SPECTRAL AND ORBITAL ANALYSIS OF URSID METEORS FROM 2006 TO 2018. M. Granados[1]. J.M. Madiedo[1]. J.L. Ortiz[2], J. Aceituno[3], E. de Guindos[3]. [1]Facultad de Ciencias Experimentales, Universidad de Huelva, 21071 Huelva, Spain. [2]Instituto de Astrofísica de Andalucía, CSIC, Apt. 3004, 18080 Granada (Spain). [3]Centro Astronómico Hispano-Alemán, Calar Alto (CSIC-MPG), E-04004 Almería, Spain.

Introduction: The Ursid meteor shower gives rise to an annual display of meteors from about December 17 to December 26, peaking on around December 23 [1]. Its activity is low, with a normal peak ZHR of about 10 meteors/hour. However, this shower exhibits activity outbursts that significantly increase this maximum zenithal hourly rate. These outbursts take place when the parent body of Ursid meteoroids, Comet 8P/Tuttle, is located at its perihelion or at its aphelion.

The Ursids have been monitored in the framework of the SMART project (Spectroscopy of Meteoroids in the Atmosphere by means of Robotic Technologies) from 2006 to 2018. The number of meteor-stations setup by this project in Spain has increased continuously since 2006 [2, 3], which resulted in a significant increase, year after year, of the number of double-station Ursid meteors recorded by our CCD and CMOS video cameras. Also in the number of emission spectra produced by bright Ursids. Our meteor cameras and spectrographs have monitored the activity of these meteors during the night. But SMART also employs forward-scatter systems that allowed us to follow the activity of the Ursids also during the day. In this way, SMART could gather very useful information to analyze the Ursid meteoroid stream, including the heliocentric orbit of the meteoroids and their chemical nature. Of special interest are the meteors and spectra recorded during the 2014 Ursid outburst (Madiedo et al., in preparation). In this work we present a preliminary analysis of some of the results that have been derived so far.

Instrumentation and methods: The activity of the Ursids has been monitored by means of different instruments. We have used an array of low-lux CCD video cameras manufactured by Watec Co. (models 902H and 902H2 Ultimate). These monitor the night sky and operate in a fully autonomous way by means of software developed by the second author [2, 3]. The atmospheric trajectory and orbital data of the event were obtained with the Amalthea software, developed by J.M. Madiedo [4]. To record the emission spectrum of bright meteors, videospectrographs based on the above-mentioned CCD video cameras and two spectrographs based on low-scan CCD devices have been employed. All of them employed holographic transmission gratings attached to the objective lens of the cameras [2, 3]. In addition, two forward scatter systems operating at two of our meteor-observing stations (Sevilla and La Hita) have been used to monitor the activity of radio meteors.

Figure 1. Sum-pixel image of a mag. -1 Ursid recorded on 2014 Dec. 22 at 06h06m35s UT from the SMART meteor-observing station located at the Calar Alto Astronomical Observatory.

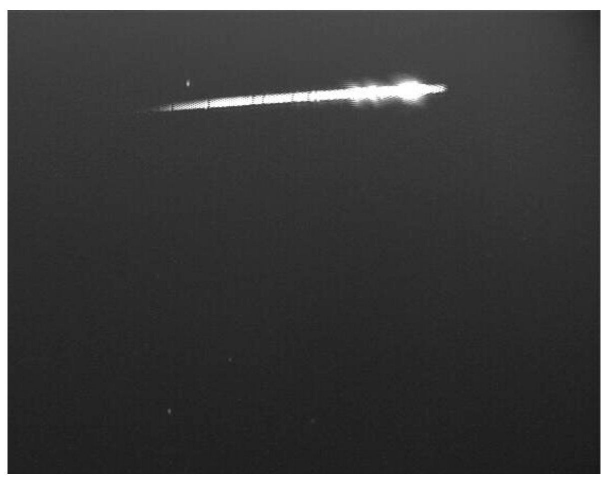

Figure 2. Sum-pixel image of a mag. -7 Ursid fireball recorded on 2016 Dec. 22 at 18h10m16s UT from the meteor-observing station located at Sevilla.

Preliminary results: The luminosity of most multi-station Ursid meteoroids identified as far as now in the meteor database of the SMART project have a luminosity below the corresponding to an stellar magnitude of -4. Figure 1 shows an example of one of these multi-station events, recorded during the 2014 Ursid outburst from Calar Alto. However, some brighter and more remarkable events have also been found. One of them is the mag. -7 Ursid fireball recorded from two of our meteor-observing stations (Sevilla and Cerro Negro) on 2006 Dec. 22 at 18h10m16s UT (Figure 2). Up to now, we have calculated the heliocentric orbit of 25 of the Ursids in our database, and ongoing work is being performed with additional events. The average geocentric velocity calculated for the events analyzed so far is of about 32 km/s.

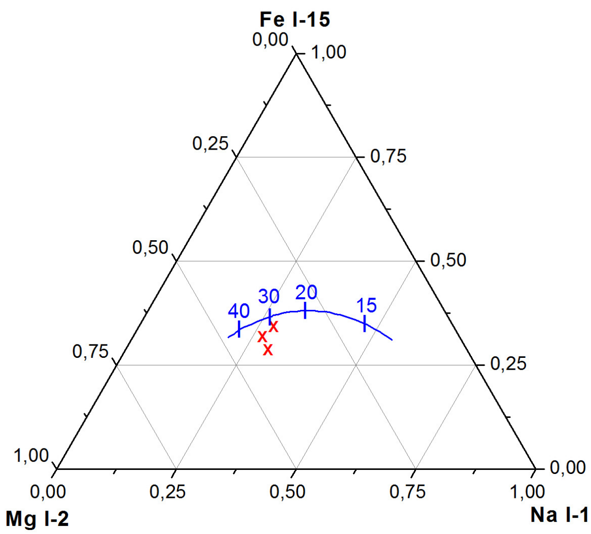

Figure 3. Expected relative intensity (solid line), as a function of meteor velocity (in km/s), of the Na I-1, Mg I-2, and Fe I-15 multiplets for chondritic meteoroids [5]. The crosses show the experimental relative intensity obtained for three Ursid meteors.

Several emission spectra of Ursid fireballs were recorded by means of the spectrographs operating in the framework of the SMART project. These spectra were analyzed by means of the CHIMET software, developed by J.M. Madiedo [2, 3]. Most lines identified in the spectra analyzed so far correspond to neutral Fe. However, the spectra are dominated by the contributions from the Na I-1 doublet at 588.9 nm and the Mg I-2 triplet at 516.7 nm. As in previous works, to obtain information about the chemical nature of the progenitor meteoroids the relative intensity of the contributions from Na I-1, Mg I-2 and Fe I-15 have been compared [5]. The preliminary result for three of the spectra processed so far is shown in the triangular diagram in Figure 3. The solid curve indicates the expected relative intensity as a function of meteor velocity for chondritic meteoroids [5]. The values corresponding to these spectra fit fairly well the expected relative intensity for a meteor velocity of about 30 km/s, which suggests a chondritic nature for the progenitor meteoroids. This shows that the composition of Ursid meteoroids is normal, in the sense explained in [5].

Conclusions: We have monitored the activity of the Ursid meteor shower from 2006 to 2018, including the outburst experienced by this shower in 2014. Our monitoring was performed in the framework of the SMART project by means of different devices. These included CCD video cameras, spectrographs and forward-scatter systems. The brightest multi-station Ursid found so far in our meteor database had a magnitude of about -7, and the average geocentric velocity of meteors analyzed up to now is of about 32 km/s. We have shown here also the preliminary results from the analysis of three Ursid emission spectra. This analysis reveals the normal composition of Ursid meteoroids.

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References: [1] Jenniskens P. (2016), Meteor Showers and their Parent Comets, Cambridge University Press. [2] Madiedo J.M. (2014), Earth, Planets & Space, 66, 70. [3] Madiedo J.M. (2017), Planetary and Space Science, 143, 238. [4] Madiedo J.M. et al. (2011), NASA/CP-2011-216469, 330. [5] Borovicka J. et al. (2005), Icarus, 174, 15.