec 902H2 camera with a Computar aspherical 3.8mm f/0.8 lens, facing south from Leeds, West Yorkshire, UK. William Stewart (WS) operates two Watec 902H cameras with Computar aspherical 8mm f/0.8 lenses, one facing east and the other facing north from Ravensmoor, Cheshire. The approximate limiting magnitudes of the systems are Leeds 3.5, Ravensmoor East 4.0 and Ravensmoor North 5.0. WS runs his cameras every night, irrespective of forecast conditions, in order to maximise the number of meteors captured.

Meteors are detected and recorded by *UFO Capture* software (developed by SonotaCo)[1] running on Windows PCs; each capture is displayed to 0.1s (processed internally to 0.04s), time-synchronised to an NTP server. Detailed analyses are performed using the *UFO* program suite. The resultant captures are processed by *UFO Analyser*, registering against the *Sky 2000* star catalogue with average positional errors of <0.3 pixels and <0.03°, to determine shower membership. The Leeds and Ravensmoor cameras operate across a baseline of 107km and multi-station events are processed by *UFO Orbit* to estimate meteor shower radiants, start and end heights, geocentric velocities and orbital elements. Further details can be found on the authors' website.[2]

Table 1. Magnitude distribution of Perseid and sporadic meteors

	Magnitude −4	−3	−2	−1	0	1	2	3	4	Mean mag.
Leeds										
Perseids	0	3	14	47	63	31	1	0	0	−0.3
Sporadics	1	3	11	25	38	20	0	0	0	−0.4
Ravensmoor East										
Perseids	2	3	13	38	56	23	0	0	0	−0.4
Sporadics	0	2	7	32	81	63	4	0	0	0.1
Ravensmoor North										
Perseids	0	3	3	9	21	43	78	16	1	1.3
Sporadics	0	1	2	13	21	71	96	18	0	1.3

2012 Perseid results

The first likely Perseid candidate was recorded on 2012 July 12 at 01:24:56 UT (Leeds) and the last on 2012 September 11 at 23:06:20 UT (Leeds). The magnitude distribution from July 11 to September 12 (measured by *UFO Analyser*) is given in Table 1 (meteors from minor showers are not included).

The activity profile of the Perseids is presented in Figure 1. (All dates are 0h UT). The histogram indicates that rates were low until there was a small increase around July 20/21. Activity picked up after August 04/05, with peak activity between August 08/09 to 13/14, although bad weather hampered observations on the nights of maximum. Rates declined rapidly after August 15/16. The activity profile is generally symmetrical, with a suggestion that it is skewed to the left, indicating that the rise to maximum is more gradual than the fall from the peak.

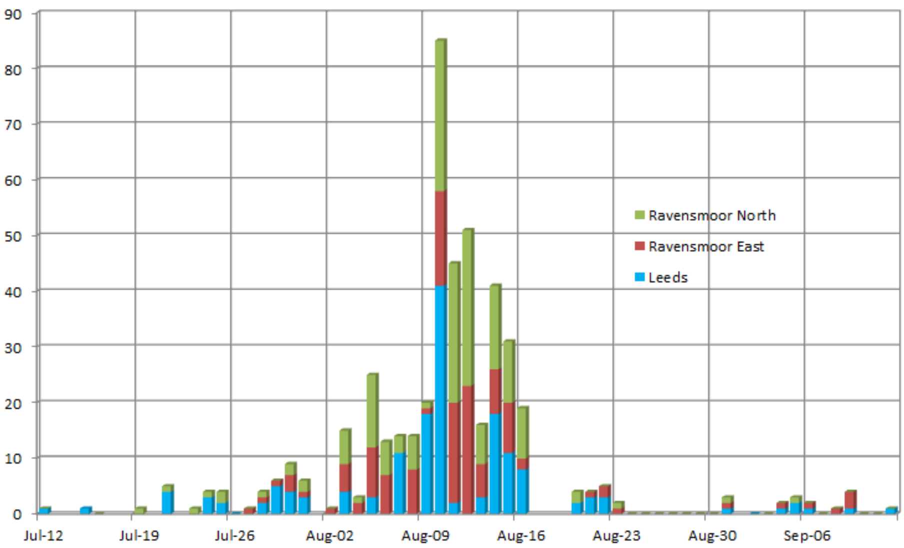

Figure 1. Daily 2012 Perseid video captures.

Multi-station Perseids

UFO Orbit supports three built-in quality assurance criteria:

Q1 – minimum criteria for radiant computation;
Q2 – standard criteria for radiant and velocity computation;
Q3 – criteria for high precision computation.

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

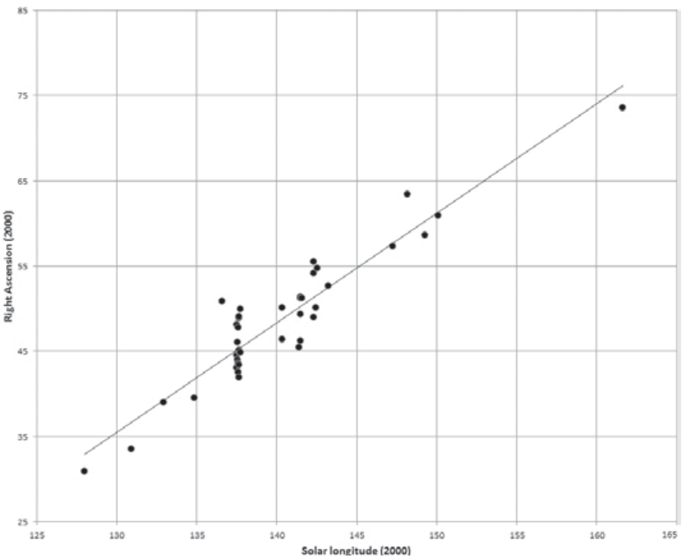

Figure 2. 2012 Perseid radiant drift in right ascension.

Between 2012 July 30 and September 03 a total of 40 Q1 two-station Perseids were recorded. In addition, Len Entwistle (LE) ran a Watec 902H camera with an aspherical Computar 3.8mm f/0.8 lens facing south from Elland, West Yorkshire on the nights of August 08/09 and 09/10, recording to videotape. ARP post-processed LE's tapes via *UFO Capture* but could not obtain an average star alignment error <1.0 pixel. Almost all of the data were rejected at the Q1 level, except for a Perseid on August 08 at 23:07:43 UT, which is a three-station capture.

Perseid radiant drift

UFO Orbit was used to derive the radiant point for each multi-station Perseid, corrected for zenith attraction. The positions of the radiant points from 40 multi-station Perseids between July 30 and September 03 were used to estimate the daily drift of the radiant in right ascension and declination.

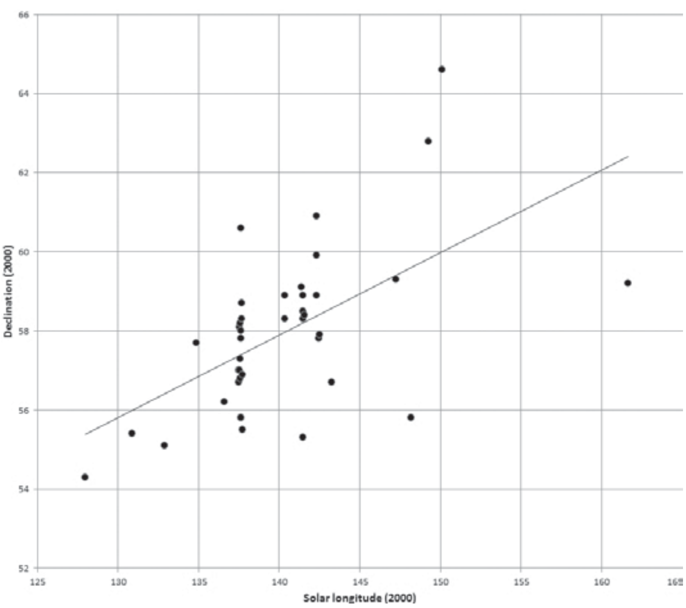

Figure 3. 2012 Perseid radiant drift in declination.

Table 2. Right ascension of the Perseid radiant at maximum

	Solar long.(°)	*RA (°)*	*RA*
ARP/WS/LE	139.9	48.2	3h 13m
HBAA	139.9	46	3h 04m
IAU MDC	140.19	48.33	3h 13m
IMO	140.0–140.1	48	3h 12m

Table 3. Declination of the Perseid radiant at maximum

	Solar long.(°)	*Dec (°)*
ARP/WS/LE	139.9	57.9
HBAA	139.9	58
IAU MDC	140.19	57.96
IMO	140.0–140.1	58

Radiant drift in RA

See Figure 2. The method of least squares gives a good linear fit:

$RA = 1.285\times(\text{Solar longitude}) - 131.56$

$r = 0.937$

The daily motion in RA during the observed period is estimated as 1°.29, which is close to the value of 1°.35 by Cook[3] quoted in the 2012 BAA *Handbook*.

If Perseid maximum occurred at solar longitude 139°.9 its estimated RA is 48°.2 (3h 13m), which differs from the value of 46° (3h 04m) given in the 2012 BAA *Handbook*, but is in agreement with the IAU Meteor Data Centre[4] and the International Meteor Organisation[5] as presented in Table 2.

Radiant drift in Dec

See Figure 3. The method of least squares gives the linear fit:

$Dec = 0.209\times(\text{Solar longitude}) + 28.67$

$r = 0.576$

There is a lot of scatter in the data, showing weak correlation, but the daily motion in Dec during the observed period is estimated as 0°.21, which is not too dissimilar from the value of 0°.12 by Cook[3] quoted in the 2012 BAA *Handbook*.

If Perseid maximum occurred at solar longitude 139°.9 its estimated declination is 57°.9, in good agreement with the values of 58° given in the 2012 BAA *Handbook*, the IAU Meteor Data

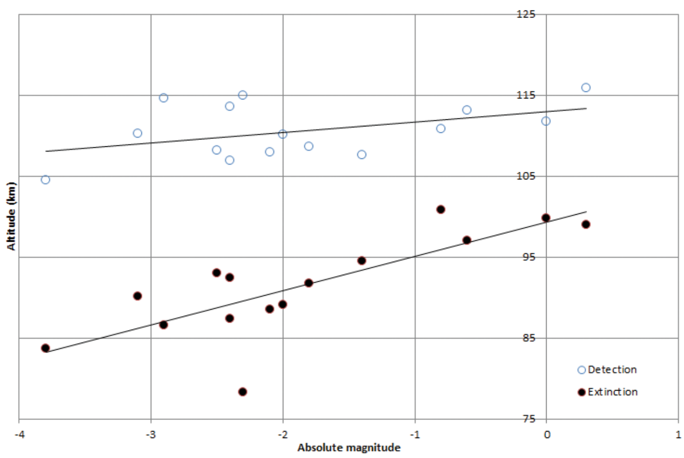

Figure 4. Detection and extinction heights of 15 Q2 Perseid meteors.

Center[4] and the International Meteor Organisation[5] as presented in Table 3.

Meteor detection and extinction altitudes

UFO Orbit computed the start and end heights of 15 Q2 Perseid meteors captured between July 30 and August 15 (see Figure 4).

The method of least squares gives the linear fits:

Detection altitude = 1.29×(Absolute mag) + 113.0
r = 0.447

Extinction altitude = 4.24×(Absolute mag) + 99.3
r = 0.785

This suggests that Perseids burn up about 4km lower in altitude for every one mag increase in brightness.

Geocentric velocities

Table 4. Geocentric velocities of Perseid meteors

	Vg (km/s)
ARP/WS/LE	59.1
IAU MDC	59.38
IMO	59

UFO Orbit computed the geocentric velocities, Vg, of the 15 Q2 Perseid meteors, as follows:

Mean 59.1 km/s
Std dev 0.96 km/s

This is again in good agreement with IAU MDC and IMO data (Table 4).

Orbits of Perseid meteors

UFO Orbit computed the orbital elements of 6 Q3 Perseids. For each pair of observations it calculated two orbits and a unified orbit. The latter are given in Table 5.

A polar view of the six unified orbits is displayed in Figure 5.

Conclusions

The results are consistent with the shower data catalogued by the BAA, IAU MDC and IMO. By applying quality assurance checks the equipment and methods should give reliable results for other meteor showers.

There is some variability in the Perseid orbital elements, especially the estimates of the semi-major axis and period, presented in Table 5. The authors' value of 'a' is significantly different from that quoted by the IAU MDC and is nearer to the value of the Perseids' parent comet 109P/Swift–Tuttle.[6] As shown in Table 1, the authors' equipment is limited to detecting bright meteors, so we are only monitoring and analysing a restricted sample of the shower.

A small error in the measured position and estimated geocentric velocity can give larger errors in the values of the orbital parameters 'a' and 'p'. We have obtained better results from relatively slower meteor showers, *e.g.* the Northern and Southern Taurids and the Geminids, which will be published at a later date. SonotaCo confirm that orbital analysis of high velocity meteors is at the limits of the current equipment.[7]

The authors recommend that the BAA Meteor Section considers reviewing the values of solar longitude and RA for the Perseid maximum published in the BAA *Handbook*.

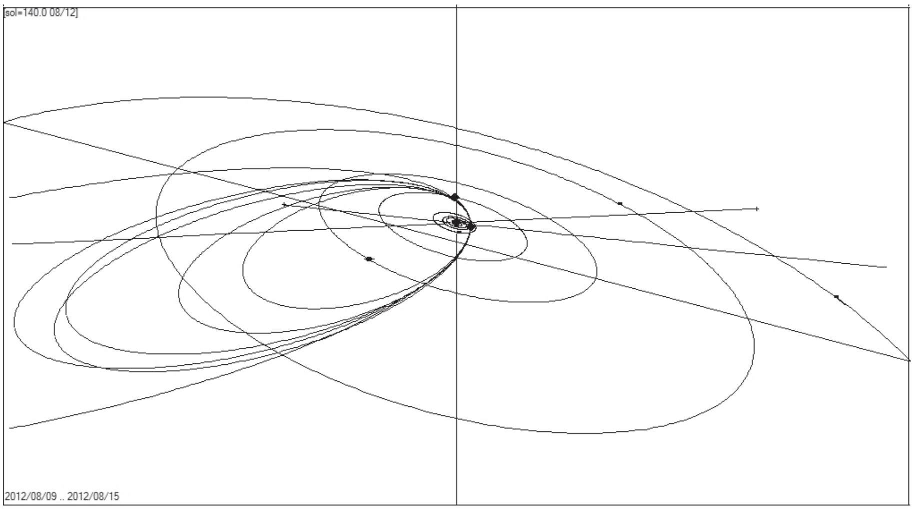

Figure 5. Polar view of the six Unified Perseid orbits.

Table 5. Orbital parameters of six Perseid meteors and IAU MDC shower data

Solar long.	*a (AU)*	*q (AU)*	*e*	*p*	*Peri*	*Node*	*Incl*
137.5025	17	0.951	0.944	70.383	150.7	137.5	114.16
137.571	15.6	0.941	0.94	61.581	148.3	137.57	114.1
137.6279	11.1	0.941	0.916	37.17	148.2	137.63	107.48
137.6401	37	0.958	0.974	224.789	152.8	137.64	112.15
137.7316	8.2	0.95	0.884	23.522	150	137.73	115.86
142.4478	14.3	0.958	0.933	53.829	152.7	142.45	114.38
Mean	17.2	0.95	0.932	78.545	150.5	138.42	113.02
Std. dev.	10.2	0.008	0.03	73.61	2	1.98	2.96
IAU MDC	71.4	0.953			151.3	140.19	113.22

Acknowledgments

The authors wish to thank Bill Ward for setting up the Meteor Observers' Forum[8] through which the NEMETODE group (Network for Meteor Triangulation and Orbit Determination) was formed. ARP thanks Len Entwisle for introducing him to SonotaCo's program suite and Bill Ward for initial assistance with the software.

Address: c/o British Astronomical Association, Burlington House, Piccadilly, London W1J 0DU.
ARP: arp@nemetode.org
WS: ws@nemetode.org
LE: le@nemetode.org

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Received 2013 January 10; accepted 2013 January 30