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Large Meteoroids from the Potentially Hazardous Asteroid 2007LQ19

J.M. Madiedo (1,2), J.M. Trigo-Rodríguez (3), J.L. Ortiz (4), A.J. Castro-Tirado (4) and J. Cabrera-Caño (2)
(1) Facultad de Ciencias Experimentales. Universidad de Huelva, 21071 Huelva, Spain, (2) Facultad de Física, Universidad de Sevilla, Depto. de Física Atómica, Molecular y Nuclear, 41012 Sevilla, Spain. (3) Institute of Space Sciences (CSIC-IEEC), Campus UAB, Fac. Ciencias C5, 08193 Bellaterra, Barcelona, Spain, (4) Instituto de Astrofísica de Andalucía, CSIC, Apt. 3004, Camino Bajo de Huetor 50, 18080 Granada, Spain. (madiedo@uhu.es)

Abstract

We analyze here two very bright fireballs produced by the ablation in the atmosphere of two large meteoroids in 2009 and 2010. These deep-penetrating events were observed over Spain. The analysis of the emission spectrum imaged for one of these fireballs has provided the first clues about the chemical nature of the progenitor meteoroids. Considerations about the parent body of this stream are also made on the basis of orbital dissimilarity criteria.

Figure 1. Composite image of the SPMN050709 fireball imaged from Doñana.

1. Introduction

The standard way of linking meteoroids with a given comet or asteroid is through the similarity of their orbits. This technique is based on the calculation of the so-called dissimilarity function, which measures the "distance" between the orbit of the meteoroid and that of the potential parent. Recently, by using data obtained from the systematic monitoring of fireballs in the atmosphere, this approach has been employed by Madiedo et al. [1] to establish a link between the potentially hazardous asteroid 2008XM1 and the Northern χ-Orionid meteoroid stream. Using a similar methodology it has also been established that NEO 2012XJ112 is a likely source of large achondritic meteoroids impacting our planet [2]. In this context, we analyze here two bright and slow-moving fireballs recorded over the South of Spain in July 2009 and 2010. Their atmospheric trajectory, radiant, and orbital parameters are calculated, and their likely parent body is identified. Besides, the emission spectrum imaged for one of these events is discussed.

2. Instrumentation

Four meteor observing stations in the South of Spain recorded the bolides discussed here: Sevilla, Huelva, El Arenosillo and Doñana. These employ an array of automated Watec CCD video cameras (models 902H2 and 902H2 Ultimate). Their operation is explained in [3, 4]. For meteor spectroscopy we employed holographic diffraction gratings (1000 lines/mm) attached to some of these devices.

3. Data reduction and results

The bolides analyzed here were assigned the SPMN codes 050709 and 040710. They were imaged on 5 July 2009 at 4h15m29.4±0.1s UTC and 4 July 2010 at 23h16m01.9±0.1s UTC, respectively.

The mag. -9.0±0.5 SPMN050709 fireball (Fig. 1) was produced by a 23±2 kg meteoroid impacting the atmosphere with an initial velocity V_∞=17.7±0.3 km s^{-1}. Its luminous phase began at a height of 90.4±0.5 km above the sea level. The bolide disappeared from the field of view of the cameras when it was located at a height of 43.9 ± 0.5 km above the sea level, and the position of the terminal point, which of course was below this level, could not be established. On the other hand, the mag. 14.5±0.5 SPMN040710 bolide was produced by a 280 ± 25 kg meteoroid that struck the atmosphere with a velocity V_∞=18.5±0.4 km s^{-1}. The event began at a height of 96.6±0.5 km and ended at 42.1±0.5 km. Their radiant and orbital data, which show that the meteoroids are dynamically related, are shown in Tab. 1.

Table 1: Radiant and orbital data (J2000).

Radiant data SPMN050709			
	Observed	**Geocentric**	**Heliocentric**
R.A. (º)	259.7±0.3	250.9±0.4	-
Dec. (º)	30.8±0.1	25.6±0.2	-
V_∞ (km/s)	17.7±0.3	14.1±0.4	37.6±0.4
Orbital parameters SPMN050709			
a (AU)	2.68±0.12	**ω (º)**	209.4±0.2
e	0.640±0.018	**Ω (º)**	103.1582 ± 10^{-4}
q (AU)	0.965±0.001	**i (º)**	16.4±0.5
Radiant data SPMN040710			
	Observed	**Geocentric**	**Heliocentric**
R.A. (º)	256.4±0.1	253.8±0.1	-
Dec. (º)	30.8±0.1	30.1±0.1	-
V_∞ (km/s)	18.5±0.4	14.8±0.5	37.3±0.4
Orbital parameters SPMN040710			
a (AU)	2.51±0.17	**ω (º)**	210.0±0.1
e	0.617±0.027	**Ω (º)**	102.7158 ± 10^{-4}
q (AU)	0.964±0.001	**i (º)**	18.7±0.5

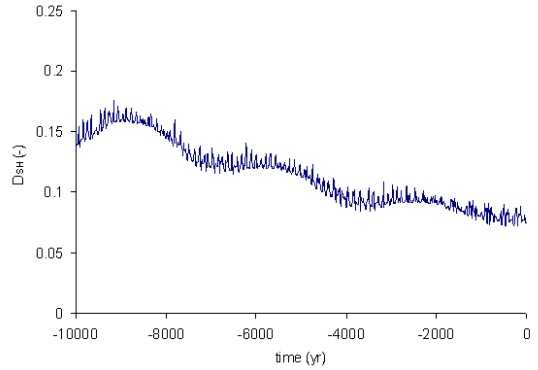

Figure 2. Evolution of D_{SH} for 2007LQ19 and the averaged orbit of the meteoroids.

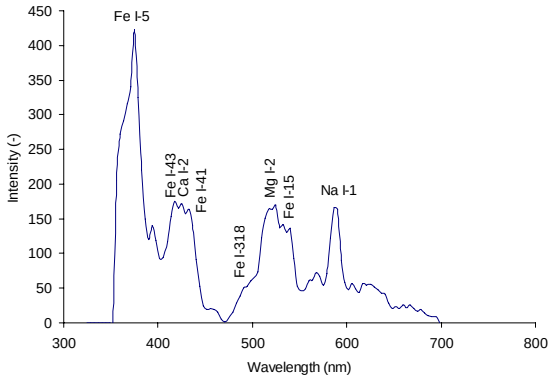

Figure 3. Calibrated emission spectrum of the SPMN050709 fireball.

We investigated the likely parent body of the meteoroids with the ORAS software. The Southworth and Hawkins dissimilarity criterion was used and the best result was obtained for NEO 2007LQ19. A numerical integration backwards in time with the orbit of this NEO was performed in order to test a link between them. These calculations were performed with the Mercury 6 symplectic integrator [5]. The gravitational influence of Venus, the Earth-Moon system, Mars, Jupiter and Saturn were taken into account for these calculations. The orbits were integrated back for 10,000 years. This analysis revealed (Fig. 2) that D_{SH} remains ≤0.15 during almost 80,000 years, confirming the dynamical link with the meteoroids.

On the other hand, the analysis of the emission spectrum imaged for the SPMN050709 fireball (Fig. 3) points towards a chondritic nature for these meteoroids.

6. Summary and Conclusions

The two fireballs analyzed here were deep-penetrating and slow-moving bright events. The calculated radiant and orbital parameters show that both meteoroids were dynamically related. The orbital analysis performed with the ORAS software by employing the Southworth and Hawkins dissimilarity function suggests that the potentially hazardous asteroid 2007LQ19 is the parent body of both meteoroids. Thus, the orbit of this NEO and the averaged orbit of both particles remain similar (with D_{SH}≤0.15) over a time period of almost 8,000 years. In addition, the analysis of the emission spectrum recorded for the SPMN050709 fireball indicates a chondritic nature for these meteoroids.

Acknowledgements

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