

**A METEORITE FALL OBSERVED IN THE FRAMEWORK OF THE SOUTHWESTERN EUROPE METEOR NETWORK (SWEMN).** M. Granados<sup>1</sup>, J.M. Madiedo<sup>2</sup>. <sup>1</sup>Observatorio Galileo, 41012 Sevilla, Spain. <sup>2</sup>Instituto de Astrofísica de Andalucía, CSIC, Apt. 3004, 18080 Granada (Spain).

**Introduction:** The atmosphere behaves as a very efficient shield that destroys most rocks that cross the Earth's path around the Sun before these materials reach the ground. Thus, when large meteoroids enter the Earth's atmosphere these produce bright fireballs during the so-called ablation process. Most meteoroids ablate completely, but some fireballs may produce, under favorable conditions, a non-zero terminal mass. In these rare cases the surviving materials reach the ground as meteorites [1, 2]. These are unique samples coming from other celestial bodies that may provide helpful information about the origin and evolution of our Solar System. For this reason, the analysis of potential meteorite-producing fireballs is one of the goals of our meteor network. For this purpose we are running the SMART project (Spectroscopy of Meteoroids in the Atmosphere by means of Robotic Technologies). This survey employs an array of automated spectrographs deployed at 10 meteor-observing stations in Spain [3, 4]. SMART also provides valuable information for our MIDAS project, which we conduct to study lunar impact flashes generated when large meteoroids hit the Moon [5-9]. With SMART we can determine the atmospheric trajectory of meteors and the orbit of their parent meteoroids, but also the evolution of the conditions in meteor plasmas from the emission spectrum produced by these events [10-17]. In this work we present a preliminary analysis of a meteorite-dropping bolide that overflowed the south of Spain on 28 January 2020.

**Instrumentation and methods:** To record the fireball analyzed here and its emission spectrum we have employed an array of low-lux CCD video cameras manufactured by Watec Co. (models 902H and 902H2 Ultimate). Some of these devices are configured as spectrographs by means of 1000 lines/mm diffraction gratings. CMOS color cameras were also employed [10]. These cameras monitor the night sky and operate in a fully autonomous way by means of software developed by J.M. Madiedo [3, 4]. The atmospheric trajectory and orbital data of the event were obtained with the Amalthea software, which was also written by the same researcher [11].

**The 28 January 2020 event:** The fireball discussed here was recorded on 28 January 2020 at 23h08m10.0±0.1s UT from our meteor-observing stations located at Calar Alto, Sevilla, and La Sagra (Figure 1). The peak luminosity of this event corresponded to an absolute stellar magnitude of  $-14 \pm 1$ , and its emis-

sion spectrum was also recorded from the meteor-observing stations located at Calar Alto and La Sagra.

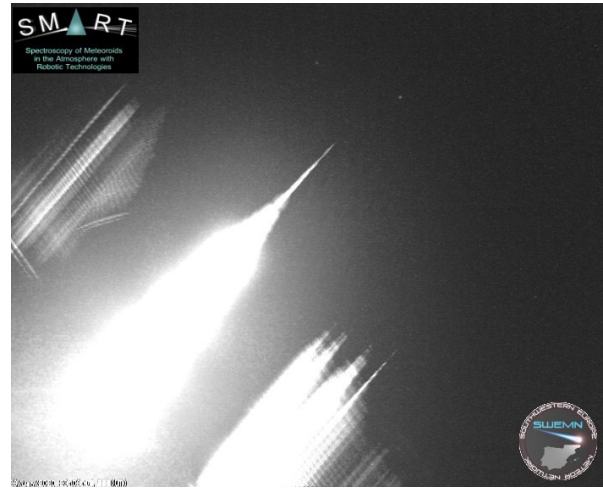


Figure 1. Sum-pixel image of the fireball discussed here, as recorded from the SWEMN meteor station located in Sevilla.

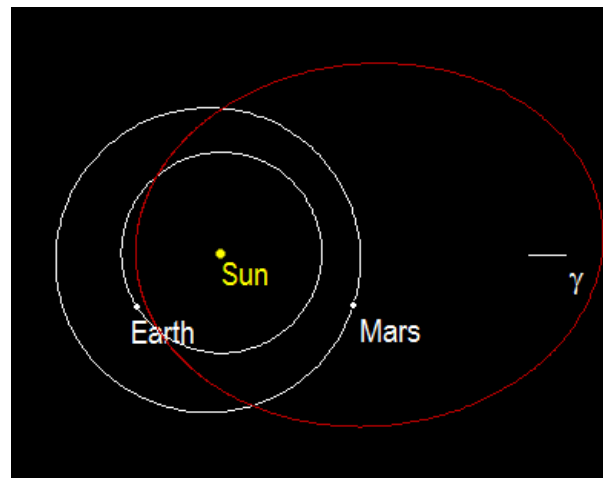


Figure 2. Projection on the ecliptic plane of the heliocentric orbit of the parent meteoroid of the fireball discussed in the text.

<b>a (AU)</b>	$2.3 \pm 0.1$	<b><math>\omega</math> (°)</b>	$48.1 \pm 0.1$
<b>e</b>	$0.63 \pm 0.01$	<b><math>\Omega</math> (°)</b>	$128.20126 \pm 10^{-5}$
<b>q (AU)</b>	$0.857 \pm 0.003$	<b>i (°)</b>	$8.0 \pm 0.1$

Table 1. Orbital data (J2000) of the progenitor meteoroid before its encounter with our planet.

**Atmospheric trajectory, radiant and orbit:** According to our analysis, the sporadic fireball started at an altitude  $H_b = 91.1 \pm 0.5$  km over the north of the prov-

ince of Cadiz (south of Spain). The meteoroid stroke the atmosphere with a velocity  $V_{\infty}=17.8\pm0.3$  km/s and the apparent radiant was located at the equatorial coordinates  $\alpha=107.00^\circ$ ,  $\delta=5.80^\circ$ . The bolide penetrated till a final height  $H_c=20.5\pm0.5$  km over the province of Sevilla. The orbital parameters of the parent meteoroid before its encounter with our planet are listed in Table 1. The projection on the ecliptic of this heliocentric orbit is shown in Figure 2. According to the value of the Tisserand parameter with respect to Jupiter ( $T_J=3.24$ ), the meteoroid followed an asteroidal orbit.

We have analyzed the terminal point of the luminous trajectory of this event. According to our results, the meteoroid was not completely destroyed in the atmosphere. Thus, a fragment with a mass of around 100 g survived the ablation process and landed as a meteorite in the province of Seville. An expedition was organized to find the specimen. However, flooding in the area where the stone fell complicated the search process, and the meteorite was not found.

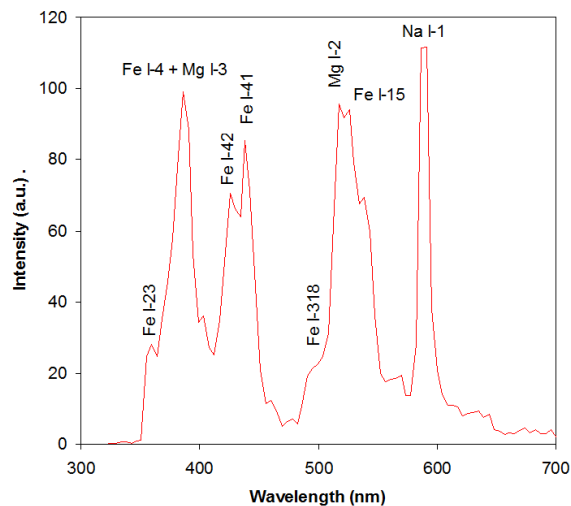


Figure 3. Emission spectrum of the fireball.

**Emission spectrum:** The emission spectrum of the fireball was recorded by means of two spectrographs operating in the framework of the SMART project. This spectrum is shown in Figure 3, where the most important contributions to the signal have been highlighted. As usual in meteor spectra, most lines identified in the spectrum correspond to neutral Fe [17-22]. Thus, as Figure 1 shows, several multiplets of this element have been identified. The emission lines of the Na I-1 doublet (588.9 nm) and the Mg I-2 triplet (516.7 nm) are very prominent. The detailed conditions in the meteor plasma are currently under analysis. For this purpose, the relative intensities of Mg I-2, Na I-2 and Fe I-15 will be compared, as has been done with

previous events [23-27]. This will provide an insight into the chemical nature of the progenitor meteoroid.

**Conclusions:** We have presented a preliminary analysis of a potential meteorite-dropping fireball that overflow the south of Spain on 2020 January 28. The atmospheric trajectory of the event was calculated, and the orbital elements of the meteoroid were obtained. The meteoroid followed an asteroidal orbit before its encounter with our planet. The progenitor meteoroid penetrated the atmosphere till and ending altitude of about 20 km. A 100 gram fragment survived the ablation process and landed in the province of Sevilla as a meteorite. The emission spectrum of the fireball was recorded, and the main contributions to this signal were identified.

**Acknowledgements:** JM Madiedo acknowledges support from the Spanish Ministry of Science and Innovation (project PID2019-105797GB-I00).

**References:** [1] Llorca J. et al. (2009) *Meteoritics & Planetary Science*, 44, 159-174. [2] Trigo-Rodríguez J. M. et al. (2009) *Meteoritics & Planetary Science*, 44, 175-186. [3] Madiedo J. M. (2017) *Planetary and Space Science*, 143, 238-244. [4] Madiedo J. M. (2014) *Earth, Planets & Space*, 66, 70. [5] Madiedo J. M. et al. (2015) *Planetary and Space Science*, 111, 105, 115. [6] Madiedo J. M. et al. (2019) *MNRAS*, 486, 3380-3387. [7] Madiedo J. M. et al. (2018) *MNRAS*, 480, 5010-5016. [8] Madiedo J. M. et al. (2015) *A&A*, 577, A118. [9] Ortiz J. L. et al. (2015) *MNRAS*, 454, 344-352. [10] Madiedo J. M. et al., in preparation. [11] Madiedo J. M. et al. (2011) *NASA/CP-2011-216469*, 330. [12] Madiedo J. M. et al. (2013) *MNRAS*, 431, 1678-1685. [13] Madiedo J. M. et al. (2014) *Icarus*, 231, 356-364. [14] Madiedo J. M. et al. (2014) *MNRAS*, 445, 3309-3314. [15] Madiedo J. M. et al. (2014) *Icarus*, 233, 27-35. [16] Madiedo J. M. (2015) *MNRAS*, 448, 2135-2140. [17] Madiedo J. M. et al. (2014) *Icarus*, 239, 273-280. [18] Madiedo J. M. et al. (2016) *Icarus*, 275, 193-202. [19] Madiedo J. M. et al. (2013) *MNRAS*, 433, 571-580. [20] Madiedo J. M. et al. (2013) *MNRAS*, 436, 2818-2823. [21] Madiedo J. M. et al. (2016) *MNRAS*, 460, 917-922. [22] Madiedo J. M. et al. (2014) *MNRAS*, 443, 1643-1650. [23] Madiedo J. M. et al. (2014) *A&A*, 569, A104. [24] Madiedo J. M. et al. (2013) *MNRAS*, 436, 3656-3662. [25] Madiedo J. M. et al. (2013) *MNRAS*, 435, 2023-2032. [26] Madiedo J. M. et al. (2014) *MNRAS*, 439, 3704-3711. [27] Madiedo J. M. (2015) *Planetary and Space Science*, 118, 90-94.