A METEORITE-DROPPING FIREBALL RECORDED ON 2018 DECEMBER 22. P. Yanguas[1]. J.M. Madiedo[2], V. Lanchares[3], A. Pagola[1], J.F. Palacián[1], J. Aceituno[4], E. de Guindos[4]. [1]Departamento de Estadística, Informática y Matemáticas e Instituto de investigación en materiales avanzados, Universidad Pública de Navarra, 31006 Pamplona, Navarra, Spain [2]Facultad de Ciencias Experimentales, Universidad de Huelva, 21071 Huelva, Spain. [3]Departamento de Matemáticas y Computación, Universidad de La Rioja, 26006 Logroño, La Rioja, Spain. [4]Centro Astronómico Hispano-Alemán, Calar Alto (CSIC-MPG), E-04004 Almería, Spain.

Introduction: Most meteoroids impacting the Earth's atmosphere ablate completely at high altitudes, even those that give rise to very bright fireballs [1]. However, some fireball events may produce, under favourable conditions, a non-zero terminal mass. In these cases these materials reach the ground as meteorites. By recovering these meteorites we can obtain unique samples coming from other celestial bodies that provide helpful information about the origin and evolution of our Solar System. For this reason, the analysis of potential meteorite-producing fireballs is of a paramount importance. With this aim, several research groups in Spain are performing a systematic monitoring of meteor and fireball activity by means of different recording techniques. We focus here on a preliminary analysis of a very bright potential meteorite-dropping event that took place over northern Spain on 2018 December 22.

Instrumentation and methods: To record the fireball analyzed here, we have employed an automated all-sky meteor camera operated from Pamplona (Navarra) by Universidad Pública de Navarra (UPNA). This employs a black and white CCD sensor and takes 15s exposures. In addition, we have used a color CCD video camera deployed at the Calar Alto Astronomical Observatory, which works at a frame rate of 25 fps. The atmospheric trajectory of the event was analyzed with the Amalthea software [2].

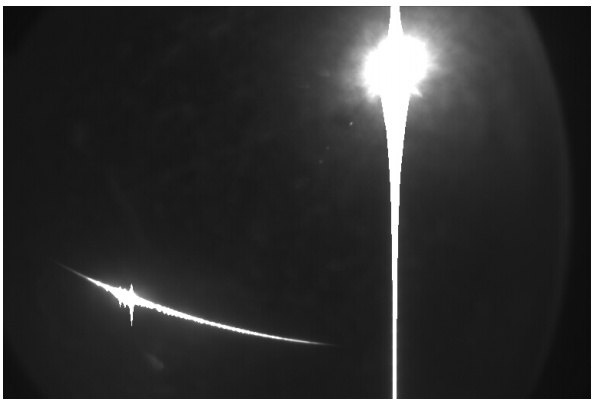

Figure 1. Long-exposure image of the fireball discussed here, as recorded by an all-sky camera operated by Universidad Pública de Navarra (UPNA). The Moon appears at the upper-right corner of the photograph.

Observations: On 2018 December 22, at 21h12m00±1s UTC, a very bright fireball was widely observed and reported by numerous casual eyewitnesses, most of them located in the region of Navarra (north of Spain) and southwest of France. Many of these reported in social networks that the bolide, with green and red colors, was brighter than the full Moon, and also that the meteoroid broke into three smaller fragments along its atmospheric path. Observers located near the central region of Navarra reported a strong thunder-like sound heard some seconds after the luminous phase of the event took place.

Figure 2. Sum-pixel image obtained from video footage recorded by a camera operating at the Calar Alto Astronomical Observatory. Down: zoomed view of the area where the fireball appears.

A long-exposure image of the event was recorded by means of the all-sky meteor camera operated by UPNA (Figure 1). But, because of its extraordinary luminosity, it was also spotted by the video camera located at the Calar Alto Astronomical Observatory (Figure 2), which operates in the framework of the SMART project [3,4]. This observatory is located in the southeast of Spain, at a distance of over 600 km from the area overflown by the bolide. The footage recorded by this video camera confirms the fireball colors reported by the eyewitnesses. Additional images were recorded from different sites, and these were published by most media in the country.

Fireball analysis: Unfortunately, because of bad weather conditions, the emission spectrum of the fireball could not be recorded by the spectrographs that SMART operates in central Spain. So, no information about the chemical nature of the meteoroid could be obtained. But its atmospheric path was analyzed by us on the same night of the occurrence of the bolide. By combining the images recorded of this event and the reports provided by the eyewitnesses, we have triangulated the trajectory and determined that the fireball appeared in the images when it was located at an altitude of about 90 km. It moved southwest over the region of Navarra and penetrated the atmosphere till a final height of about 24 km over the south of Navarra. The analysis of the terminal point of this deep-penetrating fireball shows that the meteoroid was not completely destroyed in the atmosphere. Thus, several fragments survived the ablation process and reached the ground. Meteorite recovery expeditions are currently in progress.

The maximum brightness of the bolide, which was equivalent to a stellar magnitude of -14±1, was reached as a consequence of a flare that took place at an altitude of about 43 km above the sea level. This flare is clearly visible, for instance, in the long-exposure image recorded by UPNA (Figure 1), and corresponds to the position in the photograph where the blooming effect experienced by the CCD sensor of the camera peaks. At this point, the meteoroid fragmented into the three smaller pieces reported by the eyewitnesses. This same blooming effect shows that additional flares took place immediately after. The preliminary estimate of the tensile strength σ of the meteoroid at this stage yields $\sigma > 8.7 \cdot 10^6$ dyn/cm^2.

Conclusions: We have presented a preliminary analysis of a potential meteorite-dropping multi-station fireball recorded over northern Spain on 2018 December 22. The event overflew the region of Navarra. The terminal point of the luminous path was located over the south of that region. Our calculations also indicate that several fragments survived the ablation process and reached the ground. The high-tensile-strength progenitor meteoroid penetrated the atmosphere till an ending altitude of about 24 km above the sea level. Meteorite recovery expeditions are currently in progress.

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