A SUPERBOLIDE RECORDED OVER SPAIN ON JULY 13, 2012. J.M. Madiedo[1, 2], J.M. Trigo-Rodríguez[3], J. Zamorano[4], A. Sánchez de Miguel[4], F. Ocaña[4], J. Izquierdo [4], J.L. Ortiz[5], A.J. Castro-Tirado[5], N. Morales[5], D. Galadí[6], E. de Guindos[6], J. Lacruz[7], F. Organero[8], L.A. Hernández[8], F. Fonseca[8], M. Tapia[9] and J. Cabrera[2]. [1]Facultad de Ciencias Experimentales, Universidad de Huelva, Avda. de las Fuerzas Armadas S/N. 21071 Huelva, Spain. [2]Depto. de Física Atómica, Molecular y Nuclear, Facultad de Física, Universidad de Sevilla, 41012 Sevilla, Spain, madiedo@uhu.es. [3]Institute of Space Sciences (CSIC-IEEC). Campus UAB, Facultat de Ciències, Torre C5-p2. 08193 Bellaterra, Spain. [4]Depto. de Astrofísica y CC. de la Atmósfera, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, 28040 Madrid, Spain. [5]Instituto de Astrofísica de Andalucía, CSIC, Apt. 3004, 18080 Granada, Spain. [6]Centro Astronómico Hispano-Alemán, Calar Alto (CSIC-MPG), E-04004 Almería, Spain, [7]La Cañada Observatory (MPC J87), Ávila, Spain. [8]Observatorio Astronómico de La Hita, La Puebla de Almoradiel, Toledo, Spain. [9]Laboratori d'Estudis Geofísics Eduard Fontseré (LEGEF), IEC, Barcelona, Spain.

Introduction: One of the aims of the SPanish Meteor Network (SPMN) is the recovery and analysis of meteorites. So, we focus special attention on very bright fireballs, as under appropriate conditions these unusual events may give rise to meteorite falls. For this purpose we operate 25 meteor observing stations that monitor the night sky over Spain and neighbouring areas. These provide useful data for the determination of radiant, orbital, photometric and chemical parameters [1, 2, 3]. In this context, we present here the first results of the analysis of a superbolide observed over the Iberian Peninsula on July 13, 2012.

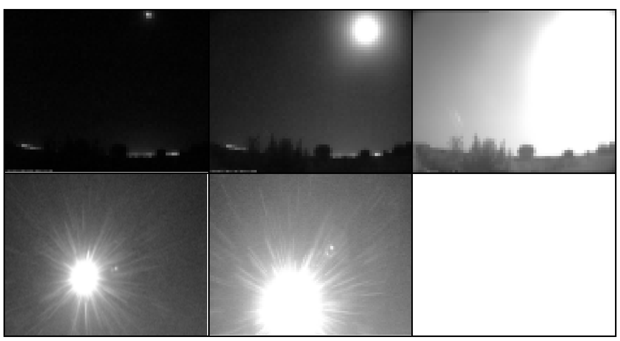

Figure 1. Selected video frames showing the initial phase, half position in the atmospheric path and maximum brightness of the fireball as imaged from La Hita Astronomical Observatory (top) and Madrid (bottom).

Figure 2. The SPMN130712 superbolide imaged from Calar Alto.

Instrumentation and data reduction methods: The fireball was imaged from seven SPMN meteor stations: Sevilla, La Hita, Huelva, El Arenosillo, Madrid, Villaverde del Ducado and Sierra Nevada (Fig. 1). It was also registered by a low-resolution camera from CAHA (Fig. 2). SPMN systems employ high-sensitivity CCD video devices (models 902H and 902H Ultimate, from Watec Co.) that provide 25 fps interlaced video sequences [1, 2]. Some of these are configured as spectrographs by attaching holographic diffraction gratings (1000 lines/mm) to the objective lens. To calculate the atmospheric trajectory, radiant and orbit we have employed our AMALTHEA software, which follows the planes intersection method [4]. The analysis of the emission spectrum was performed with our CHIMET application [5].

Radiant data			
	Observed	**Geocentric**	**Heliocentric**
R.A. (º)	261.5±0.5	257.3±0.5	-
Dec. (º)	37.6±0.4	36.4 ±0.4	-
V_∞ (km/s)	22.4±0.3	19.6±0.3	40.4±0.3
Orbital parameters			
a (AU)	7.8±0.5	**ω (º)**	203.5±0.3
e	0.87±0.02	**Ω (º)**	110.8413±10^{-4}
q (AU)	0.976±0.001	**i (º)**	25.1±0.3

Table 1. Radiant and orbital data (J2000).

The July 13, 2012 event: The bolide, which is included in our database with code SPMN130712, was recorded at 0h04m52.6±0.1s UTC. It was also witnessed by casual observers in different areas in the center and south of Spain. Some of these reported a strong thunder-like sound a few seconds later. According to our calculations, the parent meteoroid struck the atmosphere with an initial velocity V_∞=22.4±0.3 km/s. The fireball started its luminous path at 100.4±0.5 km above the ground level and reached its maximum brightness (absolute mag. -20±1) at a height of 36.7±0.5 km. The luminous phase ended at 35.4±0.5 km. The radiant position and orbital parameters are summarized in Table 1. The orbit of the meteoroid is plotted in Fig. 3. The light curve, obtained from the photometric analysis of the images, is shown in Fig. 4. As can be noticed, the fireball exhibited several bright flares along the second half of its atmospheric path. The aerodynamic pressure under which these flares took place was calculated in the usual way [6]. The result of this analysis is shown in Table 2. The last flare corresponds to the violent disruption of the meteoroid and, so, the corresponding pressure provides an estimation of the tensile strength of the particle [7].

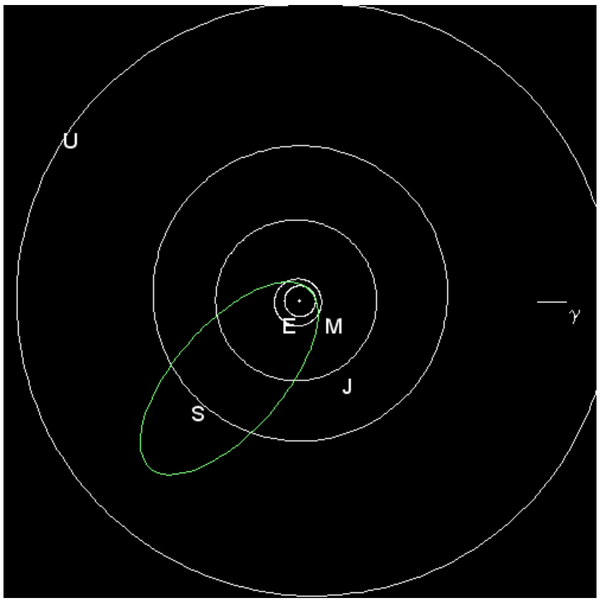

Figure 3. Projection on the ecliptic plane of the orbit of the parent meteoroid.

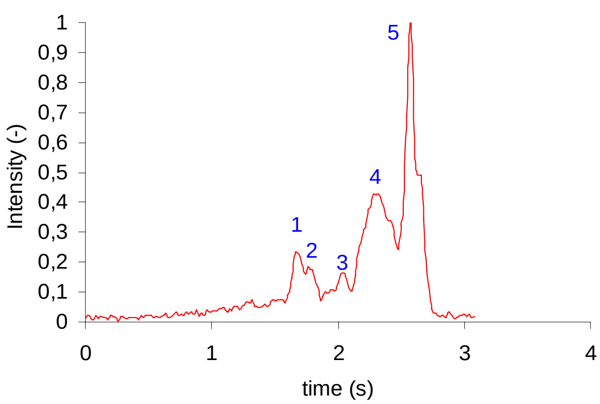

Figure 4. Light curve (relative intensity vs. time).

Flare #	Height (km)	Velocity (km/s)	Aerodynamic pressure (dyn/cm^2)
1	56±1	20.5±0.5	$1.9\pm0.6\cdot10^5$
2	55±1	20.5±0.5	$2.2\pm0.6\cdot10^5$
3	49±1	19.2±0.5	$4.6\pm0.6\cdot10^5$
4	45±1	18.6±0.5	$7.9\pm0.6\cdot10^5$
5	36±1	16.5±0.5	$2.9\pm0.6\cdot10^6$

Table 2. Aerodynamic pressure for flares and break-up processes highlighted in Figure 4.

Emission spectrum: Three spectrographs operating from La Hita, El Arenosillo and Villaverde del Ducado recorded the emission spectrum produced during the ablation of the parent meteoroid in the atmosphere. The calibrated signal is shown in Fig. 5. As can be seen, the spectrum is dominated by a strong emission from Mg I-2 (517.2 nm) and several Fe I multiplets: Fe I-41 (441.5 nm) and Fe I-15 (526.9 and 542.9 nm). In the ultraviolet, the intensity of H and K lines of ionized calcium is also strong. The contribution from Na I-1 is, however, small. The emission from atmospheric N_2 bands can also be noticed in the red region. Additional analyses are currently being performed to obtain the relative abundances of the different chemical species contained in the meteoroid.

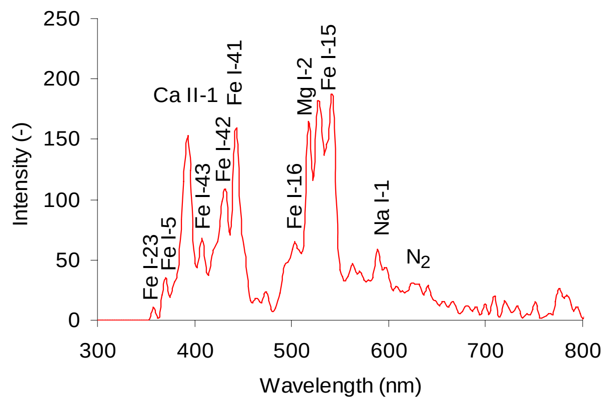

Figure 5. Calibrated emission spectrum.

Conclusions: Some preliminary results related to the analysis of a superbolide observed over Spain have been presented. Its atmospheric path and radiant were obtained and the orbit of the parent meteoroid was calculated. The emission spectrum indicates a depletion of sodium. The results support the existence of high-strength meteoroids in Jupiter Family Comets orbits. Although the terminal height seems to be too high for meteorite survival, several expeditions to the expected impact area were organized, although no meteorites were found.

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References: [1] Madiedo J.M. and Trigo-Rodríguez J.M. (2007) *EMP* 102, 133-139. [2] Madiedo J.M. et al. (2010) *Adv.in Astron* 2010 1-5. [3] Trigo-Rodriguez, et al. (2009) *MNRAS* 392, 367–375. [4] Ceplecha, Z. (1987) Bull. Astron. Inst. Cz. 38, 222-234. [5] Madiedo J.M. et al. (2012) *MNRAS*, submitted. [6] Bronshten V.A. (1981) *Geophysics and Astrophysics Monographs*. Reidel, Dordrecht. [7] Trigo-Rodríguez J.M. and Llorca J. (2006) *MNRAS*, 372, 655.