Ursid 2014 observations using the AMOS all-sky camera

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We present a report on the observation of enhanced activity from the Ursids meteor shower using the all-sky camera, at the AGO Modra, on Dec. 22–23, 2014. The time of maximum is in good accordance with the predictions of some authors. We derived a single-station meteor radiant, RA = 217.9° ± 0.1°, DEC = +76.4° ± 0.1° at solar longitude $\lambda_{\odot}$ = 270.9°, along with the activity profile of the Ursid outburst with the maximum occurring at Dec. 23th, 00^{h}40^{m} UT ± 30 min.

1 Introduction

The Ursid meteor shower (URS, 15 in the IAU MDC; before Ursids Minorids, or Tuttleids) is known for a long time as a regular annual meteor shower. Due to frequent poor weather conditions at the end of December its parameters are poorly known. A serious effort within the field of video/TV observing during last two decades observed/captured many Ursid meteors, leading to more accurately known orbits and thus providing new insight into the nature of the meteor shower. The activity profile and rates were also determined. A resonant structure in the Ursid meteoroid swarm was recognized, based on visual, forward-scatter and (at a later date) video/TV observations. As a result, Lyytinen (in Jenniskens, 2006) and some other authors (Vaubaillon[1]; Maslov, 2014) began to make forecasts for future returns of the Ursids, based on new methods/models (e.g. Vaubaillon 2002, 2004).

2 Predictions

For the year 2014 three very precise predictions for enhanced activity of Ursids were published. These are shown in *Table 1*, along with their authors and sources.

Table 1 – Predictions for Ursid activity in 2014.

Author	Time [UT]	Source
E. Lyytinen	Dec. 22, 23^{h}38^{m}	Jenniskens, 2006
M. Maslov	Dec. 22, 23^{h}54^{m}	Maslov, 2014
J. Vaubaillon	Dec. 23, 00^{h}40^{m}	McBeath, 2013

3 Parent body of the Ursids

The parent body of Ursids is the comet 8P/Tuttle (Near-Earth Object) which is described as a high-inclination, Jupiter family, periodic comet on a Halley-type orbit (*Figure 1*). Its recent orbital elements and other data are included in *Figure 2*. Very interesting close-encounters (past and future) with planets and nominal distances are listed in *Figure 3*. Important data about the nature of the comet body emerged from observations performed by the Arecibo radar facility during the latest relatively close approach in 2008 (at a distance of 0.25 AU from the Earth). Harmon et al. (2010) revealed a highly bifurcated shape for comet 8P/Tuttle, consistent with a contact binary (volume equal to the sum of 3 km and 4 km spheres).

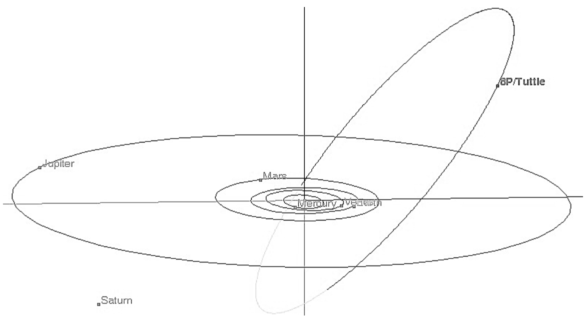
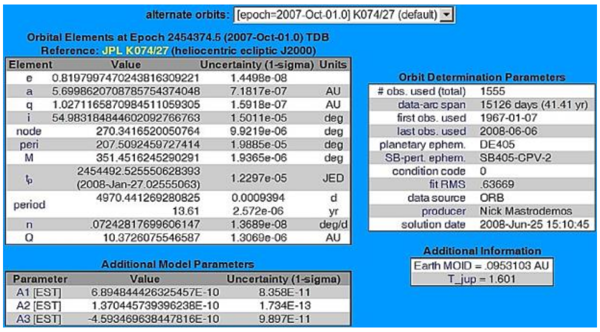


Figure 1 – Orbit of 8P/Tuttle (source: JPL Small-body Database Browser, JPL, CIT, 2015).



alternate orbits: [epoch=2007-Oct-01.0] K074/27 (default)

Orbital Elements at Epoch 2454374.5 (2007-Oct-01.0) TDB
Reference: JPL K074/27 (heliocentric ecliptic J2000)

Element	Value	Uncertainty (1-sigma)	Units
e	0.8197997470243816309221	1.4498e-08	
a	5.6998620708785754374048	7.1817e-07	AU
q	1.0271165870984511059305	1.5918e-07	AU
i	54.983184844602092766763	1.5011e-05	deg
node	270.3416520050764	9.9219e-06	deg
peri	207.5092459727414	1.9885e-05	deg
M	351.4516245290291	1.9365e-06	deg
t_p	2454492.525550628393 (2008-Jan-27.02555063)	1.2297e-05	JED
period	4970.441269280825	0.0009394	d
	13.61	2.572e-06	yr
n	.07242817699606147	1.3689e-08	deg/d
Q	10.3726075546587	1.3069e-06	AU

Orbit Determination Parameters

# obs. used (total)	1555
data-arc span	15126 days (41.41 yr)
first obs. used	1967-01-07
last obs. used	2008-06-06
planetary ephem.	DE405
SB-pert. ephem.	SB405-CPV-2
condition code	0
fit RMS	.63669
data source	ORB
producer	Nick Mastrodemos
solution date	2008-Jun-25 15:10:45

Additional Model Parameters

Parameter	Value	Uncertainty (1-sigma)
A1 [EST]	6.894844426325457E-10	8.358E-11
A2 [EST]	1.370445739396238E-10	1.734E-13
A3 [EST]	-4.593469638447816E-10	9.897E-11

Additional Information

Earth MOID = .0953103 AU
T_jup = 1.601

Figure 2 – Recent orbital elements for 8P/Tuttle (source: JPL Small-body Database Browser, JPL, CIT, 2015).

Date/Time (TDB)	Time Uncertainty (days_HH:MM)	Body	Nominal Distance (AU)
1900-Dec-29 05:39	00:01	Jupiter	0.825106857170657
1930-Feb-23 14:07	< 00:01	Saturn	1.87966865008731
1980-Dec-02 10:22	< 00:01	Earth	0.486911874428808
1995-Dec-28 21:42	< 00:01	Jupiter	0.785144270234247
2008-Jan-01 21:22	< 00:01	Earth	0.252827258824038
2048-Dec-28 10:59	< 00:01	Earth	0.175148033244741
2078-Sep-27 00:37	00:01	Jupiter	1.72668968329228
2107-Feb-09 12:04	00:03	Saturn	1.99833933373258
2130-Dec-25 20:55	00:04	Earth	0.0960562277870876
2173-Nov-10 16:13	00:09	Jupiter	0.716411169086229

Figure 3 – Close-encounters of 8P/Tuttle with planets (source: JPL Small-body Database Browser, JPL, CIT, 2015).

4 Observations

All-sky observations of the Ursid outburst were performed by the video system AMOS at the AGO in Modra on Dec. 22–23, 2014. The system AMOS is described by Zigo et al. (2013) and is able to capture

[1] http://www.imcce.fr/langues/en/ephemerides/phenomenes/meteor/DATABASE/Ursids/2014/index.php?char=shower&body=Earth&year=2014&shower=Ursids

meteors down to visual magnitude +3.5mag. The AMOS camera observed throughout the night and thus we recorded the whole of the Ursid outburst period. Images were captured using the widely used UFOCapture software[2]. Weather conditions were only moderate during the evening, but during the outburst the conditions improved (see composite image, *Figure 4*). At the AGO we captured 19 URS single-station meteors between 21^h20^m UT (Dec. 22) and 05^h35^m UT (Dec. 23). We attempted to derive the coordinates of the radiant, and also to establish the Ursid activity profile over the whole night. Data processing of the captured meteors was performed using the UFOAnalyzer software[1]. All back-projected atmospheric trajectories of URS meteors intersected in the radiant area, with the most dense zone defining the true central radiant point. For the 2014 Ursid meteor outburst, we were able to determine the single-station mean radiant to be R.A. = 217.9°±0.1°, Dec. = +76.4°±0.1°, for solar longitude $\lambda_\odot$ = 270.9° (*Figure 5*).

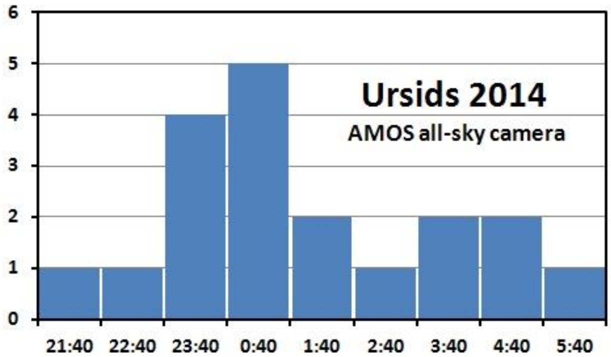


Figure 6 – A histogram, with one-hour bins, showing the Ursid activity changes around the outburst. The X-axis denotes the time in UT for Dec. 22–23, 2014. The Y-axis displays the numbers of observed Ursids.

Numbers of URS meteors (19) binned in 1 hour intervals were not corrected for either radiant elevation (due to its high declination and low change of elevation during the night) or for cloud cover (with small hourly counts this could badly influence and distort the real situation). Narrower or shifted bins are counterproductive with small numbers – they result in unacceptable fluctuations. The activity of the Ursid meteor shower during its outburst is shown in the histogram in *Figure 6*. Peak activity occurred after midnight Dec. 22–23, 2014 and we found it to be at 00^h40^m UT ±30 min. The post-midnight bar favors the prediction by Vaubaillon, while the pre-midnight bar is in good agreement with predictions by both Maslov (2014) and Lyytinen (Jenniskens, 2006). All preliminary results by other observers around the world also oscillate around these values. Brown (2014) reports a significant outburst maximum of Ursid meteors between Dec. $22^d23^h15^m$ and $23^d00^h45^m$ UT (activity full-width at half-maximum) observed by the CMOR facility. The apparent maximum occurred at Dec. 23^d00^h UT ($\lambda_\odot$ 270.85 ± 0.03 deg, equinox 2000.0). A total of 85 Ursid orbits were measured in this 1.5-hour period from a mean geocentric radiant of R.A. = 221°, Dec. = +75° with a geocentric velocity of 32 kms^{-1}.

[2] http://www.sonotaco.com

5 Results and perspectives

We determined the mean radiant of the Ursids from 19 single-station shower meteors that were observed by the all-sky camera at the AGO in Modra. The radiant coordinates were RA = 217.9° ±0.1°, DEC = +76.4° ±0.1° for solar longitude $\lambda_\odot$ = 270.9° (*Figure 5*). Radiants derived from multi-station meteor orbits are more reliable/correct, however. Currently, a calculation of the Ursid meteor radiant based on precise meteor orbits collected in the EDMOND data (Kornoš et al., 2013) is underway. We will be attempting to determine the scale (range) and scattering of the Ursid meteor stream within the Solar system space. Our all-sky, single-station video observations have provided an activity profile of the Ursids during the outburst on Dec. 22–23, 2014 with a rough time resolution (*Figure 6*).

Acknowledgment

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References

Brown P. (2014). “Ursid Meteors 2014”. CBET 4041, *CBAT IAU*, Cambridge, MA, U.S.A.

Harmon J. K., Nolan M. C., Giorgini J. D., Howell E. S. (2010). “Radar observations of 8P/Tuttle: A contact binary comet”. *Icarus*, **207**, 499–502.

Jenniskens P. (2006). *Meteor Showers and Their Parent Comets*, Cambridge Univ Press.

Kornoš L., Koukal J., Piffl R. and Tóth J. (2013). “Database of meteoroid orbits from several European video networks”. In Gyssens M. and Roggemans P., editors, *Proceedings of the International Meteor Conference*, La Palma, Canary Islands, Spain, 20-23 September 2012. IMO, pages 21–25.

Maslov M. (2014). Ursids 2014 – prediction of activity (in Russian)

McBeath A. (2013). 2014 Meteor Shower Calendar, IMO.

Vaubaillon J. (2002). “Activity level prediction for the 2002 Leonids”. *WGN, Journal of the IMO*, **30**, 144–148.

Vaubaillon J. (2004). Ph.D. Thesis, Observatoire de Paris, not published.

Zigo P., Tóth J. and Kalmančok D. (2013). “All-Sky Meteor Orbit System (AMOS)”. In Gyssens M. and Roggemans P., editors, *Proceedings of the International Meteor Conference*, La Palma, Canary Islands, Spain, 20-23 September 2012. IMO, pages 18–20.

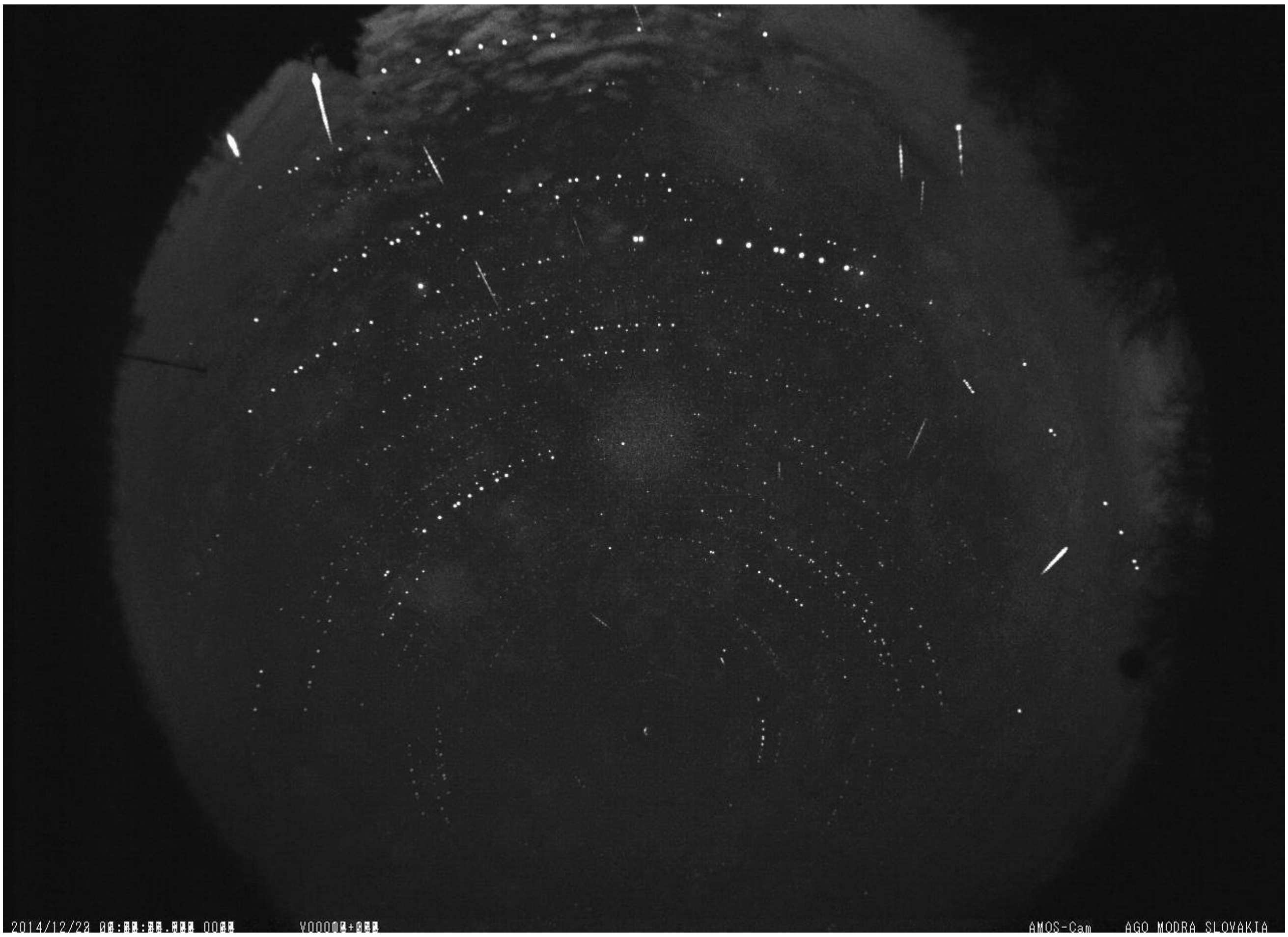

Figure 4 – The composite all-sky image from AMOS (North is down, East is right) of 14 selected Ursid meteors, recorded under favorable weather conditions (just some thin cloud near the horizon), from the night Dec. 22–23, 2014.

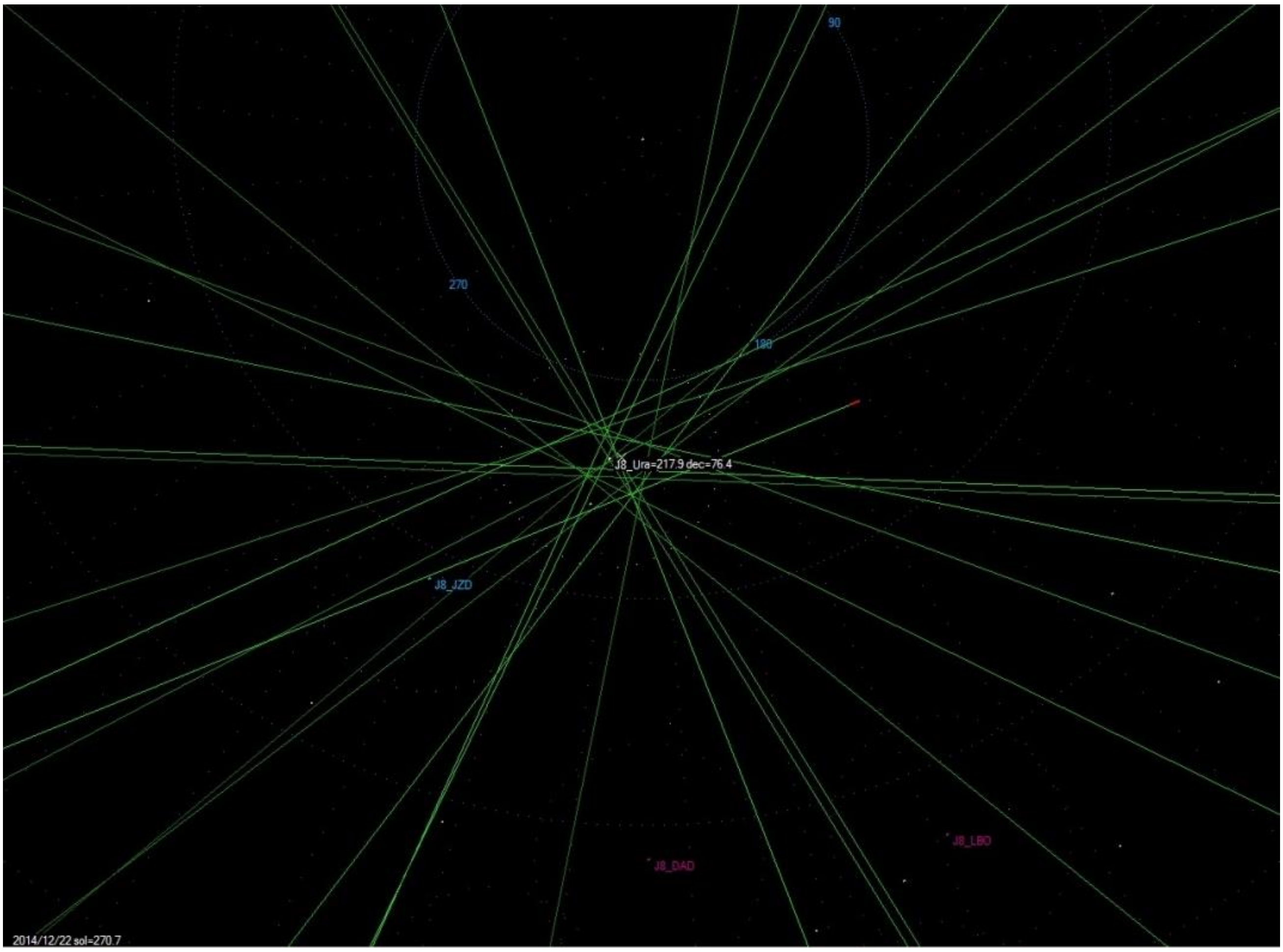

Figure 5 – Mean radiant position depicted by UFOAnalyzer from 19 Ursid meteors, recorded on Dec. 22–23, 2014.