EPSC Abstracts
Vol. 8, EPSC2013-260, 2013
European Planetary Science Congress 2013
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Two Superbolides with a Cometary Origin Observed over the Iberian Peninsula

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Abstract

Here we present the analysis of two bright fireballs observed over Spain in the framework of our continuous fireball monitoring and meteor spectroscopy campaigns. The most luminous of these had an absolute magnitude of -18 and was recorded on Sep. 25, 2010. The second fireball, with an absolute magnitude of -17, took place on August 23, 2012 and was recorded together with its emission spectrum. Because of their extraordinary luminosity, both events fall into the superbolide category.

1. Introduction

The detailed study of bright fireball events is one of the aims of the SPanish Meteor Network (SPMN). These are produced by large meteoroids which are capable, under the right geometric conditions, of producing meteorites. One of the main goals of our meteor network is the analysis of the physico-chemical properties of these meteoroids, as a continuous monitoring of the night sky can provide useful data to improve our knowledge of the mechanisms that deliver these materials to the Earth. For this purpose we operate 25 meteor observing stations that provide useful data for the determination of radiant, orbital and photometric parameters [1,2]. Besides, we pay special attention to the study of the chemical composition of meteoroids from the analysis of the emission spectrum produced when these particles ablate in the atmosphere.

Here we present the analysis of two superbolides observed over the Iberian Peninsula. The most luminous of these events had an absolute magnitude of -18 and was recorded on Sep. 25, 2010. The second fireball, with an absolute magnitude of -17, took place on August 23, 2012.

2. Instrumentation

The observing stations that imaged the events discussed here operate an array of low-lux CCD video cameras manufactured by Watec Co. Their operation is explained in [2, 3]. For meteor spectroscopy we employed holographic diffraction gratings (1000 lines/mm) attached to some of these devices [1, 4].

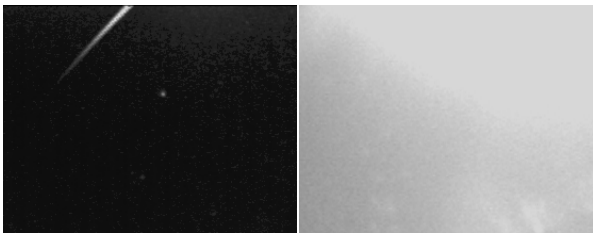

Figure 1. Composite image of the SPMN250910 "Sierra Nevada" fireball during its beginning (left) and maximum brightness phase (right).

3. Observations and results

On September 25, 2010 at 3h16m15.5±0.1s UTC, an extraordinary bolide (abs. mag. -18±0.5) was imaged next to the zenith of the Sierra Nevada Astronomical Observatory (Figure 1). The event was also recorded from Sevilla. The parent meteoroid, with a mass of about 26 kg, struck the atmosphere with an initial velocity V_∞=58.4±0.3 km/s. The "Sierra Nevada" fireball began at a height of 137.7±0.5 km and reached its maximum brightness when the bolide was located at 94.5±0.5 km above the ground level. The apparent radiant was located at α=126.6±0.4º, δ=58.2±0.3º. The orbital elements of the parent meteoroid (Table 2), which was following a short-period comet orbit, confirmed the sporadic nature of this event.

On the other hand, the "Valencia de las Torres" bolide (abs. mag. -17±0.5) was imaged on August 23, 2012 at 22h45m55.1±0.1s UTC (Figure 2) from our meteor stations located at La Hita, Sevilla, El Arenosillo, Madrid, Villaverde del Ducado and Huelva. Its emission spectrum was also recorded. The meteoroid struck the atmosphere with an initial velocity V_∞=24.8±0.3 km/s and a mass of around 184 kg. The apparent radiant was located at α=311.7±0.5º, δ=-0.6±0.4º. The fireball began at a height of 133.5±0.5 km and ended at 87.4±0.5 km over the ground level. The orbital elements (Table 2) confirmed the sporadic origin of this event and the cometary nature of the meteoroid, which was following a long-period comet orbit before impacting the atmosphere.

Figure 2. Composite image of the SPMN230812 "Valencia de las Torres" event recorded from Sevilla.

Table 1: Radiant (J2000) and trajectory data.

SPMN Code	M_v	H_b (km)	H_e (km)	α_g (º)	δ_g (º)	V_∞ (km s^{-1})	V_g (km s^{-1})	V_h (km s^{-1})
250910	-18	137.7	94.5	126.9	58.3	58.4	57.1	40.6
	±1	±0.5	±0.5	±0.4	±0.3	±0.3	±0.3	±0.3
230812	-17	133.5	87.4	311.7	-0.6	24.8	22.2	41.7
	±1	±0.5	±0.5	±0.5	±0.4	±0.3	±0.3	±0.3

Table 2: Orbital data (J2000).

SPMN Code	a (AU)	e	i (º)	Ω (º)	ω (º)	q (AU)	T_J
250910	7.5	0.88	108.9	181.8132	130	0.834	0.34
	±0.9	±0.02	±0.4	±10^{-4}	±1	±0.006	±0.03
230812	83	0.99	10.1	151.0113	239.8	0.760	1.1
	±8	±0.01	±0.2	±10^{-4}	±0.4	±0.003	±0.2

6. Summary and Conclusions

The events analyzed here fall within the superbolide category. The calculated radiant and orbital parameters confirm the sporadic nature of both events and the likely cometary origin of both meteoroids. The "Sierra Nevada" meteoroid followed a retrograde short-period comet orbit before impacting the atmosphere. The "Valencia de las Torres" meteoroid, however, would have followed a long period comet orbit. The derived chemical ratios support that the meteoroid had a composition different to carbonaceous chondrites, and roughly similar to the rock-forming elements of comet 1P/Halley.

Acknowledgements

We thank *Fundación AstroHita* for its support in the establishment and operation of the automated meteor observing station located at La Hita Astronomical Observatory (La Puebla de Almoradiel, Toledo, Spain). We also acknowledge support from the Spanish Ministry of Science and Innovation (project AYA2011-26522) and Junta de Andalucía (project P09-FQM-4555).

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