A 13 KG METEOROID FROM COMET 21P/GIACOBINI-ZINNER RECORDED AS A BOLIDE DURING THE 2011 DRACONID OUTBURST.

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Introduction: The parent body of the Draconid meteoroid stream is the short period comet 21P/Giacobini-Zinner. This cometary debris gives rise to an annual display of meteors from about October 6 to October 10, with a maximum activity around October 8. Although the Draconids is a minor meteor shower, sometimes it has produced brief but spectacular meteor storms. Two of these storms took place during last century, in 1933 and 1946 [1].

Several researchers predicted the encounter of Earth on October 8, 2011 with different dust trails ejected by comet 21P/Giacobini-Zinner in the late 19th and early 20th century. According to this, an outburst with an activity of several hundred meteors per hour was expected [2, 3]. The SPanish Meteor Network (SPMN) joined the international organised with the aim to study this outburst. Thus, some of the meteor observing stations operated by the SPMN setup additional high-sensitivity CCD video cameras in order to allow for a better coverage of this event. Besides, the Draconid meteoroids are known to be very fragile [2], and accurate data are fundamental in order to reach a better understanding about the physico-chemical properties of these particles. Thus, some of these cameras had attached holographic diffraction gratings (1000 lines/mm) in order to obtain the emission spectrum produced during the ablation of the Draconid meteoroids in the atmosphere. The moon, with a phase of about 91%, interfered with the observation, but despite this, multi-station meteors as faint as mag. +1/+2 could be recorded together with some fireballs. In this context, we present here the analysis of an extraordinarily bright Draconid event (mag. -10.5) recorded together with its spectrum during the 2011 Draconid outburst.

Methods: Three of the SPMN stations located in Andalusia were involved in the detection of the Draconid fireball considered here (Sevilla, Cerro Negro and El Arenosillo). They work in an autonomous way by means of proper software [4] and employ high-sensitivity 1/2" monochrome CCD video cameras (Watec Co., Japan). The station located in Cerro Negro operates a mobile meteor detection system from the province of Sevilla, in Spain. A detailed description of these devices has been done elsewhere [5, 6]. Most of the cameras operated with attached holographic diffraction gratings (1000 lines/mm) to obtain the emission spectra resulting from the ablation of meteoroids in the atmosphere. This provides chemical information about these particles of interplanetary matter [7, 8, 9, 10].

Results and discussion: The mag. -10.5±0.5 fireball analyzed here (code SPMN081011) was simultaneously recorded from three of our video meteor observing stations on October 8, 2011 at 19h47m59.3±0.1s UT (Fig. 1). The bolide was named "Lebrija", as it reached its maximum brightness next to the zenith of this city. The beginning of its luminous phase corresponded to a height of about 107.3 km above the ground level, with a terminal point located at a height of about 77.0 km. Its radiant and orbital parameters are shown on table I. The preatmospheric velocity calculated from the velocities measured at the beginning of the meteor trail was V_∞=23.3 ±0.3 km/s.

SPMN081011 "Lebrija"			
Radiant data			
	Observed	**Geocentric**	**Heliocentric**
R.A. (º)	269.7±0.1	264.1±0.2	-
Dec. (º)	55.1±0.1	54.6±0.1	-
Ecliptical longitude (º)	-	-	-77.99±0.04
Ecliptical latitude (º)	-	-	31.0±0.3
V_∞ (km/s)	23.3 ±0.3	20.6±0.3	39.2±0.3
Orbital data			
a (AU)	3.7±0.2	**ω (º)**	173.8±0.1
e	0.73 ±0.02	**Ω (º)**	195.1872 ± 10^{-4}
q (AU)	0.9967 ±0.0001	**i (º)**	31.0 ±0.3
Q (AU)	6.4±0.5		

Table 1. Radiant and orbital data (J2000) for the Draconid bolide described in the text.

The emission spectrum was obtained with one of the cameras operating from Cerrro Negro. It was calibrated in wavelengths by identifying typical metal lines (Ca, Fe, Mg and Na multiplets) and corrected by taking into account the efficiency of the instrument. The raw and processed spectrum are shown on Fig. 3. Most prominent lines correspond to Mg I-3 (382.9 nm), Fe I-20 (383.4 nm), Ca I-2 (422.6 nm), Fe I-41 (440.4 nm), Mg I-2 (516.7 nm) and Na I-1 (588.9 nm). A clear evolution of the emission spectrum with time can be noticed from Fig. 3. Further analysis is currently being performed in order to analyze how this spectrum evolved during the ablation process.

The fireball suffered a very bright flare at about 99.1 km over the ground level (Fig. 1), which corresponds to a velocity of about 22.5 km/s. With this information we can obtain the aerodynamic strength at which the particle suffered the break-up [11]. Taking into account the average atmospheric density from the US standard atmosphere [12] the aerodynamic strength yields $1.9 \pm 0.1 \times 10^2$dyn/cm^2.

On the other hand, the light curve (Fig. 3) was obtained from the photometric analysis of the video frames. The evolution of the brightness and velocity of the fireball vs height has been employed to infer the initial mass of the meteoroid by using the technique described in [13, 14]. In this way, the preatmospheric mass of the particle was estimated to be of about 13 kg. For a density of 2 g/cm^3 this yields a diameter for the meteoroid of about 23 cm.

Conclusions: We have monitored the Draconid storm on October 8, 2011. Fireball activity from this shower was observed during its maximum. We have analyzed here the brightest (mag. -10.5) Draconid fireball recorded by the SPMN during this outburst. Radiant and orbital data were obtained, together with the mass of the meteoroid and information about its chemical composition.

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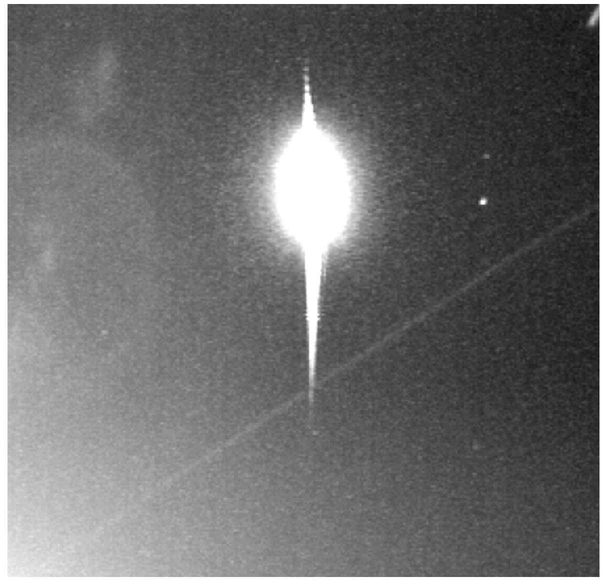

Figure 1. The Lebrija bolide (SPMN081011), with an absolute magnitude of –10.5±0.5, recorded from Sevilla.

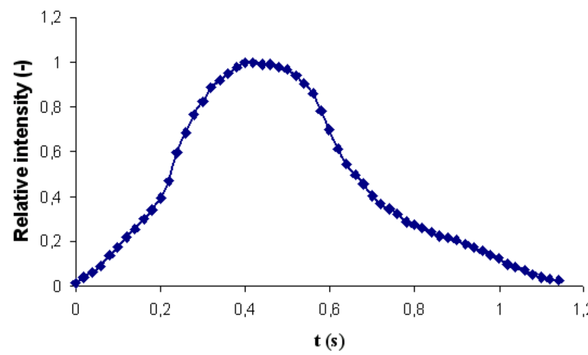

Figure 2. Light curve of the SPMN081011 Draconid fireball.

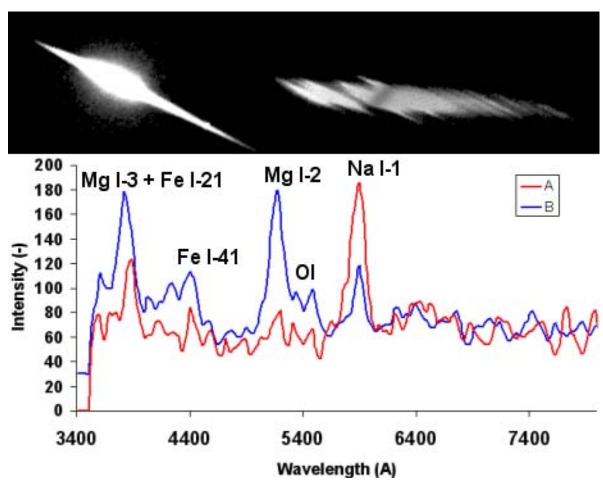

Figure 3. Raw and processed emission spectrum of the Lebrija fireball. A) Spectrum for t_0+ 0.12 s. B) Spectrum for t_0+ 0.62 s (t_0 is the instant of meteor apparition).