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A Deep-penetrating Fireball associated with the Potentially Hazardous Asteroid 1979VA

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Abstract

We analyze a bright slow-moving fireball observed over the Iberian Peninsula on October 5, 2011. This deep-penetrating event, which lasted about 10 seconds, travelled over 100 km in the atmosphere and was simultaneously recorded from two meteor observing stations operating from Portugal and Spain. A thunder-like sound associated to this bolide was reported by numerous casual eyewitnesses. The orbit of the parent meteoroid is calculated and the possibility of meteorite survival is also discussed. By employing orbital dissimilarity criteria, we have found that the likely parent body of the meteoroid is the potentially hazardous asteroid 4015 Wilson-Harrington (1979VA).

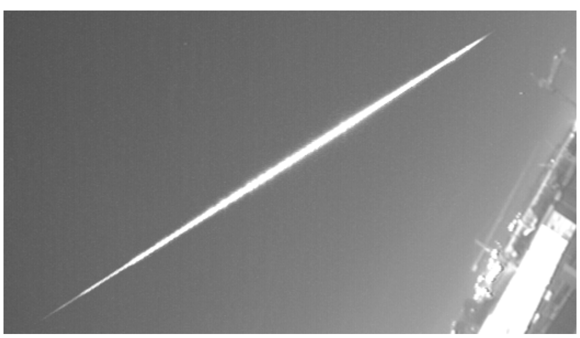

Figure 1: Composite image of the fireball as recorded from Sevilla.

1. Introduction

On October 5, 2011 a slow-moving fireball (Fig. 1) was witnessed over the Iberian Peninsula. Numerous casual observers could see the bolide from North to South Portugal and the South of Spain. Some of these also reported a thunder-like sound associated to this event. The bolide, which overflew the south of Portugal following the SW-NE direction, was imaged from two meteor observing stations in both countries. From these recordings we have calculated the atmospheric trajectory of the fireball, for which a non-zero terminal mass was inferred. The detailed circumstances of this event are presented and analyzed here. From this analysis, the heliocentric orbit of the parent meteoroid is also calculated. On the basis of orbital dissimilarity criteria, considerations about the likely parent body of the meteoroid are also made.

2. Instrumentation

The fireball was recorded from one station operated by the SPanish Meteor Network (SPMN) in Sevilla and also from a meteor observing station operated by the second author in Tomar (Portugal). The system at Sevilla employs an array of high-sensitivity monochrome CCD video cameras (models 902H and 902H2 Ultimate, from Watec Co.) to monitor the night sky [1, 2]. On the other hand, the meteor observing system operating at Tomar employs five low-lux CCD video cameras (models Mintron 12V6HC-EX / 12V1C-EX and Watec 902H2 Ultimate) named TEMPLAR1 to TEMPLAR5 and controlled by the METREC software [3].

3. Data reduction and results

The bolide was included in our database with the SPMN code 051011. This code was assigned after the recording date. Thus, the fireball was imaged on Oct. 5, 2011, at 19h48m09s ± 1s UTC. The analysis of the atmospheric trajectory was performed by means of the planes intersection method [4]. This reveals that the luminous phase began over Portugal at a height of 85.2±0.5 km above the ground level and ended at 31.9±0.5 km. The meteoroid struck the atmosphere with an initial velocity V_∞=13.9±0.3

km/s and the inclination of the trajectory with respect to the ground was of about 26º. The apparent radiant was located at α=273.12±0.01º, δ=-19.39±0.01º. The bolide lasted about 10 seconds and travelled around 112 km in the atmosphere. The radiant and orbital data are summarized in Tab. 1. At its brightest phase, the bolide reached an absolute magnitude of -9.5 ± 0.5. The progenitor meteoroid had an initial mass of 39 ± 4 kg.

Table 1: Radiant and orbital data (J2000).

Radiant data			
	Observed	**Geocentric**	**Heliocentric**
R.A. (º)	273.12±0.01	261.7±0.7	-
Dec. (º)	-19.39±0.01	-34.4±1.0	-
V_∞ (km/s)	13.9±0.3	8.5±0.4	37.8±0.5
Orbital parameters			
a (AU)	2.6±0.3	**ω (º)**	351.1±0.1
e	0.62±0.06	**Ω (º)**	12.05662 ± 10^{-4}
q (AU)	0.9953 ± 10^{-4}	**i (º)**	2.5±0.1

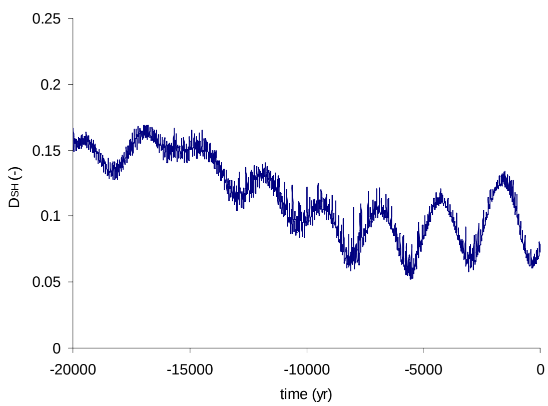

Figure 2. Evolution from present time of the D_{SH} criterion for NEO 1979VA and the orbit of the progenitor meteoroid.

In order to find the likely parent body of the progenitor meteoroid of the bolide we have employed the D_{SH} dissimilarity criterion [5]. The calculations were performed with the ORAS software [6]. As a result of this analysis, we have obtained a value of D_{SH} = 0.07 for NEO 1979VA. Then, the Mercury 6 symplectic integrator [7] was employed to perform a numerical integration backwards in time for 10,000 years of the orbit of the meteoroid and this NEO in order to determine whether their orbital evolution was similar. The resulting evolution of the dissimilarity function is shown in Fig. 2, which reveals that D_{SH} remains below or equal to the cut-off value of 0.15 during about 14,000 years, a period of time larger than the 5,000 years time scale required by Porubčan et al. [8]. This result strongly suggests a link between the fireballs and this PHA. In fact, we have also found a good correlation between the evolution over time of the orbital elements of 1979VA and those of the meteoroid.

6. Summary and Conclusions

At its brightest phase, the bolide reached an absolute magnitude of -9.5 ± 0.5. The fireball penetrated the atmosphere till a final height of 31.9 ± 0.5 km above the sea level. The progenitor meteoroid had an initial mass of 39 ± 4 kg. The heliocentric orbit of the meteoroid was computed. The orbital analysis performed by employing the Southworth and Hawkins dissimilarity function suggests that the parent body of this particle is the potentially hazardous asteroid 1979VA is the parent body of both meteoroids. According to our calculations, the orbits of the meteoroid and this NEO remain similar ($D_{SH} \leq 0.15$) over a time period of time of about 14,000 years.

Acknowledgements

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