Short paper

# Taurids 2012 – Dual-station meteor videography

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NEMETODE, a network of low-light video cameras between Cheshire and West Yorkshire, monitors the activity of meteor showers, enabling precise measurement of radiant positions and, from the best quality data, the altitudes and geocentric velocities of meteors and their solar system orbits. The results from dual-station observations of the 2012 Taurid showers are presented and discussed.

## Equipment and methods

NEMETODE members William Stewart (WS) and Alex R. Pratt (ARP) employed the same equipment and methods as described in their paper on the 2012 Perseids[1] and on the NEMETODE website.[2]

## Taurid meteor streams

The Taurids are categorised as two streams, Southern Taurids (0002 STA), active from early September to late November, and Northern Taurids (0017 NTA), active from late October to early December, with low ZHRs of 5 at maximum.[3] The Taurids' parent body is traditionally listed as comet 2P/Encke, although recent work suggests that they are also associated with a number of Apollo asteroids and perhaps other Near Earth Objects (NEOs) that are members of the Taurid complex.[4]

## NEMETODE results

The first and last probable STA candidates were recorded on 2012 Sept 11/12 (Ravensmoor East and North) and Dec 29/30 (Ravensmoor East). The respective dates of the NTA candidates were Oct 5/6 (RM E) and Dec 15/16 (RM N).

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

### Dual-station Taurids

*UFO Orbit* supports three built-in quality assurance criteria:

Q1 – minimum criteria for radiant computation

**Table 1. Magnitude distribution of the Taurid meteors**

| *Absolute Mag:* | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | Sum | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Southern Taurids** | | | | | | | | | | | | |
| Leeds | 0 | 0 | 0 | 0 | 2 | 8 | 5 | 2 | 0 | 0 | 17 | −0.6 |
| Ravensmoor East | 0 | 0 | 1 | 0 | 5 | 5 | 8 | 17 | 6 | 0 | 42 | 0.2 |
| Ravensmoor North | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 13 | 15 | 3 | 37 | 1.4 |
| **Northern Taurids** | | | | | | | | | | | | |
| Leeds | 0 | 1 | 1 | 1 | 2 | 4 | 14 | 9 | 0 | 0 | 32 | −0.3 |
| Ravensmoor East | 0 | 0 | 0 | 2 | 1 | 4 | 9 | 20 | 6 | 0 | 42 | 0.5 |
| Ravensmoor North | 1 | 0 | 0 | 0 | 0 | 1 | 3 | 13 | 7 | 2 | 27 | 1 |

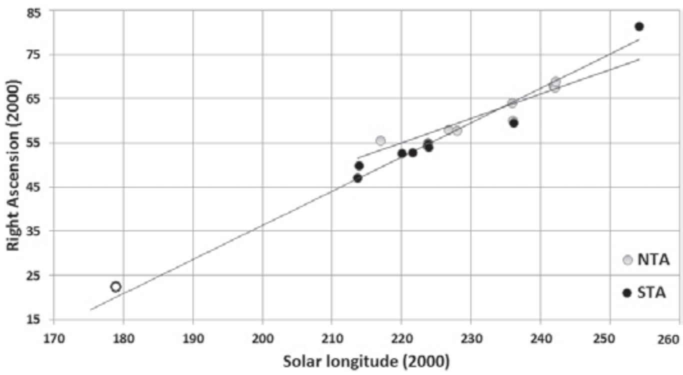


**Figure 1.** Taurids' radiant drift in right ascension.

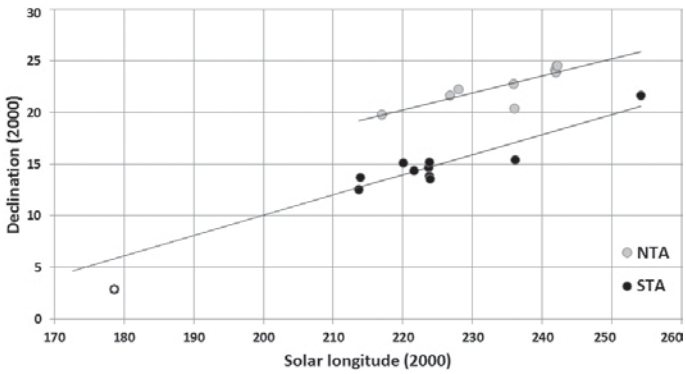


**Figure 2.** Taurids radiant drift in declination.

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 2012 Oct 26/27 and Dec 5/6 a total of 10 Q1-level dual-station STA meteors were recorded, with 9 Q1 NTA meteors captured between Oct 29/30 and Nov 23/24. In addition, an STA outlier was recorded on 2012 Sep 21/22 – this is discussed later.

### Radiant drift

*UFO Orbit* was used to derive the radiant point for each dual-station Taurid, corrected for zenith attraction. These were used to estimate the daily drift in right ascension and declination of the STA and NTA radiants.

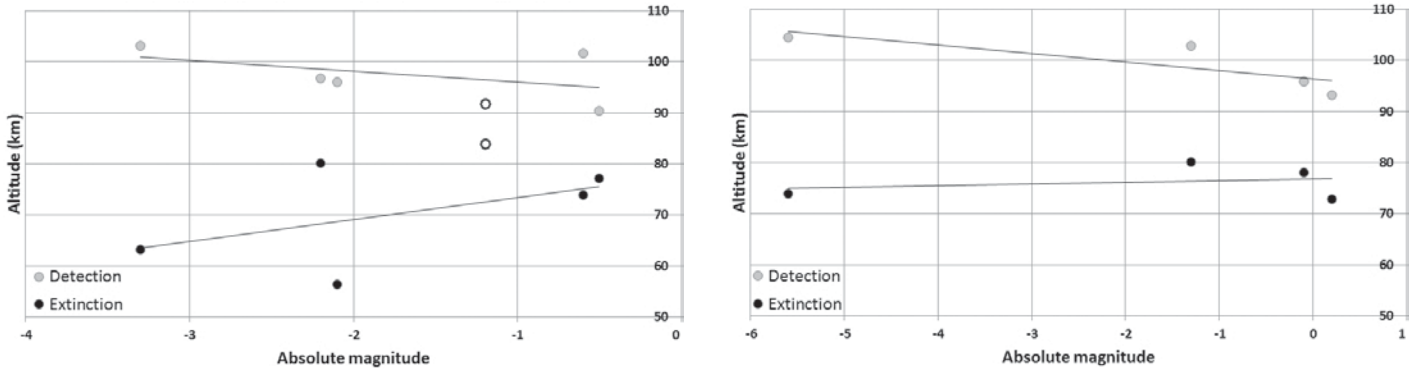


**Figure 3.** Detection and extinction altitudes of Taurid meteors. *Left:* Southern Taurids; *right:* Northern Taurids.

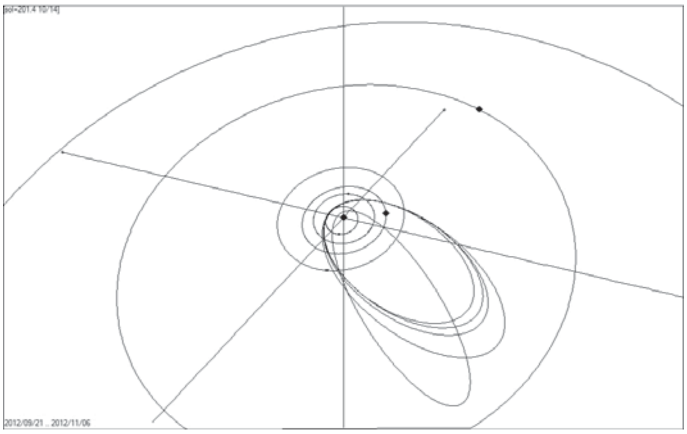

**Figure 4a.** Polar view of the unified orbits: Southern Taurids.

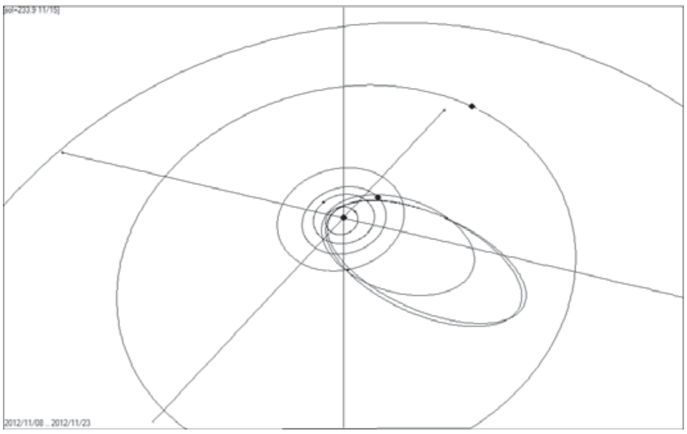

**Figure 4b.** Polar view of the unified orbits: Northern Taurids.

**Table 2. The position of the Taurids' radiants at maximum and their daily motion.**

| | *Solar long.(°)* | *RA(°)* | *RA* | *dRA(°)* | *Dec(°)* | *dDec(°)* |
|---|---|---|---|---|---|---|
| **Southern Taurids (STA)** | | | | | | |
| NEMETODE | 223 | 54.2 | 3h 37m | 0.78 | 14.6 | 0.20 |
| *HBAA*[5] | 223 | 56 | 3h 44m | 0.79 | 14 | 0.15 |
| IAU MDC[6] | 224 | 49.4 | 3h 18m | 0.73 | 13 | 0.18 |
| IMO[7] | 201 | 35.7 | 2h 23m | 0.74 | 8.8 | 0.18 |
| SonotaCo[8] | 219.7 | 50.1 | 3h 20m | 0.73 | 13.4 | 0.16 |
| **Northern Taurids (NTA)** | | | | | | |
| NEMETODE | 230 | 60.6 | 4h 02m | 0.55 | 21.9 | 0.17 |
| *HBAA*[5] | 230 | 56 | 3h 44m | 0.76 | 22 | 0.10 |
| IAU MDC[9] | 224 | 58.6 | 3h 54m | 0.80 | 21.6 | 0.16 |
| IMO[7] | 229 | 58.4 | 3h 54m | 0.82 | 22.4 | 0.15 |
| SonotaCo[8] | 234.4 | 62.0 | 4h 08m | 0.65 | 24.0 | 0.12 |

The method of least squares gives the linear fits:

(STA) $RA = 0.778 * \lambda_{solar} - 119.31$ $r = 0.974$
(NTA) $RA = 0.554 * \lambda_{solar} - 66.82$ $r = 0.938$
(STA) $Dec = 0.196 * \lambda_{solar} - 29.071$ $r = 0.923$
(NTA) $Dec = 0.166 * \lambda_{solar} - 16.275$ $r = 0.830$

where $\lambda_{solar}$ = solar longitude (°) and r is the correlation coefficient.

The STA outlier is shown in Figures 1 and 2 (open circle) at solar longitude 179° but has not been included in calculating the least squares fits.

If we assume that the maxima of the STA and NTA streams occurred at solar longitudes 223°.0 and 230°.0 respectively,[5] the estimated values of RA and Dec, and daily motion in RA (dRA°) and Dec (dDec°) are presented in Table 2 for comparison with other sources.

## Detection and extinction altitudes

For the small number of Q2 events, 5 STA meteors (2012 Nov 3/4 to 5/6) and 4 NTA meteors (Nov 8/9 to 23/24), *UFO Orbit* computed the detection and extinction altitudes, and absolute magnitudes. (See Figure 3). (Note: Absolute magnitude is the magnitude the meteor would have if it was in the zenith, 100km above the observer.)

The STA outlier is marked by open circles.

The limited dataset indicates that bright Taurids become visible at about 100km altitude and are extinguished at about 70km.

## Geocentric velocities

*UFO Orbit* determined the geocentric velocities (Vg) of the 5 STA and 4 NTA Q2-level meteors, which gave the following results:

(STA) Mean 28.0 km/s Standard deviation 0.5 km/s
(NTA) Mean 27.0 km/s Standard deviation 3.0 km/s

These are compared with other sources in Table 3.

**Table 3. Geocentric velocities of the Q2 Taurid meteors.**

| | *Vg (km/s)* |
|---|---|
| **Southern Taurids** | |
| NEMETODE | 28.0 |
| IAU MDC[6] | 28 |
| IMO[7] | 29.1 |
| SonotaCo[8] | 27.2 |
| **Northern Taurids** | |
| NEMETODE | 27.0 |
| IAU MDC[9] | 28.3 |
| IMO[7] | 29.3 |
| SonotaCo[8] | 26.7 |

## Orbits

*UFO Orbit* derived the Q3 orbital elements of 4 STA meteors (Nov 5/6) and 3 NTA meteors (Nov 8/9 to 23/24). For each pair of observations it calculated two orbits and a Unified orbit; the latter are given in Table 4.

The STA outlier is highlighted in red. It was originally classified as a Southern Taurid, but its orbital parameters are dissimilar to the STA stream and its Vg of 36.4 km/s is rather high.

The brightest Q3 Northern Taurid (absolute magnitude −5.6) was one of our most spectacular dual-station captures to date. Still images and videos of this fireball are posted on our website.[12]

A polar view of the Unified orbits is displayed in Figure 4.

The STA outlier is shown in Figure 4 with the 4 STA meteors, which all occurred about six weeks later.

**Table 4. Orbital elements of the Q3 Taurid meteors.**

| | Solar long. | Abs mag | Vg | a (au) | q (au) | e | p | Peri | Node | Incl |
|---|---|---|---|---|---|---|---|---|---|---|
| *STA outlier* | | | | | | | | | | |
| | 179.154282 | −1.1 | 36.4 | 2.326 | 0.146 | 0.937 | 3.550 | 140.023 | 359.155 | 13.735 |
| *Southern Taurids* | | | | | | | | | | |
| | 223.714508 | −0.6 | 28.0 | 2.081 | 0.362 | 0.826 | 3.003 | 113.776 | 43.714 | 5.241 |
| | 223.844910 | −2.1 | 27.3 | 1.911 | 0.366 | 0.808 | 2.642 | 114.248 | 43.845 | 6.145 |
| | 223.848572 | −3.3 | 27.8 | 2.004 | 0.359 | 0.821 | 2.838 | 114.502 | 43.848 | 4.765 |
| | 223.918991 | −2.2 | 28.3 | 2.318 | 0.372 | 0.840 | 3.531 | 111.682 | 43.919 | 6.269 |
| Mean | | | 27.9 | 2.078 | 0.365 | 0.824 | 3.004 | 113.552 | 43.831 | 5.605 |
| Std. dev. | | | 0.4 | 0.174 | 0.005 | 0.013 | 0.382 | 1.282 | 0.085 | 0.723 |
| IAU MDC[6] | | | 28 | 2.07 | 0.352 | | | 115.4 | 37.3 | 5.4 |
| 2P/Encke[10] | | | | 2.215 | 0.336 | 0.848 | 3.30 | 186.536 | 334.574 | 11.779 |
| *Northern Taurids* | | | | | | | | | | |
| | 226.808731 | −5.6 | 30.0 | 2.303 | 0.315 | 0.863 | 3.496 | 298.196 | 226.810 | 2.002 |
| | 227.989014 | −1.3 | 29.2 | 2.295 | 0.340 | 0.852 | 3.477 | 295.294 | 227.989 | 2.659 |
| | 241.780609 | −0.1 | 24.1 | 1.792 | 0.452 | 0.748 | 2.400 | 285.510 | 241.774 | 1.909 |
| Mean | | | 27.8 | 2.130 | 0.369 | 0.821 | 3.125 | 293.000 | 232.191 | 2.190 |
| Std. dev. | | | 3.2 | 0.292 | 0.073 | 0.064 | 0.627 | 6.647 | 8.320 | 0.409 |
| IAU MDC[9] | | | 28.3 | 2.12 | 0.350 | | | 294.9 | 226.2 | 3.1 |
| 2004 TG10[11] | | | | 2.234 | 0.309 | 0.862 | 3.34 | 317.272 | 205.176 | 4.175 |

## Conclusions

The Taurid meteor streams are active for 3 months, although having low ZHRs they do not usually display a clear peak, which is shown by the range of values in Table 2. The NEMETODE cameras recorded four Q3 STA meteors on 2012 Nov 5/6 (solar longitude 223°.8), but no peak activity in NTA events was detected.

Taurids are relatively slow meteors and 9% of the STA and NTA events were magnitude −2 or brighter, which could give the impression of fireballs. They are not normally ‘a rich fireball source’ (Table 1), though in some years they do produce fireball swarms[13,14] and hence justify ongoing observation.

The low values of Vg allowed useful orbital data to be obtained, although only a small number of dual-station events were recorded. Figure 2 shows a clear distinction between the Northern and Southern streams. There is good agreement between the orbital elements of the Q3 Taurid meteors, the IAU MDC data and the orbits of comet 2P/Encke and asteroid 2004 TG10 (Table 4).

The authors suggest that each shower’s value of Vg be included in the BAA *Handbook* Meteor Diary. We have insufficient data to recommend changes to the Taurids data in the *Handbook*, apart from that the ‘Normal Limits’ should be expanded to ‘Sep–Dec’. NEMETODE now has additional cameras with an increased overlap of their fields of view and extra quality checks are in place. We look forward to capturing additional data during the 2013 campaign.

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## References

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