PHYSICO-CHEMICAL ANALYSIS OF A DEEP-PENETRATING α-HYDRID FIREBALL OBSERVED IN 2022. J.M. Madiedo[1, 2], J.L. Ortiz[1], J. Aceituno[3], E. de Guindos[3], J. Izquierdo[4]. J.C. Toscano-Bermúdez[5]. [1]Instituto de Astrofísica de Andalucía, CSIC, Apt. 3004, Camino Bajo de Huetor 50, 18080 Granada, Spain. [2]Observatorio Galileo, 41012 Sevilla, Spain. [3]Centro Astronómico Hispano-Alemán, Calar Alto (CSIC-MPG), E-04004 Almería, Spain. [4]Dpto. de Física de la Tierra y Astrofísica, Universidad Complutense de Madrid, 28040 Madrid, Spain. [5]Escuela Técnica Superior de Ingeniería, Universidad de Sevilla, 41092 Sevilla, Spain.

Introduction: The SMART (Spectroscopy of Meteoroids by means of Robotic Technologies) project is being developed since 2006 with the aim to obtain information about the chemical composition of meteoroids ablating in the atmosphere. This survey, which is being conducted by the Southwestern Europe Meteor Network (SWEMN), employs an array of automated spectrographs deployed at a series of meteor-observing stations in different locations in Spain, including the major astronomical observatories in this country [1-3]. In this way 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 [1-4]. In this work we present a preliminary analysis of an extraordinary fireball that was spotted over the south of Spain on 2022 January 9.

Figure 1. Sum-pixel image of the fireball discussed in the text, as recorded from the Calar Alto Astronomical Observatory.

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 [5]. These cameras monitor the night sky and operate in a fully autonomous way by means of software developed by J.M. Madiedo [1, 2]. The atmospheric trajectory and orbital data of the event were obtained with the AMALTHEA and SAMIA software packages, which were also written by the same researcher [1, 3].

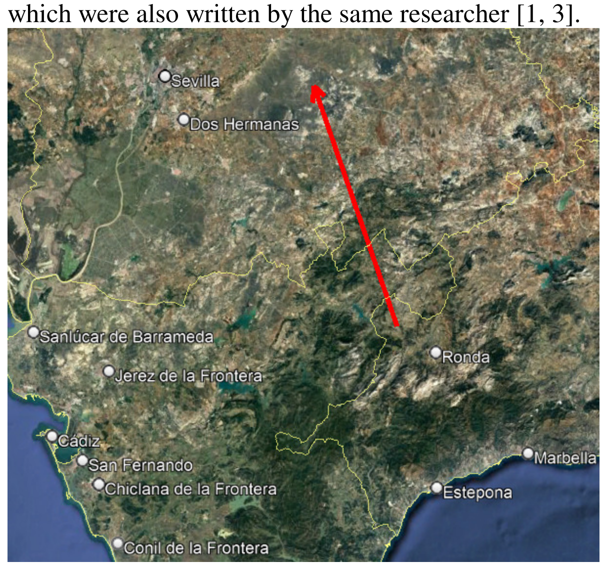

Figure 2. Projection on the ground of the atmospheric trajectory of the fireball.

The 2022 January 9 event: The fireball discussed in this work was recorded on 2022 January 9, at 0h18m08±1s UT. It was spotted from our meteor-observing stations located at Calar Alto, Sevilla, El Aljarafe, Madrid, Sierra Nevada, La Sagra, Huelva, Tarragona, and La Hita (Figure 1). After its appearance date and time, this event was included in the SWEMN digital database [3] under the code SWEMN20220109_001808.

The peak luminosity of this impressive event corresponded to an absolute stellar magnitude of –14±1. Besides, its emission spectrum was also recorded from the meteor-observing stations located at Calar Alto, Sierra Nevada, La Hita, Huelva, and La Sagra. The event was also observed by numerous eyewitnesses, most of them located in the south of Spain. These described the phenomenon as an extraordinary bolide that turned night into day for a fraction of a second, as our own cameras also recorded. Another remarkable feature of this fireball is that it exhibited several flares along its atmospheric trajectory. These took place as a consequence of the sudden disruption of the progenitor meteoroid. The peak luminosity of the bolide was reached during one of these breakups. Our cameras could also record the fragmentation of the meteoroid by the end of its trajectory, with several fragments moving in slightly different paths.

Results and discussion: The large amount of recordings from nearby meteor stations, including videos from high-frame-rate and high-definition cameras, allowed us to calculate with high accuracy the circumstances of this stunning bolide. According to our calculations, the meteoroid struck the atmosphere with an initial velocity of about 38 km/s and the fireball began at a height of 103.5 km over the west of the province of Málaga (Andalusia, Spain). From that initial position it moved northeast and overflew the northeast of the province of Cádiz, and next continued over the province of Sevilla. The terminal point of its atmospheric trajectory was located at a height of about 31.0 km, over a point next to the city of Marchena (province of Sevilla). For that reason we named this event "Marchena" in the SWEMN meteor database. The analysis of the final stage of the luminous event reveals that the meteoroid was completely ablated in the atmosphere.

The projection on the ground of this atmospheric trajectory is shown in Figure 2. With this information, the orbit in the Solar System of the progenitor meteoroid was also calculated (Figure 3). The derived value of the Tisserand parameter with respect to Jupiter (T_J=1.5) indicates that this particle followed a cometary orbit before its encounter with our planet. From the computed radiant and orbital elements, we also concluded that the meteoroid belonged to the α-Hydrids (AHY).

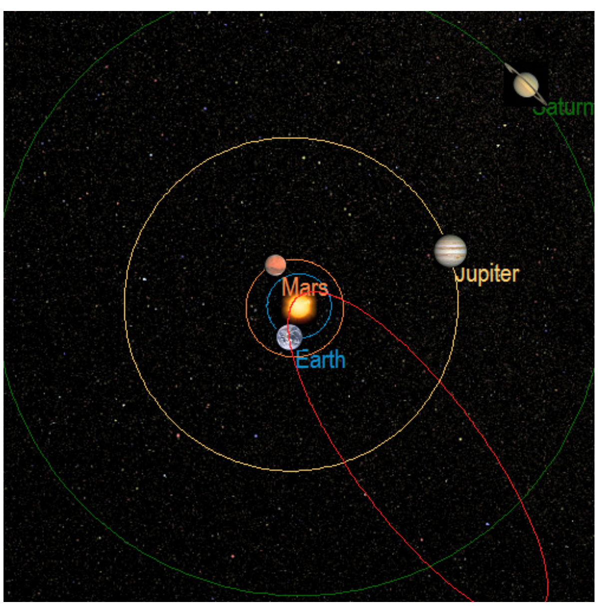

Figure 3. Projection on the ecliptic plane of the heliocentric orbit of the parent meteoroid.

Our results are consistent with a cometary origin for the α-Hydrids, and with the existence of large and tough meteoroids in the AHY stream. Thus, because of its high tensile strength, the parent meteoroid of the fireball could penetrate the atmosphere so deep. The emission spectrum recorded for the event is currently under in-deep analysis. In this signal we have found typical contributions previously found in meteor spectra, such of those of the Mg I-3 triplet, the Na I-1 doublet, neutral Ca and neutral Fe. This analysis will provide important information about the nature of the meteoroid.

Conclusions: We have described an extraordinary mag. -14 fireball event associated with the α-Hydrids (AHY). It overflew the southwest of Spain, but as a consequence of its brightness it could be observed along the whole Iberian Peninsula. The terminal height was also remarkable, since the event ended at about 31 km over the ground as a consequence of the high tensile strength of the meteoroid. This particle followed a cometary orbit before its encounter with our planet, which reveals the existence of tough and large meteoroids in the AHY stream. The emission spectrum of the fireball, which is currently under analysis, contains typical contributions from neutral Fe, Ca, Mg and Na. The in-deep study of this signal will provide key information about the AHY meteoroid stream and its parent body.

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