Bright fireballs recorded along March 2021 in the framework of the Southwestern Europe Meteor Network

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The most relevant bolides recorded along March 2021 in the framework of the Southwestern Europe Meteor Network (SWEMN) and the SMART project are presented here. These fireballs, which overflew the Iberian Peninsula and neighboring areas, had an absolute peak luminosity ranging between magnitude –8 and –11. We also analyze the main features appearing in the emission spectra recorded for some of these bright meteors.

1 Introduction

We present here the most remarkable bolides recorded during March 2021 over Spain and neighboring areas by the Southwestern Europe Meteor Network (SWEMN). Because of adverse weather conditions during the first two weeks of this month, the most remarkable fireball activity was spotted by our systems during the second half of March.

SWEMN is a research network coordinated by the Institute of Astrophysics of Andalusia (IAA-CSIC) with the aim to analyze the Earth's meteoric environment. Currently the network is also integrated by researchers from the Complutense University of Madrid (UCM), the Public University of Navarre (UPNA), and the Calar Alto Observatory (CAHA). We also receive input from amateur astronomers who collaborate with this meteor network.

To identify and analyze meteors in the Earth's atmosphere, SWEMN develops the Spectroscopy of Meteoroids by means of Robotic Technologies (SMART) survey (Madiedo, 2014; Madiedo, 2017). To obtain a much more complete insight into the properties of the Earth-Moon meteoric environment, SMART works in close connection with another project conducted by the Institute of Astrophysics of Andalusia: The Moon Impacts Detection and Analysis System (MIDAS) (Ortiz et al., 2015; Madiedo et al., 2018). Thus, SMART employs our atmosphere as a detector to identify meteors generated by meteoroids crossing the Earth's orbit. At the same time, MIDAS considers the Moon as a laboratory that provides information about meteoroids hitting the lunar ground (Madiedo et al., 2019a). Previous works showed that there exists a strong synergy between both systems (Madiedo et al. 2015a, b; Madiedo et al. 2019b).

The bolides presented in this work reached a peak absolute magnitude ranging from –8 to –11. The results obtained from the analysis of their atmospheric path and radiant are discussed below. The orbital elements of the progenitor meteoroids were also obtained. As in previous reports (Madiedo et al., 2021), we also present the emission spectrum recorded for some of these bright meteors.

2 Instrumentation and methods

The meteors described here were recorded by means of analog CCD video cameras manufactured by Watec. (models 902H and 902H2 Ultimate). Their field of view ranges from 62 × 50 degrees to 14 × 11 degrees. To record meteor spectra, we have attached holographic diffraction gratings (1000 lines/mm) to the lens of some of these cameras. 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 90 × 40 degrees. A detailed description of this hardware and the way it operates was given in previous works (Madiedo, 2017).

The atmospheric path and radiant of meteors, and also the orbit of their parent meteoroids, were obtained with the Amalthea software, developed by J.M. Madiedo (Madiedo, 2014). This program employs the planes-intersection method (Ceplecha, 1987). However, for Earth-grazing events atmospheric trajectories are obtained by Amalthea by means of a modification of this classical method (Madiedo

et al., 2016). Emission spectra were analyzed with the ChiMet software (Madiedo, 2015a).

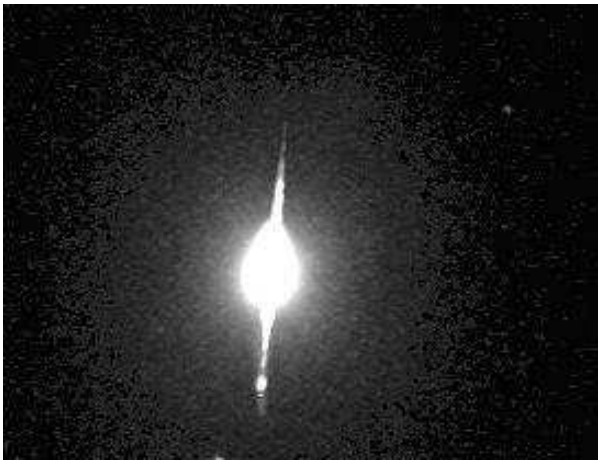

Figure 1 – Stacked image of the SWEMN20210312_233300 "Azuaga" fireball as recorded from the SWEMN meteor-observing station deployed at La Hita Astronomical Observatory.

Figure 2 – Atmospheric path and projection on the ground of the trajectory of the SWEMN20210312_233300 "Azuaga" fireball.

3 The 2021 March 12 meteor event

The first remarkable bolide spotted by our meteor-observing stations on March 2021 was observed on the 12th day of that month, at $23^h33^m00.5 \pm 0.1^s$ UTC (*Figure 1*). The event, which had a peak absolute magnitude of -11 ± 1, was recorded by the cameras deployed at Calar Alto, Sierra Nevada, La Sagra, La Hita, Sevilla, El Arenosillo, and Madrid. This event was labeled in our meteor database with the code SWEMN20210312_233300. A video showing images of the fireball and its trajectory was uploaded to YouTube[7].

Atmospheric trajectory, radiant and orbit

From the analysis of the atmospheric trajectory of the fireball we concluded that it overflew the province of Badajoz (*Figure 2*). The observed pre-atmospheric velocity of the meteoroid is $v_\infty = 20.2 \pm 0.3$ km/s, with the apparent radiant located at the equatorial coordinates $\alpha = 163.03^o$, $\delta = +48.94^o$. The meteor began at a height $H_b = 99.9 \pm 0.5$ km, and ended at an altitude $H_e = 62.9 \pm 0.5$ km. The zenith angle of this trajectory was of about 11 degrees. At its terminal point the bolide was close to the vertical of the town of Azuaga, and so we named the fireball after this location. The atmospheric path of the bolide and its projection on the ground are shown in *Figure 2*.

Table 1 – Orbital data (J2000) of the progenitor meteoroid of the SWEMN20210312_233300 "Azuaga" fireball.

a (AU)	4.8 ± 0.5	ω (º)	215.22 ± 0.07
e	0.81 ± 0.02	Ω (º)	352.32460 ± 10^{-5}
q (AU)	0.912 ± 0.001	i (º)	15.6 ± 0.2

The meteoroid had a geocentric velocity $v_g = 16.9 \pm 0.3$ km/s. Its orbital parameters before its encounter with our planet are shown in *Table 1*, and this orbit is drawn in *Figure 3*. According to the calculated value of the Tisserand parameter with respect to Jupiter ($T_J = 2.1$), the meteoroid followed a Jupiter family comet (JFC) orbit before entering the Earth's atmosphere. Radiant and orbital data do not match any of the meteoroid streams listed in the IAU meteor database[8]. So, we concluded that this event was produced by the sporadic background.

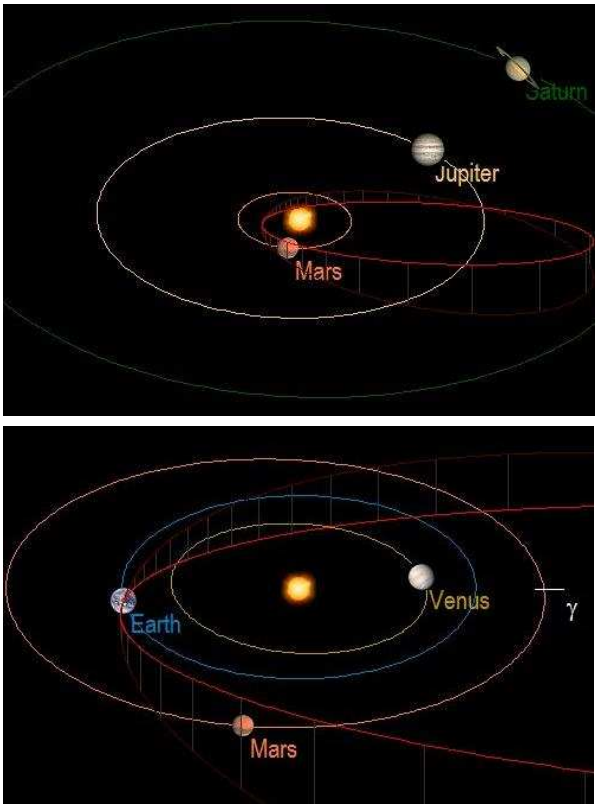

Figure 3 – Up: orbit (red line) of the parent meteoroid of the SWEMN20210312_233300 fireball, and projection of this orbit (dark red line) on the ecliptic plane; Down: close-up view of the orbit.

[7] https://youtu.be/iYAiTSkuriY

[8] http://www.astro.amu.edu.pl/~jopek/MDC2007/

Emission spectrum

The emission spectrum of the fireball was recorded by our spectrographs from the astronomical observatories of Calar Alto, La Hita, and El Arenosillo. It was analyzed with the ChiMet software, which calibrates the signal in wavelength and then corrects it by taking into account the spectral sensitivity of the device (Madiedo et al., 2014; Madiedo, 2015b). The calibrated spectrum and the most significant emission lines identified with ChiMet are shown in *Figure 4*. As usual in meteor spectra, most of these lines correspond to neutral iron (Borovička, 1993; Madiedo, 2014; Espartero and Madiedo, 2016). In this case we have identified the emissions from Fe I-23, Fe I-4, Fe I-43, Fe I-42, Fe I-41, Fe I-318, and Fe I-15. The most significant emission, however, is that of the Na I-1 doublet (588.9 nm), followed by the contribution corresponding to the Mg I-2 triplet (516.7 nm). Further analysis of the relative intensities of these lines will provide information about the nature of the meteoroid.

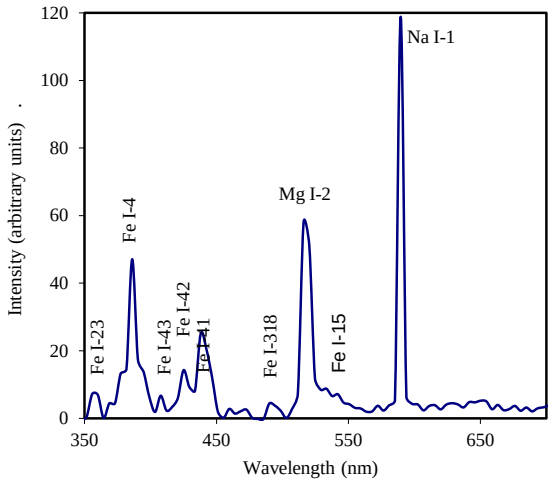

Figure 4 – Calibrated emission spectrum of the SWEMN20210312_233300 "Azuaga" fireball.

4 The 2021 March 15 fireball

This fireball event was recorded by SWEMN systems on 2021 March 15 at $0^h51^m08.8 \pm 0.1^s$ UTC, and its peak absolute magnitude was –11 ± 1 (*Figure 5*). It was spotted from the meteor-observing stations operating at La Sagra, Sierra Nevada, Calar Alto, Madrid, and Sevilla. The fireball, which can be viewed on this YouTube video[9], was included in the SWEMN meteor database under the code SWEMN20210315_005108.

Atmospheric path, radiant and orbit

The analysis of the images revealed that the fireball overflew the Mediterranean Sea, between the coasts of Andalusia (Spain) and Morocco. The parent meteoroid of this bolide entered the atmosphere with an initial velocity $v_\infty = 36.9 \pm 0.4$ km/s. The apparent radiant of the meteor was located at the equatorial coordinates $\alpha = 253.1^o$, $\delta = +48.4^o$. The bolide began at an altitude $H_b = 111.3 \pm 0.5$ km over the Mediterranean Sea, over the vertical of a point located at about 74 km of the coast of Spain and 62 km of the coast of Morocco. The terminal point of the trajectory was reached at a height $H_e = 59.1 \pm 0.5$ km over the sea. This trajectory and its projection on the ground are shown in *Figure 6*. We named this event "Alborán", since it began over the Alborán Ridge.

Figure 5 – Stacked image of the SWEMN20210315_005108 "Alborán" fireball over one of the domes of the Calar Alto Astronomical Observatory.

Figure 6 – Atmospheric path and projection on the ground of the trajectory of the SWEMN20210215_005108 "Alborán" fireball.

The calculation of the orbital elements of the progenitor meteoroid yields the results listed in *Table 2*, and the corresponding heliocentric orbit is shown in *Figure 7*. The value derived for the geocentric velocity is $v_g = 34.9 \pm 0.4$ km/s. The value of the Tisserand parameter with respect to Jupiter ($T_J = 2.3$) shows that this meteoroid also followed a cometary orbit (JFC type). According to radiant and orbital information listed in the IAU Meteor

[9] https://youtu.be/k6mv4IEOaBw

Data Center, this meteoroid belonged to the x-Herculid meteoroid stream (XHE#0346), which produces an annual display of meteors with a peak activity around March 12 (Jenniskens et al., 2016).

Table 2 – Orbital data (J2000) of the progenitor meteoroid of the SWEMN20210215_005108 "Alborán" fireball.

a (AU)	2.9 ± 0.2	ω (º)	197.5 ± 0.8
e	0.67 ± 0.02	Ω (º)	354.37180 ± 10^{-5}
q (AU)	0.975 ± 0.001	i (º)	59.4 ± 0.4

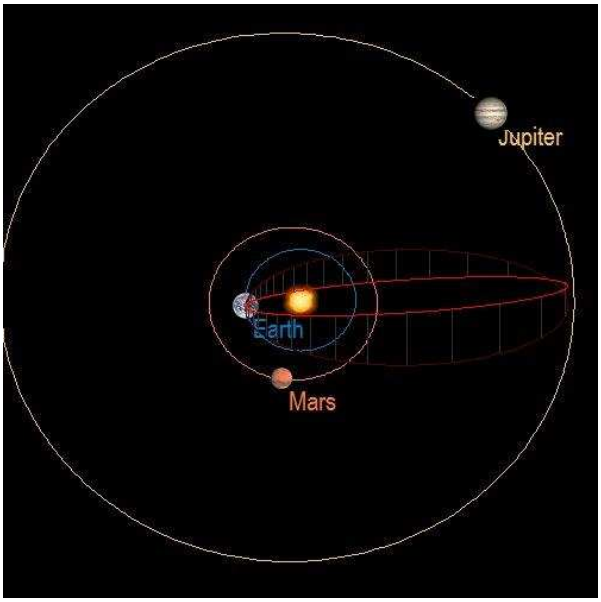

Figure 7 – Orbit (red line) of the parent meteoroid of the SWEMN20210215_005108 fireball, and its projection (dark red line) on the ecliptic plane.

5 The 2021 March 17 fireball

At $5^h06^m59.4 \pm 0.1^s$ UTC on March 17, our cameras recorded a bolide with a peak absolute magnitude of –8 ± 1 from the meteor-observing stations located at La Hita, Sierra Nevada, El Arenosillo, Calar Alto, La Sagra, Sevilla and Madrid (*Figure 8*). A video showing this event was uploaded to YouTube[10]. This bright meteor was included in our database with the code SWEMN20210317_050659.

Atmospheric path, radiant and orbit

By analyzing our recordings we obtained that the event overflew the provinces of Jaén and Ciudad Real. The pre-atmospheric velocity observed for this meteor was v_∞ = 28.9 ± 0.3 km/s. The bolide began at an altitude H_b = 99.9 ± 0.5 km over the north of the province of Jaén and ended at a height H_e = 52.1 ± 0.5 km over the south of the province of Ciudad Real. We named this meteor "Villamanrique", since this final stage was located almost over the vertical of this town. The apparent radiant of the bolide was located at the equatorial coordinates α = 188.9º, δ = +5.2º. The atmospheric trajectory of the fireball and its projection on the ground are shown in *Figure 9*.

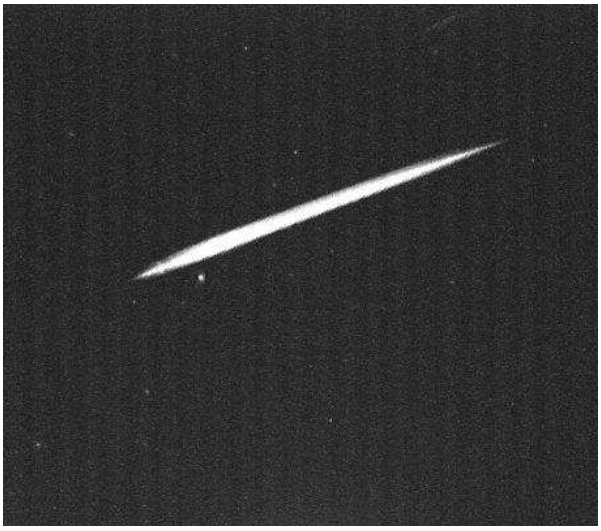

Figure 8 – Stacked image of the SWEMN20210317_050659 "Villamanrique" fireball as recorded from La Hita Observatory.

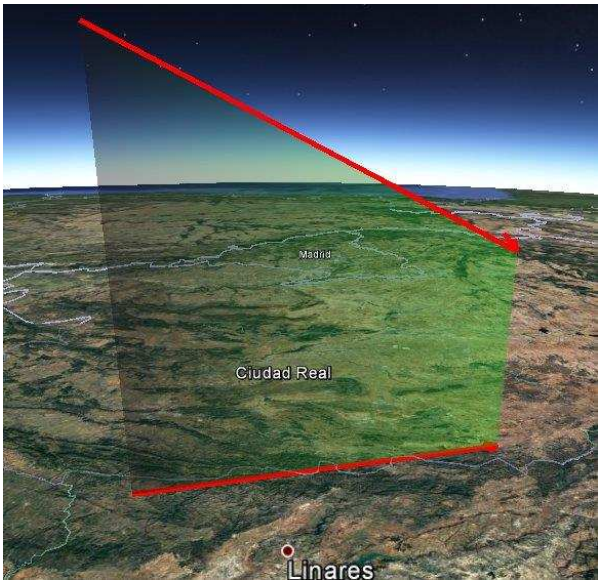

Figure 9 – Atmospheric path and projection on the ground of the trajectory of the SWEMN20210317_050659 fireball.

Table 3 – Orbital data (J2000) of the progenitor meteoroid of the SWEMN20210317_050659 "Villamanrique" fireball.

a (AU)	2.26 ± 0.08	ω (º)	285.24 ± 0.06
e	0.809 ± 0.008	Ω (º)	356.54225 ± 10^{-5}
q (AU)	0.433 ± 0.003	i (º)	5.6 ± 0.1

The heliocentric orbit of the meteoroid is shown in *Figure 10*, and the value of the corresponding orbital parameters are listed in *Table 3*. The geocentric velocity obtained in this case is vg = 27.1 ± 0.3 km/s. We concluded that this meteoroid followed an asteroidal orbit before its encounter with our planet, since the Tisserand parameter with respect to Jupiter yields T_J = 3.06. However, this value is in the limit between asteroidal and Jupiter family cometary orbits. Radiant and orbital data reveal that the

[10] https://youtu.be/3yd1TlLEbC8

bolide was an η-Virginid (EVI#0011). This meteor shower peaks around March 14 (Jenniskens et al., 2016).

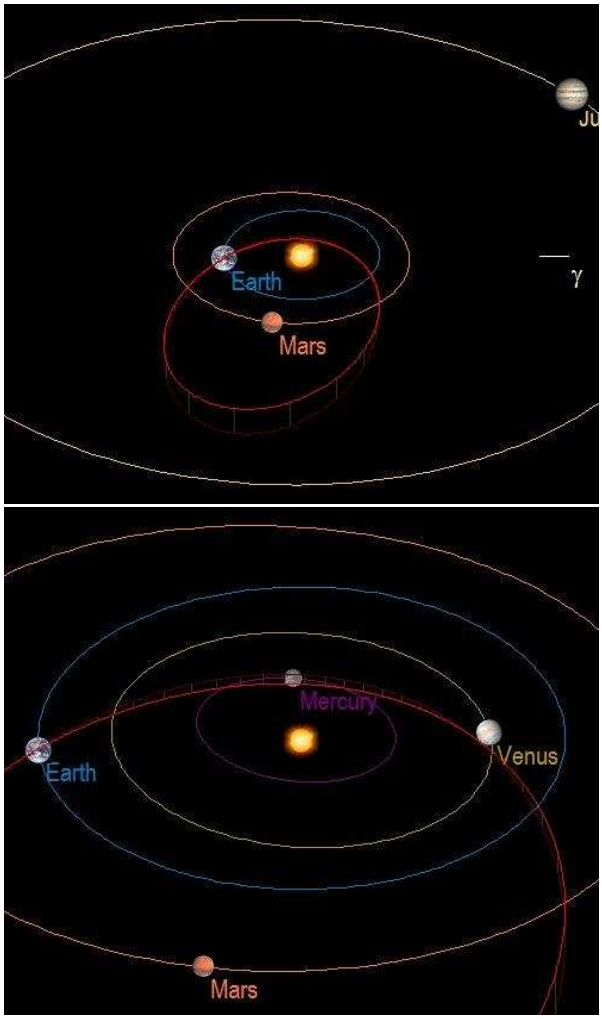

Figure 10 – Up: orbit (red line) of the parent meteoroid of the SWEMN20210317_050659 fireball, and its projection (dark red line) on the ecliptic plane; Down: close-up view of the orbit.

6 The 2021 March 21 fireball

The bolide observed on the 21st of this month was recorded at $20^h58^m34.7 \pm 0.1^s$ UTC and reached a peak absolute magnitude of -8 ± 1. As can be seen in *Figure 11*, it exhibited several flares along its atmospheric trajectory as a consequence of the disruption of the meteoroid. The event was spotted from the meteor-observing stations operated by the SWEMN network at the astronomical observatories of La Hita, Calar Alto, and El Arenosillo. It was included in our meteor database with the code SWEMN20210321_205834.

Atmospheric path, radiant and orbit

The observed initial velocity of the meteoroid was $v_\infty = 30.6 \pm 0.4$ km/s, and the apparent radiant of the event was located at the equatorial coordinates $\alpha = 190.0^o$, $\delta = +1.5^o$. It overflew the Mediterranean Sea, between the coasts of Andalusia (Spain) and Africa. Thus, the bolide began at an altitude $H_b = 88.6 \pm 0.4$ km over the sea. At this stage it was over the vertical of a point located at about 26 km from the coast of Algeria and 133 km from the coast of Spain. The fireball ended at a height $H_e = 58.8 \pm 0.4$ km over a point located at about 51 km from the coast of Morocco and 100 km from the coast of Spain. We named this fireball "Cábliers", since it overflew the Cábliers Bank, located under the Mediterranean Sea. *Figure 12* shows the atmospheric trajectory of this meteor and its projection on the ground.

The computed orbital elements are shown in *Table 4*, and the heliocentric orbit is drawn in *Figure 13*. The geocentric velocity of the meteoroid yields $v_g = 28.1 \pm 0.3$ km/s. According to the data provided by the IAU meteor database, we concluded that this fireball was also associated with the η-Virginids (EVI#0011), as we found for the previously described SWEMN20210317_050659 bolide. In this case the Tisserand parameter with respect to Jupiter yields $T_J = 3.04$, which shows that the meteoroid followed an asteroidal orbit before its encounter with Earth. Nevertheless, this value is in the limit between asteroidal and Jupiter family cometary orbits.

Table 4 – Orbital data (J2000) of the progenitor meteoroid of the SWEMN20210321_205834 "Cábliers" fireball.

a (AU)	2.3 ± 0.1	ω (º)	288.4 ± 0.2
e	0.827 ± 0.008	Ω (º)	1.17314 ± 10^{-5}
q (AU)	0.402 ± 0.002	i (º)	4.8 ± 0.1

Figure 11 – Stacked image of the SWEMN20210321_205834 "Cábliers" fireball as recorded from Calar Alto.

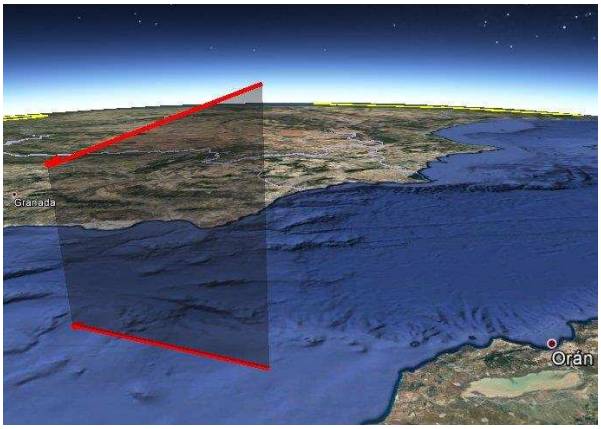

Figure 12 – Atmospheric path and projection on the ground of the trajectory of the SWEMN20210321_205834 fireball.

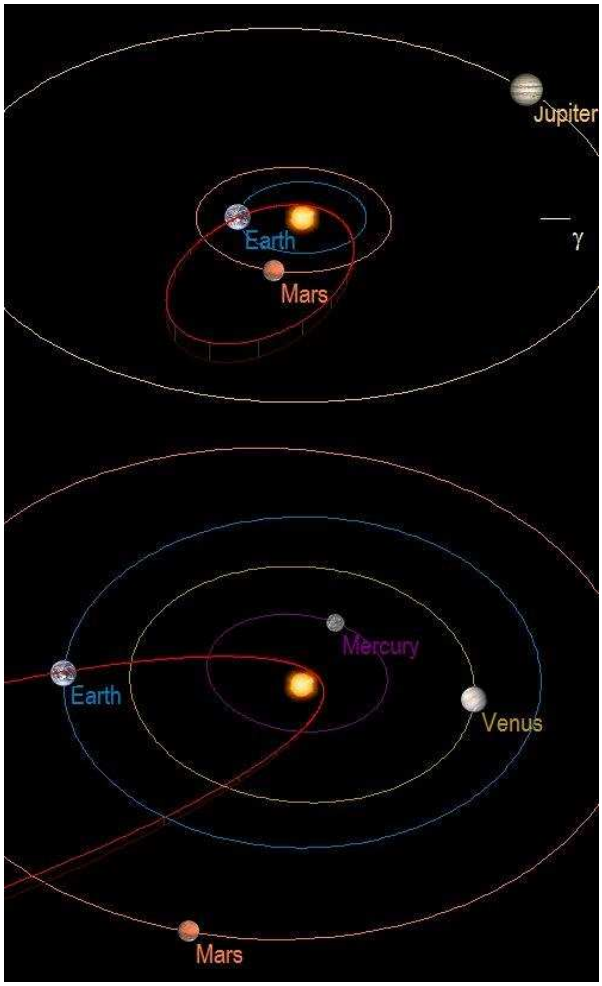

Figure 13 – Up: orbit (red line) of the parent meteoroid of the SWEMN20210321_205834 fireball, and its projection (dark red line) on the ecliptic plane; Down: close-up view of the orbit.

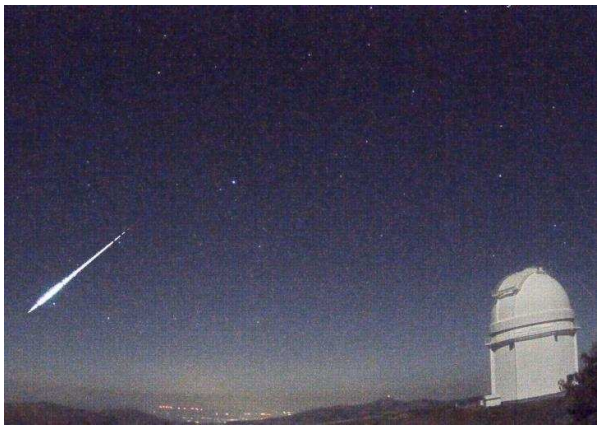

Figure 14 – Stacked image of SWEMN20210325_004454 "Alcira" fireball as recorded from Calar Alto.

7 The 2021 March 25 fireball

This bright meteor was detected at $0^h44^m54.0 \pm 0.1^s$ UTC on 2021 March 25, and reached a peak absolute magnitude of -9 ± 1 (*Figure 14*). The bolide was spotted from the SWEMN meteor-observing stations located at La Hita, La Sagra, Calar Alto, Madrid, and Sierra Nevada. A video showing this fireball was uploaded to YouTube[11]. It was included in the SWEMN meteor database with the code SWEMN20210325_004454.

Atmospheric path, radiant and orbit

The analysis of the atmospheric trajectory reveals that the meteoroid entered the atmosphere with an initial velocity $v_\infty = 42.0 \pm 0.4$ km/s. The apparent radiant of the meteor was located at the equatorial coordinates $\alpha = 209.0^o$, $\delta = -9.8^o$. The luminous event began at an altitude $H_b = 96.6 \pm 0.5$ km over the north of the province of Alicante, and ended over the province of Valencia, at a height $H_e = 50.0 \pm 0.5$ km. The meteor overflew Alcira, a town located in the province of Valencia. For this reason we named the fireball after this place. *Figure 15* shows its atmospheric trajectory and the projection on the ground of this path.

Table 5 – Orbital data (J2000) of the progenitor meteoroid of the SWEMN20210325_004454 "Alcira" fireball.

a (AU)	2.5 ± 0.1	ω (º)	329.4 ± 0.2
e	0.967 ± 0.003	Ω (º)	4.30143 ± 10^{-5}
q (AU)	0.084 ± 0.002	i (º)	3.0 ± 0.1

Figure 15 – Atmospheric path and projection on the ground of the trajectory of the SWEMN20210325_004454 fireball.

By means of the Amalthea software we derived the values listed in *Table 5* for the orbital elements of the parent meteoroid. This orbit is plotted in *Figure 16*. The calculated value of the geocentric velocity of this particle yields $v_g = 40.4 \pm 0.4$ km/s. According to the information found in the IAU meteor database, these results show that the fireball was a κ-Virginid (KVI#0509). This poorly-known meteoroid stream produces every year a display of meteors peaking around March 26 (Segon et al., 2013). So, this event was recorded one day before this peak. The Tisserand parameter with respect to Jupiter yields $T_J = 2.3$, which shows that this meteoroid followed a cometary orbit (JFC type) before entering our atmosphere.

[11] https://youtu.be/f5FN0TDUoKs

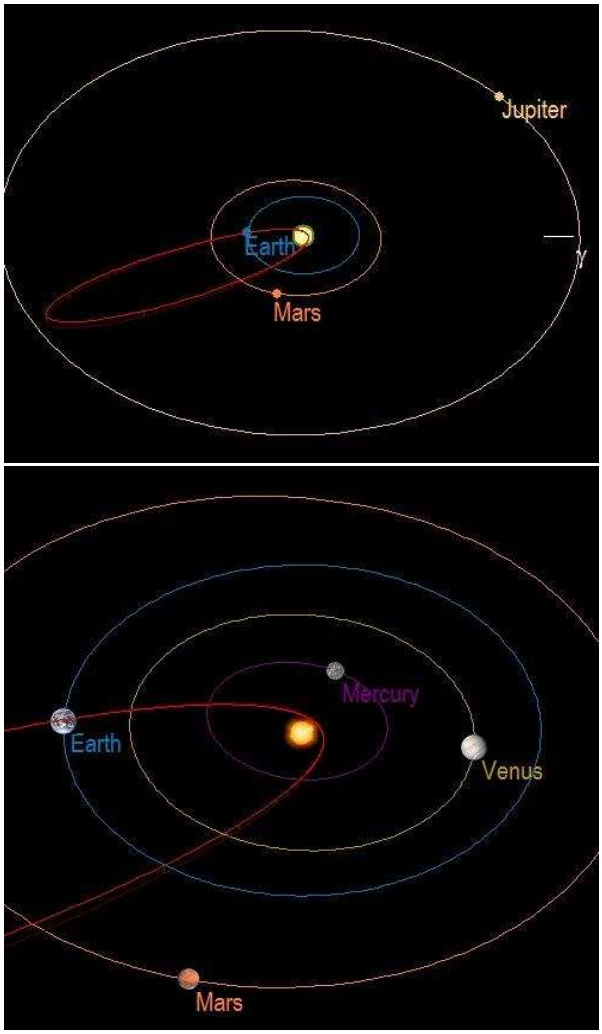

Figure 16 – Up: orbit (red line) of the parent meteoroid of the SWEMN20210325_004454 fireball, and its projection (dark red line) on the ecliptic plane; Down: close-up view of the orbit.

Figure 17 – Stacked image of the SWEMN20210328_042115 "Villacarrillo" fireball over the domes of the Calar Alto Astronomical Observatory.

8 The 2021 March 28 fireball

The last event in this report was recorded on 2021 March 28 at $4^h21^m15.8 \pm 0.1^s$ UTC (*Figure 17*). It reached a peak absolute magnitude of -10 ± 1. Despite non favorable weather conditions, it was recorded from several SWEMN stations: La Hita, La Sagra, Calar Alto, Sevilla, Madrid, and Sierra Nevada. A video showing images and the trajectory of this fireball was uploaded to YouTube[12]. The event was included in our meteor database with the code SWEMN20210328_042115.

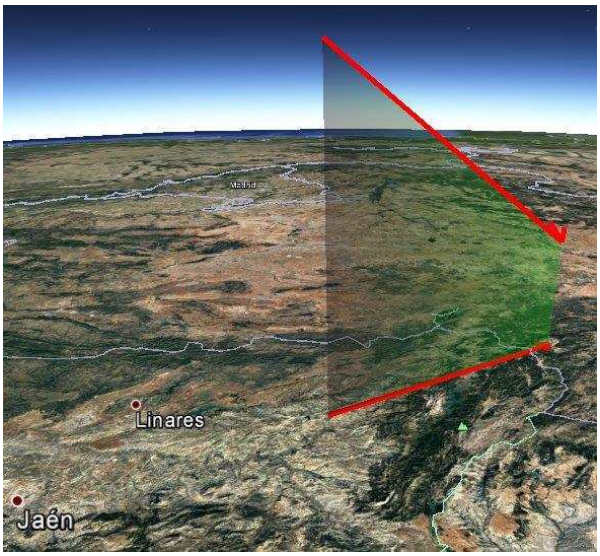

Figure 18 – Atmospheric path and projection on the ground of the trajectory of the SWEMN20210328_042115 fireball.

Atmospheric path, radiant and orbit

From the calculation of the atmospheric trajectory of the meteor we concluded that this event overflew the regions of Andalusia and Castilla-La Mancha (south of Spain). The parent meteoroid entered the atmosphere with an initial velocity $v_\infty = 24.5 \pm 0.3$ km/s, and the apparent radiant was located at the equatorial coordinates $\alpha = 195.0^o$, $\delta = +5.1^o$. The bolide began at an altitude $H_b = 89.6 \pm 0.5$ km. At this initial stage the event was located almost over the vertical of Villacarrillo, a village located in the province of Jaén (Andalusia). For this reason we named this bolide after this location. The terminal point was located over the province of Albacete (Castilla-La Mancha), at a height $H_e = 29.3 \pm 0.5$ km. *Figure 18* shows the atmospheric trajectory of the "Villacarrillo" bolide and its projection on the ground.

Table 6 – Orbital data (J2000) of the progenitor meteoroid of the SWEMN20210328_042115 "Villacarrillo" fireball.

a (AU)	1.95±0.05	ω (º)	272.9±0.1
e	0.71±0.01	Ω (º)	7.42063 ± 10^{-5}
q (AU)	0.561±0.004	i (º)	5.2±0.1

The calculation of the orbital elements of the meteoroid yields the results listed in *Table 6*. The corresponding orbit

[12] https://youtu.be/FJmgkYGTUWA

is drawn in *Figure 19*. The geocentric velocity derived for this case was $v_g = 22.2 \pm 0.3$ km/s, and the Tisserand parameter with respect to Jupiter ($T_J = 3.5$) indicates that the meteoroid followed an asteroidal orbit. According to the information included in the IAU meteor database, from these results we concluded that the fireball was a σ-Leonid (SLE#136). This is a poorly-known meteoroid stream whose meteor activity peaks around March 29 (Molau and Rendtel, 2009).

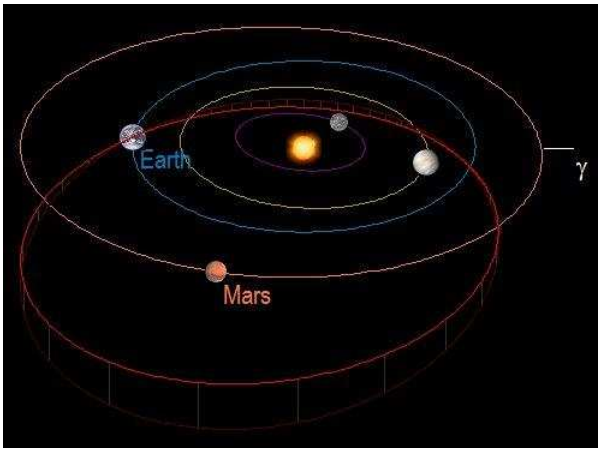

Figure 19 – Orbit (red line) of the parent meteoroid of the SWEMN20210328_042115 fireball, and its projection (dark red line) on the ecliptic plane.

Emission spectrum

Our spectrographs located at La Hita and La Sagra meteor-observing stations recorded the emission spectrum of this fireball. *Figure 20* shows the calibrated signal, together with the most important emissions present in this spectrum. As can be noticed, we have identified lines produced by several Fe I multiplets, as those of Fe I-318 and Fe I-15. The latter is the most remarkable emission together with those of Mg I-2 and Na I-1. In addition to this line of neutral sodium, the emission of Na I-6 at 562.8 nm was also identified. The lines of Ca I-21 (559.9 nm) and Ca I-3 (649.3 nm) are also present in the signal, together with several contributions of atmospheric N_2 in the red region of the spectrum.

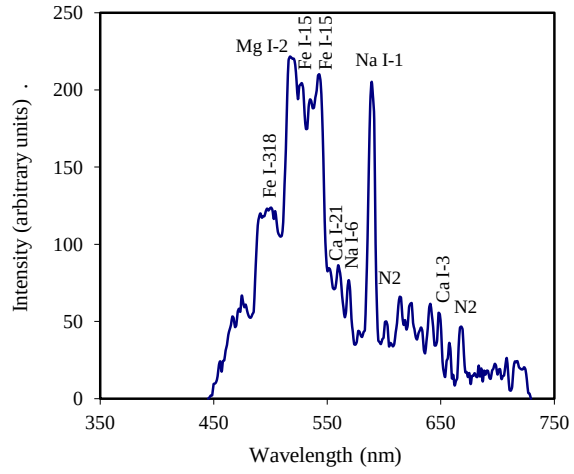

Figure 20 – Calibrated emission spectrum of the SWEMN20210328_042115 "Villacarrillo" fireball.

A deeper analysis of this spectrum will be performed in order to obtain information about the chemical nature of meteoroids in the σ-Leonid stream. Thus, the analysis of emission spectra produced by events associated with poorly-known streams is one of the aims of the SMART survey (see, for instance, Madiedo et al., 2013; Madiedo 2014).

9 Conclusion

The most remarkable bolides recorded during March 2021 in the framework of the Southwestern Europe Meteor Network (SWEMN) have been described. The absolute magnitude of these bright meteors during their peak luminosity ranged from –8 to –11. Our analysis has revealed that these events were produced by meteoroids belonging to the sporadic background and several minor and poorly-known streams.

The "Azuaga" fireball, recorded on March 12, overflew the province of Badajoz and was associated with the sporadic background. It reached a peak absolute magnitude of –11. The meteoroid followed a cometary orbit (JFC orbit) before hitting the Earth's atmosphere. In the spectrum of this meteor we have identified the emissions from several neutral iron multiplets (Fe I-23, Fe I-4, Fe I-43, Fe I-42, Fe I-41, Fe I-318, and Fe I-15). The most significant contributions in this signal are the corresponding to the Na I-1 doublet and the Mg I-2 triplet.

The "Alborán" bolide, spotted on March 15, overflew the Mediterranean Sea and reached a peak absolute magnitude of –11. It was produced by a member of the x-Herculid meteoroid stream (XHE#0346), which produces an annual display of meteors with a peak activity around March 12. Our results show that meteoroids in this stream follow a JFC orbit.

Another bright meteor was spotted by our network on March 17. This bolide, which was named "Villamanrique", overflew the south of Spain and had a luminosity equivalent to magnitude –8. It was associated with the η-Virginids (EVI#0011). Our results suggest an asteroidal origin for this stream. However, the value of the Tisserand parameter with respect to Jupiter is in the limit between asteroidal and JFC orbits.

The Mediterranean Sea was flown over by another mag. –8 η-Virginid fireball on March 21. This bright meteor was named "Cábliers". Again, the value of the Tisserand parameter with respect to Jupiter is in the limit between asteroidal and JFC orbits, and so our results cannot clarify the nature (asteroidal or cometary) of the parent body of this stream.

The "Alcira" bolide, with a peak absolute magnitude of –9, was spotted on March 25 and overflew the provinces of Alicante and Valencia. It was produced by a meteoroid belonging to the κ-Virginid stream (KVI#0509). This is recently-discovered and poorly-known meteoroid stream which produces an annual meteor shower that peaks around

March 26. According to our results, the meteoroid followed a Jupiter family comet orbit before entering the Earth's atmosphere.

The last fireball presented in this report was recorded on March 28 and had a peak absolute luminosity equivalent to magnitude –10. It overflew the regions of Andalusia and Castilla-La Mancha, and was generated by a meteoroid from the σ-Leonids (SLE#136). This is a poorly-known meteoroid stream whose meteor activity peaks around March 29. Our calculation reveals that this meteoroid followed an asteroidal orbit before hitting our atmosphere. The most remarkable contributions in the spectrum of this bolide are those of Fe I-15, Mg I-2, and Na I-1. The lines of Na I-6, Ca I-21 and Ca I-3 have been also found. A deeper analysis of this spectrum will provide key information about the composition of meteoroids in this stream.

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