Analysis of remarkable bolides observed between June and July 2022 in the framework of the Southwestern Europe Meteor Network

J. M. Madiedo[1], J. L. Ortiz[1], J. Izquierdo[2], P. Santos-Sanz[1], J. Aceituno[3], E. de Guindos[3], P. Yanguas[4], J. Palacián[4], A. San Segundo[5], D. Ávila[6], B. Tosar[7], A. Gómez-Hernández[8], J. Gómez-Martínez[8], A. García[9], and A.I. Aimee[10]

[1] **Departamento de Sistema Solar, Instituto de Astrofísica de Andalucía (IAA-CSIC), 18080 Granada, Spain**
madiedo@cica.es, ortiz@iaa.es, psantos@iaa.es

[2] **Departamento de Física de la Tierra y Astrofísica, Universidad Complutense de Madrid, 28040 Madrid, Spain**
jizquierdo9@gmail.com

[3] **Observatorio Astronómico de Calar Alto (CAHA), E-04004, Almería, Spain**
aceitun@caha.es, guindos@caha.es

[4] **Departamento de Estadística, Informática y Matemáticas e Institute for Advanced Materials and Mathematics, Universidad Pública de Navarra, 31006 Pamplona, Navarra, Spain**
yanguas@unavarra.es, palacian@unavarra.es

[5] **Observatorio El Guijo (MPC J27), Galapagar, Madrid, Spain**
mpcj27@outlook.es

[6] **Estación de Meteoros de Ayora, Ayora, Valencia, Spain**
David_ayora007@hotmail.com

[7] **Casa das Ciencias. Museos Científicos Coruñeses. A Coruña, Spain**
borjatosar@gmail.com

[8] **Estación de Registro La Lloma, Olocau, Valencia, Spain**
curso88@gmail.com

[9] **Estación de Meteoros de Cullera (Faro de Cullera), Valencia, Spain**
antonio.garcia88@joseantoniogarcia.com

[9] **Southwestern Europe Meteor Network, 41012 Sevilla, Spain**
swemn.server@gmail.com

Some of the bright bolides spotted in the framework of the Southwestern Europe Meteor Network from June to July 2022 are discussed here. These were observed from Spain. Their absolute magnitude ranges from –6 to –11. Fireballs included in this work were generated by different sources: the sporadic background, major meteoroid streams, and poorly known streams.

1 Introduction

We perform a systematic monitoring of meteor activity in the framework of the SMART project (Spectroscopy of Meteoroids by means of Robotic Technologies), which started operation in 2006 to analyze the properties of meteoroids ablating in our planet's atmosphere. This includes chemical data derived from the emission spectra of meteors generated by these particles of interplanetary matter. This survey, which is being conducted in the framework of the Southwestern Europe Meteor Network (SWEMN), employs an array of automated spectrographs deployed at meteor-observing stations in Spain (Madiedo, 2014; Madiedo, 2017). This allows to derive the luminous path of meteors and the orbit of their progenitor meteoroids, and also to study the evolution of meteor plasmas from the emission spectrum produced by these events (Madiedo, 2015a,b). SMART also provides important information for our MIDAS project, which is being conducted to study lunar impact flashes produced when large meteoroids impact the Moon (Madiedo et al., 2018; Madiedo et al. 2019; Ortiz et al., 2015).

In this work we focus on the preliminary analysis of five fireballs recorded by the SWEMN network between June and July 2022. This work has been fully written by AIMIE (acronym for Artificial Intelligence with Meteoroid Environment Expertise) from the records included in the SWEMN fireball database (Madiedo et al., 2021; Madiedo et al., 2022).

2 Equipment and methods

To record the events presented in this work we have used Watec 902H2 and Watec 902 Ultimate cameras. Their field of view ranges from 62 × 50 degrees to 14 × 11 degrees. we have also employed digital CMOS color cameras (models Sony A7S and A7SII) operating in HD video mode (1920 × 1080 pixels). These cover a field of view of around 70 × 40 degrees. A detailed description of this hardware and the way it operates was given in previous works (Madiedo, 2017). Besides digital CMOS cameras manufactured by ZWO, model ASI185MC were used. The atmospheric paths of the events were triangulated by employing the SAMIA software, developed by J. M. Madiedo. This program employs the planes-intersection method (Ceplecha, 1987).

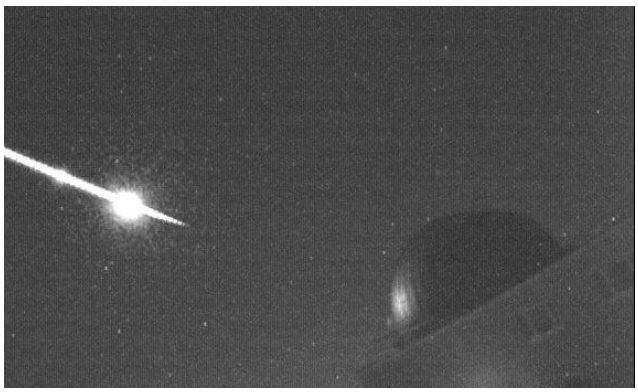

Figure 1 – Stacked image of the final part of the SWEMN20220610_001139 "Ardales" fireball as recorded from Sierra Nevada.

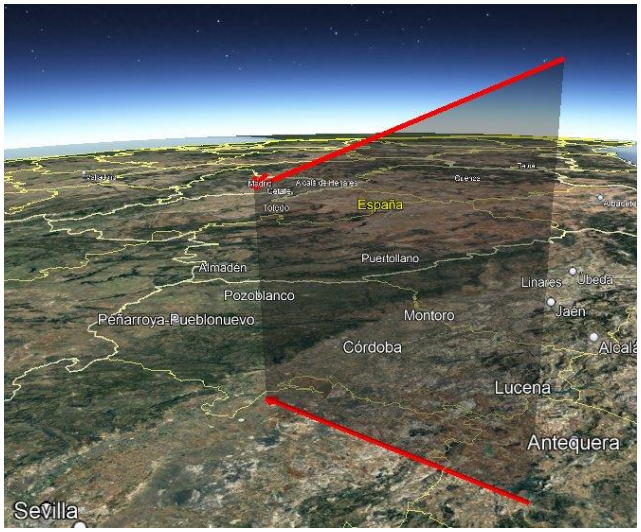

Figure 2 – Atmospheric path of the SWEMN20220610_001139 "Ardales" fireball, and its projection on the ground.

3 Description of the 2022 June 10 meteor

This bright fireball was spotted on 2022 June 10, at $0^h11^m39.0 \pm 0.1^s$ UT (*Figure 1*). The meteor, that showed different flares along its trajectory in the Earth's atmosphere, had a peak absolute magnitude of –9.0 ± 1.0. These flares took place because of the sudden disruption of the meteoroid. The code given to this event in the SWEMN database is SWEMN20220610_001139. A video showing images of the bolide and its atmospheric trajectory was uploaded to YouTube[17].

Atmospheric trajectory, radiant and orbit

This bright meteor overflew the provinces of Málaga and Sevilla (south of Spain). Its initial altitude was H_b = 102.9 ± 0.5 km and the bolide penetrated the atmosphere till a final height H_e = 64.4 ± 0.5 km. From the analysis of the atmospheric path we also found that the apparent radiant was located at the position α = 277.41º, δ = –26.68º. Besides, we deduced that the meteoroid hit the atmosphere with a velocity v_∞ = 36.7 ± 0.3 km/s. *Figure 2* shows the obtained trajectory in our atmosphere of the fireball. *Figure 3* shows the orbit in the Solar System of its progenitor meteoroid.

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

a (AU)	3.1 ± 0.1	ω (º)	127.74 ± 00.06
e	0.928 ± 0.005	Ω (º)	258.844369 ± 10^{-5}
q (AU)	0.227 ± 0.002	i (º)	9.32 ± 0.07

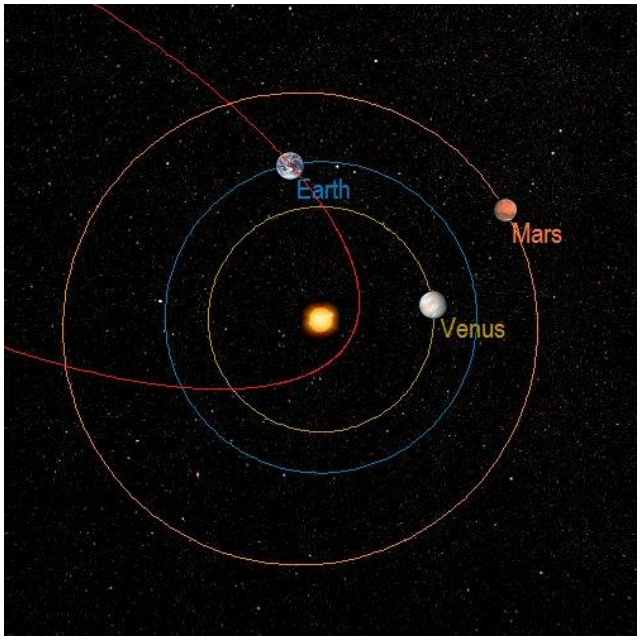

Figure 3 – Projection on the ecliptic plane of the orbit of the SWEMN20220610_001139 "Ardales" meteor.

The bolide was named "Ardales" since the event was located over this locality during its initial phase. *Table 1* shows the orbital parameters of the progenitor meteoroid before its encounter with our planet. The geocentric velocity of this meteoroid was v_g = 34.9±0.3 km/s. The Tisserand parameter referred to Jupiter (T_J = 2.21) indicates that the particle was moving on a cometary (JFC) orbit before colliding with the atmosphere. By taking into account this orbit and the radiant position, the event was produced by the lambda Sagittariids (IAU meteor shower code LSA#0803). This poorly known meteor shower peaks around June 4 (Amaral et al., 2020).

[17] https://youtu.be/qM3m-elQjhM

Figure 4 – Stacked image of the SWEMN20220630_215833 "Cacín" meteor as recorded from Sierra Nevada..

Figure 5 – Atmospheric path of the SWEMN20220630_215833 "Cacín" event, and its projection on the ground.

4 Analysis of the 2022 June 30 bolide

We spotted this bright meteor from the meteor-observing stations located at Huelva, La Hita, CAHA, Sierra Nevada (OSN), La Sagra, Sevilla, and El Aljarafe. The fireball was recorded on 2022 June 30, at $21^h58^m33.0 \pm 0.1^s$ UT. The peak luminosity the bright meteor, that exhibited different flares along its trajectory in the atmosphere, was equivalent to an absolute magnitude of -10.0 ± 1.0. These flares appeared as a consequence of the sudden break-up of the meteoroid. The code given to the fireball in the SWEMN meteor database is SWEMN20220630_215833. The bright meteor can be viewed on this video[18]. The fireball is shown in *Figure 4*. A wide number of casual observers saw how the bright meteor crossed the sky. These reported the event on social networks.

Atmospheric path, radiant and orbit

This bright meteor overflew the province of Córdoba (south of Spain). Its initial altitude was $H_b = 102.5 \pm 0.5$ km. The event penetrated the atmosphere till a final height $H_e = 66.0 \pm 0.5$ km. The position obtained for the apparent radiant correspond to the equatorial coordinates $\alpha = 276.26^o$, $\delta = -20.81^o$. The pre-atmospheric velocity found for the meteoroid yields $v_\infty = 28.2 \pm 0.3$ km/s. *Figure 5* shows the calculated trajectory in the Earth's atmosphere of the bolide. The heliocentric orbit of the meteoroid is drawn in *Figure 6*.

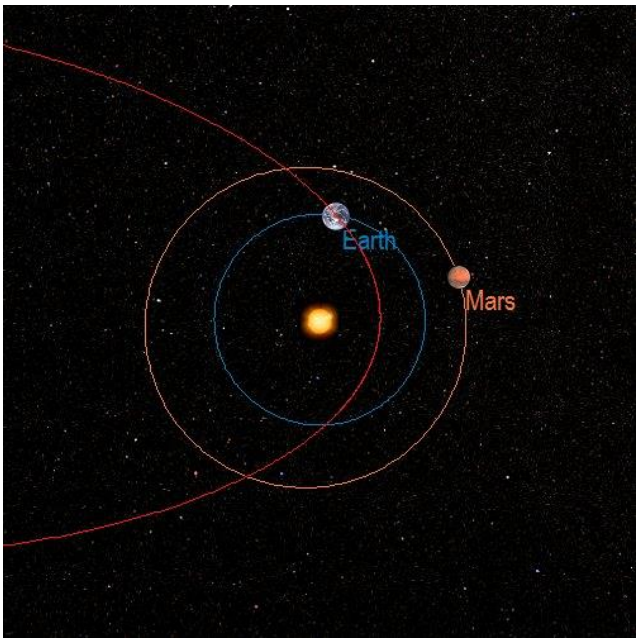

Figure 6 – Projection on the ecliptic plane of the orbit of the SWEMN20220630_215833 "Cacín" event.

We named this fireball "Cacín", because the event was located over this locality during its initial phase. The orbital parameters of the progenitor meteoroid before its encounter with our planet have been included in *Table 2*. The geocentric velocity obtained for the particle yields $v_g = 25.8 \pm 0.3$ km/s. From the value obtained for the Tisserand parameter with respect to Jupiter ($T_J = 1.76$), we found that the particle was moving on a cometary (HTC) orbit before colliding with the Earth's atmosphere. These parameters and the calculated radiant confirm that the bright meteor was produced by the sporadic background).

Table 2 – Orbital data (J2000) of the progenitor meteoroid before its encounter with our planet.

a (AU)	6.2 ± 0.8	ω (º)	84.4 ± 00.1
e	0.90 ± 0.01	Ω (º)	279.336754 ± 10^{-5}
q (AU)	0.575 ± 0.002	i (º)	0.30 ± 0.05

[18] https://youtu.be/12FTod4YlMo

5 Analysis of the 2022 July 25 meteor

On 2022 July 25, at $23^h04^m20.0 \pm 0.1^s$ UT, SWEMN meteor stations captured this bright bolide (*Figure 7*). The maximum brightness the bright meteor, that exhibited a series of flares along its atmospheric trajectory, was equivalent to an absolute magnitude of –10.0 ± 1.0. These flares arose as a consequence of the sudden disruption of the meteoroid. It was added to the SWEMN meteor database with the code SWEMN20220725_230420. The fireball can be viewed on this YouTube video[19].

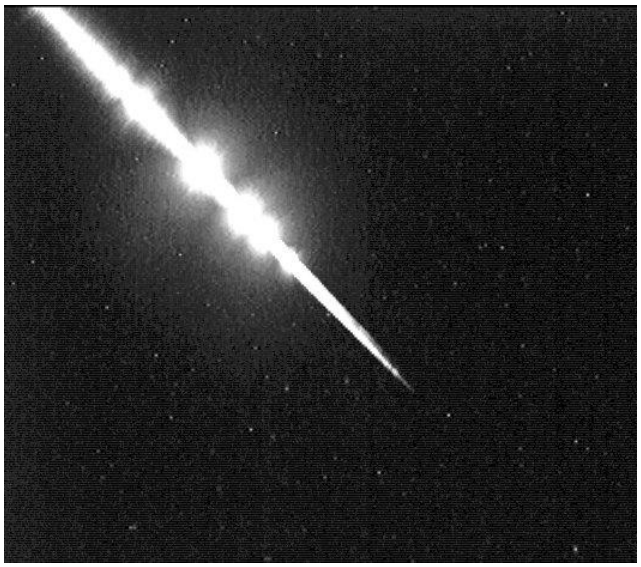

Figure 7 – Stacked image of the final part of the SWEMN20220725_230420 "Las Ventas" meteor as recorded from Sierra Nevada.

Atmospheric path, radiant and orbit

This fireball overflew the provinces of Jaén and Granada (south of Spain). The initial altitude of the meteor yields H_b = 103.5 ± 0.5 km, and ended at a height H_e = 26.8 ± 0.5 km. The equatorial coordinates found for the apparent radiant are α = 223.72º, δ = +39.50º. The pre-atmospheric velocity inferred for the meteoroid yields v_∞ = 15.7 ± 0.3 km/s. The calculated path in the atmosphere of the bright meteor is shown in *Figure 8*. The heliocentric orbit of the meteoroid is drawn in *Figure 9*.

We named this fireball "Las Ventas", since the event was located over this locality during its initial phase. *Table 3* shows the orbital parameters of the parent meteoroid before its encounter with our planet. The value calculated for the geocentric velocity was v_g = 11.5 ± 0.4 km/s. The Tisserand parameter with respect to Jupiter (T_J = 2.84) reveals that the particle was moving on a cometary (JFC) orbit before impacting the Earth's atmosphere. Radiant and orbital data do not match any of the meteoroid streams listed in the IAU meteor database. So, we concluded that this bolide was produced by the sporadic background.

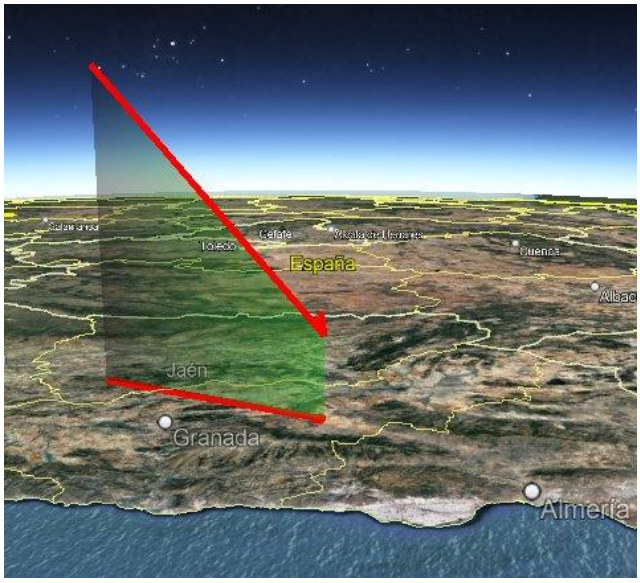

Figure 8 – Atmospheric path of the SWEMN20220725_230420 "Las Ventas" event, and its projection on the ground.

Table 3 – Orbital data (J2000) of the progenitor meteoroid before its encounter with our planet.

a (AU)	3.0 ± 0.2	ω (º)	170.7 ± 00.2
e	0.66 ± 0.02	Ω (º)	122.662704 ± 10-5
q (AU)	1.0104 ± 0.0001	i (º)	12.1 ± 0.4

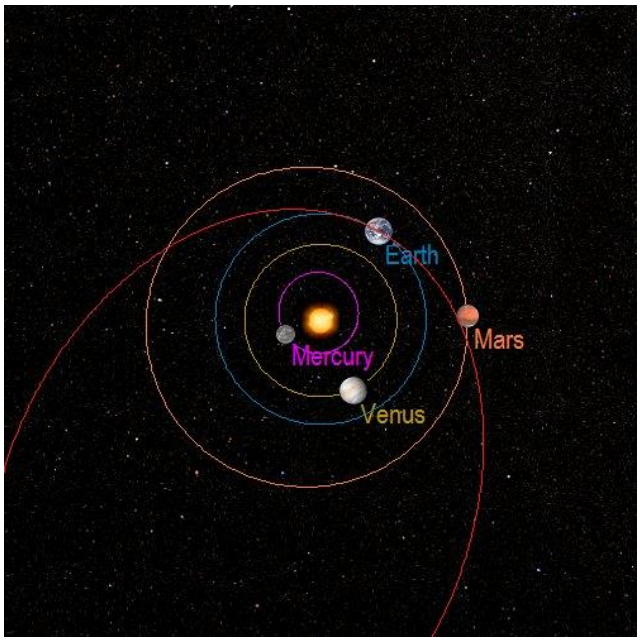

Figure 9 – Projection on the ecliptic plane of the orbit of the SWEMN20220725_230420 "Las Ventas" bolide.

6 Description of the 2022 July 26 event

On 2022 July 26, at $1^h09^m41.7 \pm 0.1^s$ UT, our devices captured this fireball. It had a peak absolute magnitude of –6.0 ± 0.5 (*Figure 10*). The code assigned in the SWEMN database to this bolide is SWEMN20220726_010941. The bright meteor can be viewed on YouTube[20].

[19] https://youtu.be/GbvuIGFLnqY

[20] https://youtu.be/mks-MJTsHOI

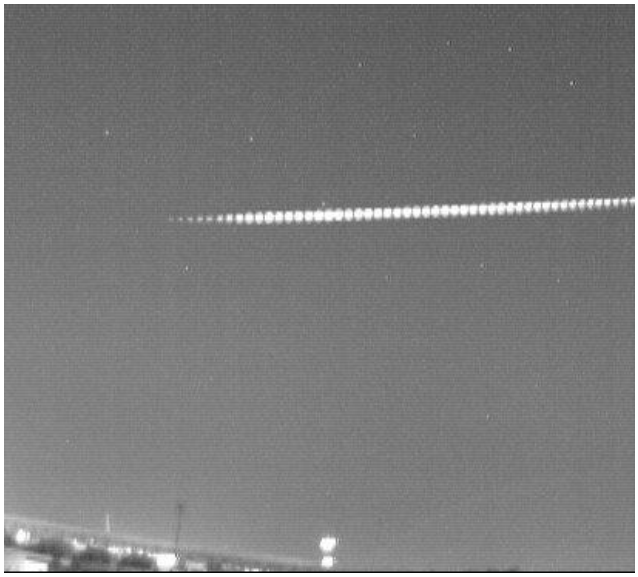

Figure 10 – Stacked image of the SWEMN20220726_010941 "Alpalhao" fireball as recorded from Sevilla.

Atmospheric path, radiant and orbit

This bright meteor overflew Spain and Portugal. Its initial altitude was H_b = 110.2 ± 0.5 km. The event penetrated the atmosphere till a final height H_e = 85.4 ± 0.5 km. The apparent radiant was located at the equatorial coordinates α = 61.33º, δ = +35.49º. The meteoroid stroke the atmosphere with an initial velocity v_∞ = 62.2 ± 0.0 km/s. The calculated trajectory in the Earth's atmosphere of the fireball is shown in *Figure 11*.

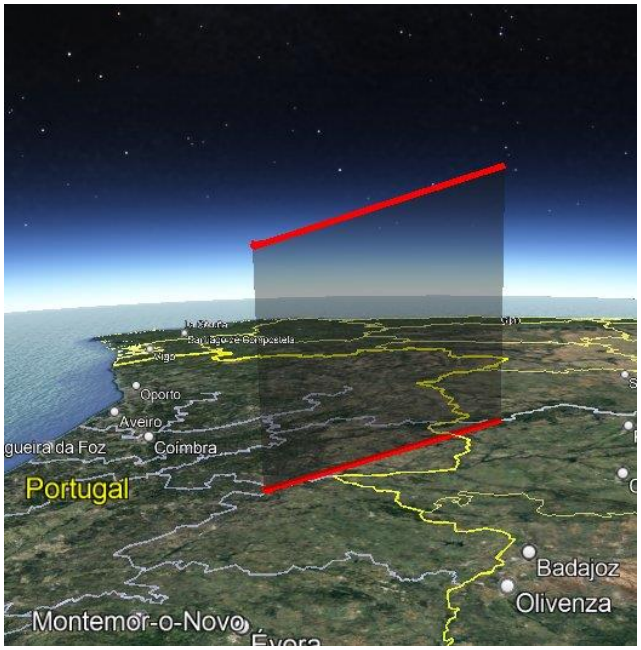

Figure 11 – Atmospheric path of the SWEMN20220726_010941 "Alpalhao" bolide, and its projection on the ground.

Figure 12 shows the orbit in the Solar System of the parent meteoroid. The name given to the bright meteor was "Alpalhao", because the event was located over this locality during its final phase. The parameters of the orbit of the parent meteoroid before its encounter with our planet have been included in *Table 4*, and the geocentric velocity derived in this case was v_g = 60.9 ± 0.0 km/s. The value derived for the Tisserand parameter referred to Jupiter (T_J = –0.16) indicates that the meteoroid followed a cometary (HTC) orbit before hitting our atmosphere. According to these data and the calculated radiant, the event was associated with the sporadic component.

Table 4 – Orbital data (J2000) of the progenitor meteoroid before its encounter with our planet.

a (AU)	12.1 ± 0.2	ω (º)	72.04 ± 00.09
e	0.9701 ± 0.0007	Ω (º)	122.760711 ± 10-5
q (AU)	0.361 ± 0.001	i (º)	143.18 ± 0.04

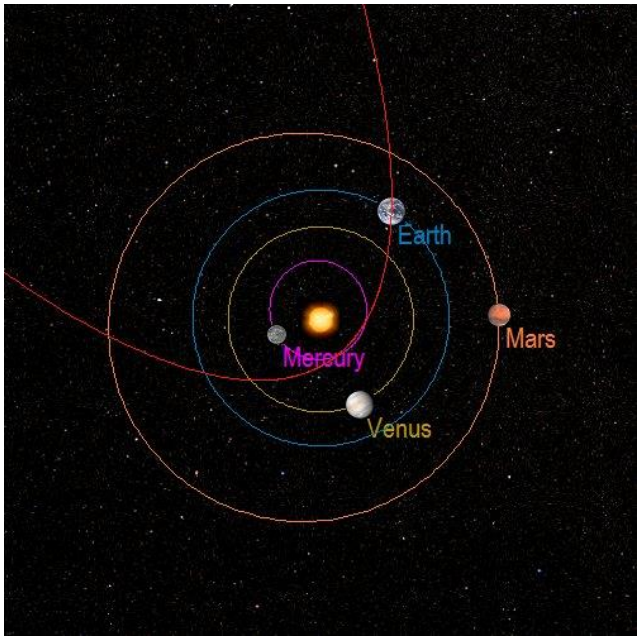

Figure 12 – Projection on the ecliptic plane of the orbit of the SWEMN20220726_010941 "Alpalhao" bolide.

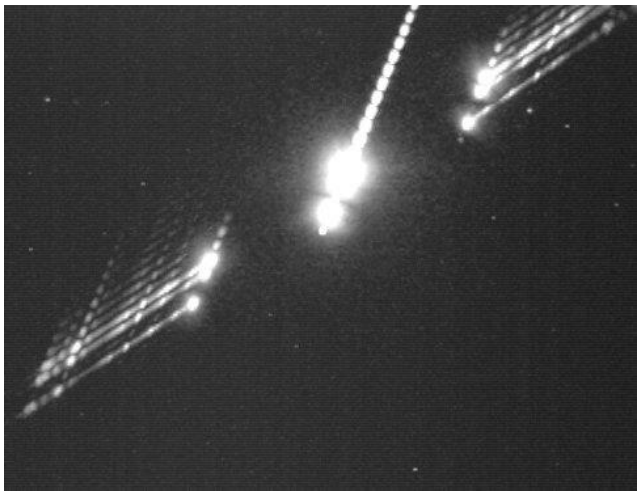

Figure 13 – Stacked image of the SWEMN20220728_022851 "Albolote" bolide as recorded from Calar Alto.

7 Analysis of the 2022 July 28 meteor

This notable bolide was spotted by our cameras at $2^h28^m51.0 \pm 0.1^s$ UT on 2022 July 28. The event, that presented various flares along its trajectory in the Earth's atmosphere, had a peak absolute magnitude of –11.0 ± 1.0 (*Figure 13*). These flares arose as a consequence of the sudden break-up of the meteoroid. It was included in the SWEMN meteor database with the code

SWEMN20220728_022851. The event can be viewed on YouTube[21].

Atmospheric path, radiant and orbit

According to the analysis of the trajectory in our atmosphere of the fireball it was inferred that this bright meteor overflew the province of Granada (south of Spain). The luminous event began at an altitude H_b = 116.1 ± 0.5 km. The event penetrated the atmosphere till a final height H_e = 74.4 ± 0.5 km. The position inferred for the apparent radiant correspond to the equatorial coordinates α = 23.98º, δ = +53.39º. The entry velocity in the atmosphere found for the parent meteoroid was v_∞ = 59.1 ± 0.4 km/s. *Figure 14* shows the obtained atmospheric trajectory of the bright meteor. The orbit in the Solar System of the meteoroid is shown in *Figure 15*.

Figure 14 – Atmospheric path of the SWEMN20220728_022851 "Albolote" meteor, and its projection on the ground.

Table 5 – Orbital data (J2000) of the progenitor meteoroid before its encounter with our planet.

a (AU)	8.9 ± 2.6	ω (º)	157.5 ± 00.4
e	0.89 ± 0.03	Ω (º)	124.721789 ± 10-5
q (AU)	0.9791 ± 0.0008	i (º)	111.0 ± 0.2

We named this bright meteor "Albolote", because the bolide overflew this locality during its final phase. The orbital parameters of the progenitor meteoroid before its encounter with our planet have been listed in *Table 5*. The geocentric velocity of the meteoroid was v_g = 57.9 ± 0.4 km/s. From the value calculated for the Tisserand parameter with respect to Jupiter (T_J = 0.15), we found that before colliding with the Earth's atmosphere the meteoroid was moving on a cometary (HTC) orbit. These parameters and the derived radiant confirm that the fireball was linked to the Perseids (IAU code PER#0007). The progenitor body of this shower, which peaks around August 12, is Comet 109P/Swift-Tuttle (Jenniskens et al., 2016).

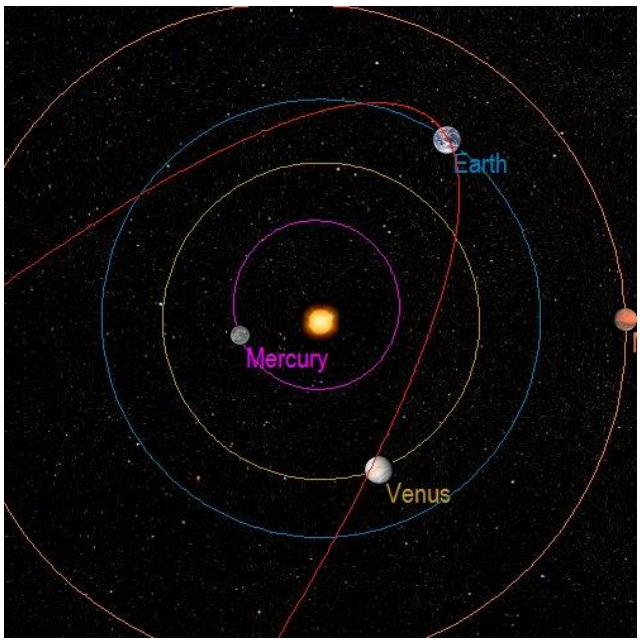

Figure 15 – Projection on the ecliptic plane of the orbit of the SWEMN20220728_022851 "Albolote" meteor.

8 Conclusions

We have presented in this work some of the most remarkable meteors captured by our meteor-observing stations during June and July 2022. Their maximum brightness ranges from mag. –6 to mag. –11.

The "Ardales" bolide was captured on June 10. It belonged to the poorly known stream of the lambda Sagittariids (LSA#0803). Its peak magnitude was –9.0 and overflew the south of Spain. The particle was moving on a cometary (JFC) orbit before hitting our atmosphere.

The next bolide discussed here was a bright meteor that was captured on June 30 named "Cacín". It reached a peak absolute magnitude of –10.0, and its progenitor meteoroid belonged to the sporadic component. This bolide overflew the provinces of Córdoba and Granada (south of Spain). The particle was moving on a cometary (HTC) orbit before colliding with the Earth's atmosphere.

The third event analyzed here was the "Las Ventas" bright meteor. This was captured on July 25. It reached a peak absolute magnitude of –10.0 and belonged to the sporadic background. This meteor event overflew the provinces of Jaén and Granada (south of Spain). The meteoroid was moving on a cometary (JFC) orbit before hitting our planet's atmosphere. This deep-penetrating meteor reached a terminal height of about 26 km.

Next, we have presented a sporadic bright meteor that was captured on July 26 named "Alpalhao". It reached a peak absolute magnitude of –6.0. This meteor overflew Spain and Portugal. The meteoroid was also moving on a

[21] https://youtu.be/6t6oVvFljaw

cometary (HTC) orbit before striking the Earth's atmosphere.

And the last event discussed here was the "Albolote" event, that was captured on July 28. Its peak magnitude was –11.0. The meteor event was produced by a Perseid (PER#0007) meteoroid from Comet 109P/Swift-Tuttle and overflew the province of Granada (south of Spain). This meteoroid was moving on a cometary (HTC) orbit before impacting the Earth's atmosphere.

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