Perseids 2013 – Multi-station meteor videography

Alex R. Pratt, William Stewart, Mike Foylan, Leonard Entwisle & Michael O'Connell

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 2013 Perseids meteor shower are presented and discussed, including an estimate of the Perseids' population index.

Equipment and methods

William Stewart (WS) Alex Pratt (ARP) and Len Entwisle (LE) employed the same equipment and methods as described on the NEMETODE website[1] and in their paper on the 2012 Perseids.[2] In early 2013 January WS commissioned a third camera and realigned his two original cameras to achieve better overlap with ARP. In the Republic of Ireland Mike Foylan (MF, Co. Meath) operated two Watec 902DMS cameras with 8mm f/0.8 lenses, and Michael O'Connell (MC, Co. Kildare) ran his Watec 902H and 12mm f/0.8 lens. LE's meteor camera was active on the nights of August 10/11 and 12/13, recording to VHS tape. ARP post-processed LE's tape via *UFO Capture*.

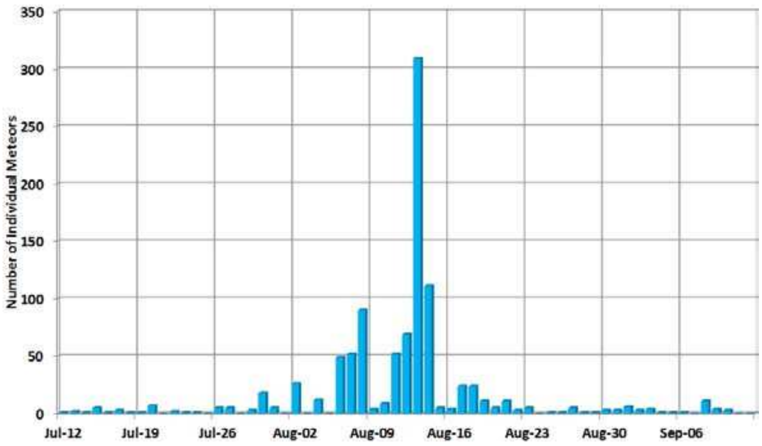

Figure 1. Daily Perseid video captures (All dates are 0h UT).

The Perseid meteor stream

The Perseids (007 PER) are active from mid-July to early September, with a ZHR of ~100 at maximum on August 12/13 (2013) and a FWHM (full width half maximum) period of about 2 days. They are swift meteors, with geocentric velocities of 59 km/s, many of the brightest leaving persistent trains. Their parent body is comet 109P/Swift–Tuttle.[3]

Results

The year's first probable Perseid candidate was recorded on 2013 July 11/12 (Ravensmoor North East) and the last on 2013 Sept 09/10 (Ravensmoor North). In total, 1137 recordings were made of 986 individual Perseids by WS (683), ARP (368), MF (52), LE (30) and MC (4).

The activity profile of the Perseids is presented in Figure 1. The histogram indicates that rates were low up to the end of July, followed by a steady rise to peak activity on the night of August 12/13, which was favourably clear. Cloudy skies hampered observations on some of the nights before and after maximum, then rates declined rapidly after August 20/21.

The magnitude distribution during this period (measured by *UFO Analyser*) is given in Table 1.

The population index, *r*, of a meteor shower is the ratio of the number of meteors in adjacent magnitude classes. Most meteor showers have a population index between 2.1 and 3.0. Values of *r* lower than 2.5 indicate an older meteor stream that is depleted of smaller, fainter meteoroids. Mason & Sharp[4] have shown that if *n* is the number of meteors with apparent magnitude *m*, the population index can be estimated from the linear relationship between $\log_{10}n$ and *m*. This is presented in Figure 2, derived from Perseids in the magnitude range –6 to 0, giving a population index of 2.37 and correlation coefficient of 0.995.

(Contemporary sources give different values of the Perseids' population index, from 2.2[3] to 2.6.[5])

Table 1. Magnitude distribution of the Perseid meteors, 2013

Apparent magnitude	−6	−5	−4	−3	−2	−1	0	1	2	3	4	*Sum*	*Mean*
Count	1	3	5	20	55	155	263	351	222	60	2	1137	0.5

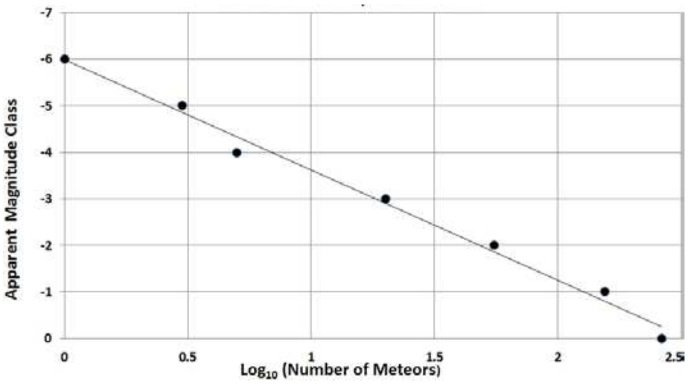

Figure 2. The population index of the Perseid shower.

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.)

Between 2013 July 25/26 and Aug 31/Sept 01 a total of 85 Q1-level multi-station Perseids were recorded.

Radiant drift

UFO Orbit was used to derive the radiant point for each multi-station Q1 Perseid, corrected for zenith attraction. These were used to estimate the daily drift of the radiant in right ascension and declination.

The method of least squares gave the linear fits and correlation coefficients (r):

RA= 1.4388 * (λ_{solar}) – 153.85 r = 0.943

(where λ_{solar}= the solar longitude)

Dec= 0.2895 * (λ_{solar}) + 17.22 r = 0.625

Combining the 2012[2] and 2013 results gave:

RA= 1.3937 * (λ_{solar}) –147.33 r = 0.940

Dec= 0.2627 * (λ_{solar}) + 20.981 r = 0.612

and these are shown in Figures 3 and 4.

If we assume that Perseid maximum occurred at solar longitude 140°.0,[3] its estimated RA is 47°.8 (3h 11m) and Dec 57°.8. The estimated daily motion in RA (dRA) is 1°.39 and in Declination (dDec) is 0°.26. These are presented in Table 2 for comparison with other sources.

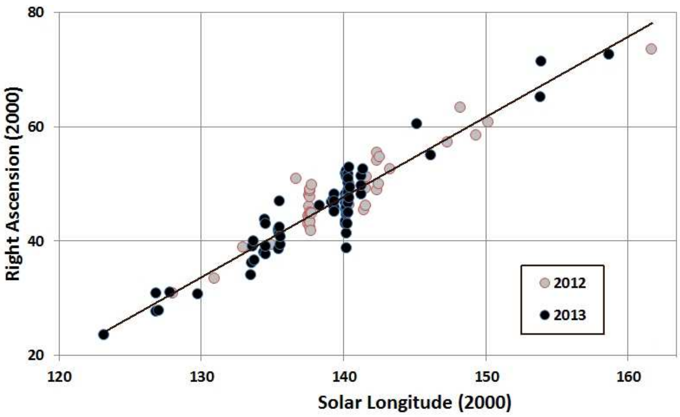

Figure 3. Perseids radiant drift in right ascension (2012–2013).

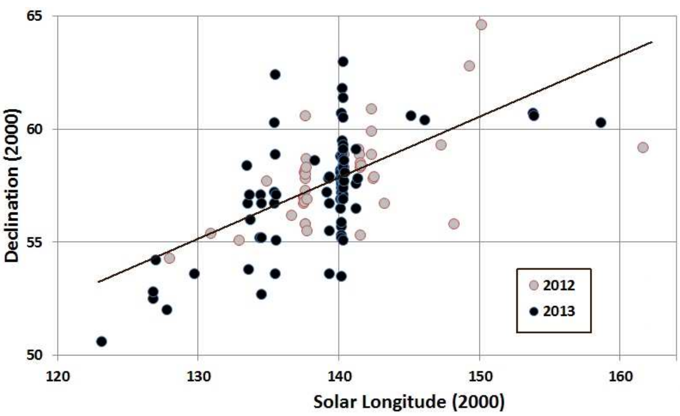

Figure 4. Perseids radiant drift in declination (2012–2013).

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

	Solar long.(°)	*RA(°)*	*RA*	*dRA(°)*	*Dec(°)*	*dDec(°)*
		(All positions are for epoch 2000.0)				
NEMETODE	140.0	47.8	3h 11m	1.39	57.8	0.26
HBAA[6]	139.9	46	3h 04m	1.35	58	0.12
IAU MDC[7]	140.19	48.33	3h 13m	1.38	57.96	0.18
IMO[3]	140	48	3h 12m	1.33	58	0.13
SonotaCo[8]	139.2	47.2	3h 09m	1.17	57.7	0.19

Detection and extinction altitudes

UFO Orbit computed the start and end altitudes of the 85 Q1 Perseid meteors and their absolute magnitudes (see Figure 5). Note: 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)=–1.0202* (abs. mag) + 108.47
r = 0.279

Extinction altitude (km)= 3.5993 * (abs. mag) + 98.385
r = 0.710

(The outlier with abs. mag +1.3 was not used in the altitudes analysis.)

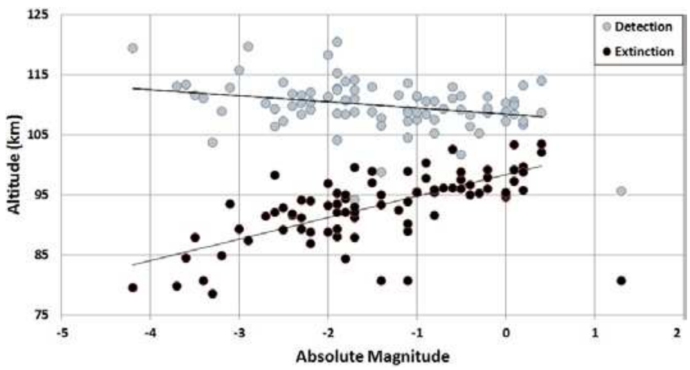

Figure 5. Detection and extinction altitudes of 84 Perseid meteors.

Our results from bright Perseids suggest that for every magnitude increase in brightness they penetrate about 4km deeper into the atmosphere.

Table 3. Geocentric velocities of Perseid meteors

	Vg (km/s)
NEMETODE	59.1
IAU MDC[7]	59.4
IMO[3]	59
SonotaCo[8]	58.7

Geocentric velocities

UFO Orbit computed the geocentric velocities (V_g) of 36 Q2 Perseids captured between 2013 July 30/31 and Aug 31/Sept 01, which gave the following:

Mean 59.1 km/s
Standard deviation 1.2 km/s

These are compared with other sources in Table 3.

Orbits

UFO Orbit computed the orbital elements of 6 Q3 Perseids, captured between Aug 07/08 and 12/13. 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[10] (Figure 6) showing their aphelia lying generally between the orbits of Saturn and Uranus.

Conclusions

In comparison with the previous year's results, more than twice as many Perseids were recorded in 2013, particularly Q1 and Q2 events, although only the same number of Q3 captures were obtained. In our report on the 2012 Perseids,[2] we discussed that the analysis of high velocity meteors is at the limits of our hardware and software, particularly for those matching the Q3 criteria.

The radiant drift in RA and Dec and the orbital elements are slightly different, but the detection and extinction altitudes and geocentric velocities are in good agreement with those obtained in 2012.[2]

Since these observations were made, additional stations and cameras have been added to the network, including some with longer focal length lenses, *e.g.* 6mm and 8mm rather than 3.8mm, which should result in higher precision astrometry, and the authors expect this will improve the quality of their coverage of the Perseids in 2014. A 12mm lens is probably the optimum for this work, but it gives a smaller field of view for multi-camera overlap and is more likely to record partial meteor trails.

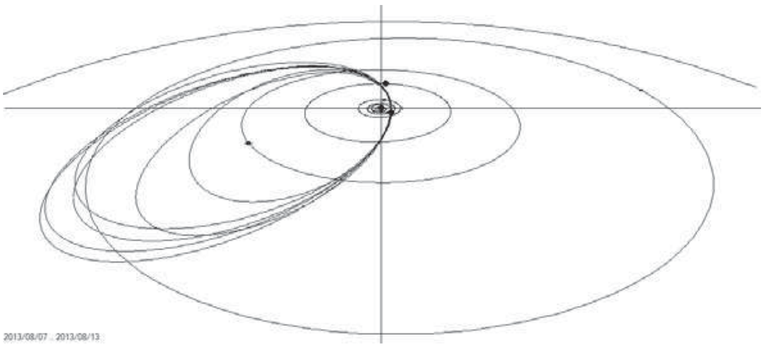

Figure 6. Solar system diagram computed from the orbits of 6 2013 Perseids.

Acknowledgments

The authors thank Dr John Mason and Nick James for their constructive comments on a first draft of this paper.

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

References

1 **http://www.nemetode.org/**
2 Pratt A. R., Stewart W. & Entwisle L, 'Perseids 2012 – Multi-station meteor videography', *J. Brit. Astron. Assoc.*, **123**(3), 157–159 (2013)
3 **http://imo.net/calendar/2013#per**
4 Mason J. W. & Sharp I. D., 'The Perseid meteor stream, 1980', *J. Brit. Astron. Assoc.*, **91**(4), 383, 390 (1981)
5 **http://www.amsmeteors.org/2013/02/2013-meteor-shower-list/**
6 BAA *Handbook* 2013, 98 (from NASA SP-319, pp. 185–186, 1973)
7 **http://tinyurl.com/ohlzu88**
8 SonotaCo, 'A meteor shower catalog based on video observations in 2007–2008', *WGN*, **37**:2, 59 (2009)
9 **http://ssd.jpl.nasa.gov/sbdb.cgi?sstr=109P**
10 **http://tinyurl.com/qam7r2w**

Received 2014 May 04; accepted 2014 September 03

Table 4. Orbital elements of 6 Perseid meteors, IAU MDC shower data and parent comet 109P/Swift–Tuttle *(NASA JPL HORIZONS)*

	Solar long.	Abs mag	Vg	a (AU)	q (AU)	e	p	Peri	Node	Incl
	135.417053	–2.3	59.3	60.725	0.951	0.984	473.399	150.989	135.417	112.691
	138.266235	–1.9	58.7	24.088	0.944	0.961	118.273	149.422	138.266	111.502
	140.122955	–2.3	59.7	33.518	0.966	0.971	194.133	154.969	140.123	113.077
	140.198029	–2.2	57.6	15.661	0.960	0.939	62.003	153.191	140.198	108.618
	140.249496	–3.7	59.6	32.903	0.957	0.971	188.814	152.660	140.249	113.777
	140.344940	–3.2	59.7	39.728	0.957	0.976	250.503	152.481	140.345	114.049
Mean	139.1		59.1	34.437	0.956	0.967	214.521	152.285	139.100	112.286
Std. dev.			0.8	15.375	0.008	0.016	142.769	1.902	1.969	2.009
IAU MDC[7]	140.19		59.38	71.4	0.953	0.960		151.3	140.19	113.22
Comet 109P/Swift–Tuttle[9]				26.092	0.960	0.963	133.28	152.982	139.381	113.454