Orbit and association of the 3 June 2004 fireball over Washington – an update

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Abstract – A new, slightly improved orbital solution is given, based on an improved method of calculation. In the revised result, the effect of diurnal aberration on the observed radiant position and observed speed has been taken into account: this was not taken into account in the initial result.

Introduction

This paper slightly improves on the orbital solution from my previous paper (author, this website). Unlike in the previous paper, the effect of Diurnal Aberration (the rotation of the earth around its polar axis) is now properly taken into account. A small error in the correction for zenith attraction has been corrected. The difference with the results communicated in the previous paper is small, yet this new result should be mathematically more "correct" (leaving aside questions on the accuracy of the trajectory and speed reconstruction).

1. Correction for Diurnal Aberration

Diurnal aberration works on two parameters: the radiant position, and the speed. The radiant position is slightly shifted by diurnal aberration, and the observed speed slightly increased or decreased (depending on circumstances). The influence on the speed can be up to 0.2-0.4 km/s, the shift in radiant position is usually very small but can attain some 2-3 degrees for slow meteors.
In the revised results, the observed radiant position (α, δ) has been corrected using equations from Lovell (1954):

$\Delta\alpha = -(26.58 / V_\infty) * \cos(\varphi) * \cos(H) * \sec(\delta)$
$\Delta\delta = -(26.58 / V_\infty) * \cos(\varphi) * \sin(H) * \sin(\delta)$

In which H is the hour angle of the apparent radiant and φ the geographic latitude. The values for Δ α, δ are added to the observed radiant position to obtain a corrected position. The observed radiant location (α, δ) and V_∞ were transformed into Vx, Vy, Vz components. The speed was then corrected for diurnal aberration by equation (34) from Ceplecha (1987):

$Vxc = Vx - V_E \cos(\alpha_E)$
$Vyc = Vy - V_E \sin(\alpha_E)$
$Vzc = Vz$

In which α_E is the RA of the east point (= the RA corresponding to azimuth 90°, altitude 0°) for the geographic location of the fireball (for equations, see Meeus 1991); and V_E is the speed of the earth surface at latitude φ, calculated with (Lovell 1954):

$V_E = 0.4639 * \cos(\varphi)$ km/s

Then:

$$Vc = \sqrt{(Vcx^2 + Vcy^2 + Vcz^2)}$$

And:

$$V_{geo} = \sqrt{(Vc^2 - 11.17^2)}$$

After correction for Diurnal Aberration, the radiant position has to be corrected for zenith attraction, which has been done by equation (Lovell 1954):

$$\tan(0.5\,\Delta za) = (V_\infty - V_{geo}) / (V_\infty + V_{geo}) * \tan(0.5\,Z)$$

In which *Z* is the zenith distance of the observed radiant, and Δ*za* the zenith attraction (in degrees).

2. Revised geocentric radiant and orbit

The difference between the revised result for the radiant position and the result previously reported is negligible. The revised geocentric speed however, is 0.25 km/s faster. This difference most notably works through in the aphelion distance *Q*, and the semi-major axis *a* and eccentricity *e*, and to some extend in the inclination *i*.

Table 1: revised radiant data

Apparent radiant:	**Geocentric radiant :**	**Heliocentric radiant:**
RA 214.2°	RA 207.1°	λ 166.5°
δ +49.4°	δ +46.7°	β 16.6°
V_∞ 17.9 km/s	V_{geo} 14.2 km/s	V_{helio} 39.4 km/s

Table 2: revised orbit

	q	**a**	**e**	**i**	**ω**	**Ω**	**Q**	**π**
New result	1.01	4.4	0.77	16.6	187.5	73.09	7.9	260.6
Previous result	1.01	4.3	0.76	16.3	187.5	73.09	7.6	260.6

Table 3: orbital comparison to comet 7P/Pons-Winnecke and June Bootid fireball EN 270698, using Drummonds' D' criterion (Drummond 1981).

Object	**q**	**e**	**i**	**ω**	**Ω**	**Q**	**π**	**D'**
3 June 2004 fireball	*1.01*	*0.77*	*16.6*	*187.5*	*73.09*	*7.9*	*260.6*	
7P/Pons-Winnecke (1915)	0.971	0.702	18.3	172.4	100.5	5.5	272.9	*0.089*
EN 270698	1.016	0.690	18.4	183.6	96.0	5.5	279.6	*0.104*

3. Conclusions and further remarks

With the orbit slightly revised, the conclusions nevertheless do not differ much from those of my previous paper (author, this website). The orbit suggests a cometary origin, and the orbit is similar to that of comet 7P/Pons-Winnecke and the June Bootid meteor stream.

The spreadsheet written for the conversion of the apparent radiant position and initial speed to the geocentric radiant position and speed, taking into account diurnal aberration and zenith attraction, can be found at URL: *http://marcolangbroek.tripod.com/metsoft.html*

The spreadsheet for obtaining the orbital elements from the geocentric radiant and speed can be found at the same URL.

Acknowledgement

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References

In addition to the references cited in my previous paper (author, this website):

- Lovell A.C.B. (1954): *Meteor Astronomy*. Clarendon press, Oxford.

- Meeus J. (1991): *Astronomical Algorithms*. Willman-Bell, Richmond.