UCM Meteor and Fireball Research group: Results 2012-2014

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Abstract

Most of the activity of the group is based on the Fireball Detection Station located at the Observatorio UCM, a system consisting of 6 high-sensitivity videocameras covering the whole sky with wide-angle lenses during nighttime. It works as a node in the SPanish Meteor and Fireball Network (SPMN), a network of similar stations covering the atmosphere over Spain.

This continuous monitoring during the last 2 years has resulted in the detection from the Observatorio UCM of 4 superbolides that occurred over Iberian Peninsula [Icarus 233 (2014): 27-35; MNRAS 436.4 (2013): 656-3662; LPI (2013) No. 1719, p.1055].

Besides, the group has worked on the recording and analysis of some meteor showers. Most of the attention was focused on the Draconids 2011 campaign at Observatorio de Sierra Nevada [MNRAS 433.1 (2013): 560-570; IMC Proc. (2012): 70-73], and the 2012 Geminids balloon-borne mission over Spain [LPI (2013) No. 1719, p.2202]. The group also contributed with observations of the Draconids 2012 unexpected storm from Madrid and Izaña [MNRAS 437.4 (2014): 3812-3823.].

The products of the station have been used for undergraduate thesis projects at the Physics Faculty (e-prints UCM 13292) and other undergraduate projects. In 2013 the station received new equipment thanks to the Certamen Arquímedes award, complementing the detection with spectroscopic and frame-integrating devices.

Stations operated by the SPMN-UCM group

Madrid NE	40º 27' 01" N	3º 39' 36" W
Madrid NO	40º 27' 19" N	3º 42' 42" W
Madrid S	40º 24' 00" N	3º 42' 09" W
Majadahonda	40º 28' 08" N	3º 51' 48" W
V. del Ducado	41º 00' 04" N	2º 29' 29" W

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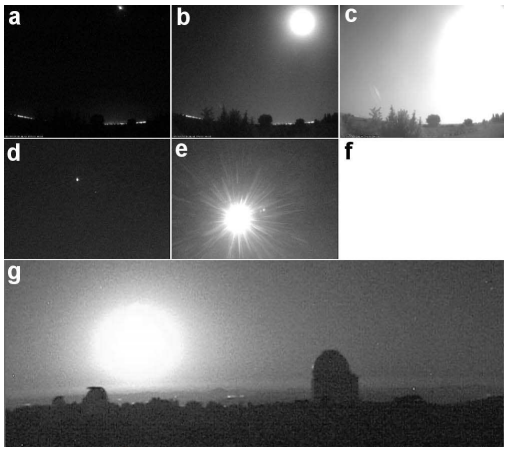
Superbolides research

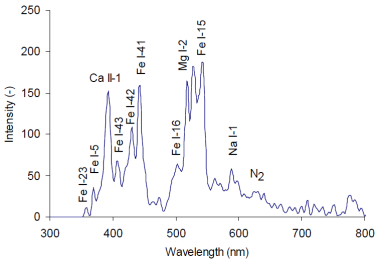
Most of the stations operated by the UCM group run every night , as one of the main goals of the network is detecting superbolides. These bright fireballs (brighter than -17 apparent magnitude) are very rare and completely unexpected. The detection and study of these events is the best tool to understand the origin and nature of the meter-sized population of meteoroids with orbits crossing the Earth orbit.

During the last 2 years our stations have recorded 4 superbolides flying over the Peninsula. [Icarus 233 (2014): 27-35; MNRAS 436.4 (2013): 656-3662; LPI (2013) No. 1719, p.1055] The combination of all the data coming from double station and multiple station recordings within the SPMN has lead to the determination of the atmospheric trajectory, heliocentric orbit and oher physical properties such as their preatmospheric mass and tensile strength.



Video frames showing the initial phase, half position in the atmospheric path and maximum brightness of the SPMN130712 fireball as imaged from La Hita Astronomical Observatory - a), b) and c) - and Madrid - d), e) and f). g) Image taken from Calar Alto. Adapted from Madiedo J.M., et al (MNRAS 436.4 (2013): 656-3662)

Moreover some of the stations have spectroscopic capabilities. The use of diffraction gratings in the videocameras is essential to observe the differential ablation of the components of the meteoroids. The study of the composition of these particles is directly related to the nature of the parents bodies, providing valuable chemical analysis of many minor bodies.



Calibrated emission spectrum of the SPMN130712 superbolide. Intensity is expressed in arbitrary units. Madiedo J.M., et al (MNRAS 436.4 (2013): 656-3662)

Meteor showers monitoring

As part of the continuous monitoring performed by the video stations, many meteors showers are detected. Sometimes some of them are relevant enough to deploy some extra stations to do a detailed research of the shower or event. Some of these campaigns have been along several years (e.g., Perseids [LPSC (2013) No. 1717, p.1159]) or for some particular events as the 2011 Draconids outburst [MNRAS 433.1 (2013): 560-570; IMC Proc. (2012): 70-73], or the recent 2014 Camelopardalids outburst [in press].

Composite image with all the fireballs and meteors recorded the 12th August 2014 by one camera of the station operated by Jaime Izquierdo from the center of Madrid. More than 20 meteors are recorded (most of the Perseids). The bright streak in the top left is the track of the Full Moon along the night.

Balloon-borne missions

Since 2011 we have been sending high-sensitivity video cameras to the stratosphere on-board weather balloons. It improves detection efficiency thanks to much lower extinction. These experiments are much cheaper that the airborne missions that have been already organised for relevant meteor outbursts. At the moment we have already carried out missions for the Draconids 2011, Geminids 2012 [LPI (2013) No. 1719, p.2202] and Camelopardalids 2014., and we are prepared to do these launches on a regular basis for the major meteor showers.

Launch images: (Bottom, left, center) D8 Draconids: two balloon configuration . D12-Geminids: (Up right) configuration diagram. (Up left) Watec 902H2 + Avenir 12mm F1.2. (Bottom right) Recovering stick. [LPI (2013) No. 1719, p.2202]

Trace of a SPO meteor on a registered and stack image. The brightest star is Beta Peg [LPI (2013) No. 1719, p.2202].

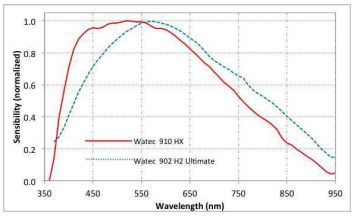
Apart from the difficulties involved in the launch and recovering of the probe in a stratospheric mission (ground tracks longer than 200km), the processing of the images is also critical. In the figure on the right, the difference on the registration and the stracking on the images is very obvious.

Composition of stack frames, with a bright star and a meteor trailing along the FoV in a wobbly phase of the flight [LPI (2013) No. 1719, p.2202].

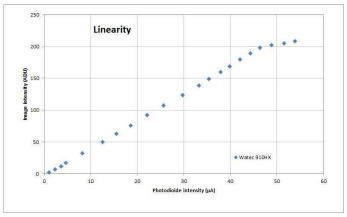
Instrumentation

Part of the research of the group has been focused on instrumentation development at the Laboratory for Scientific Advanced Instrumentation (Laboratorio de Instrumentación Científica Avanzada, LICA-UCM). The products of the station have been used for undergraduate thesis projects at the Physics Faculty (e-prints UCM 13292) and other undergraduate projects. In 2013 the station received new equipment thanks to the Certamen Arquímedes award, complementing the detection with spectroscopic and frame-integrating devices.

One of the new elements is a Watec 910 HX camera. It had never previously been used for meteor detection and the manufacturer claimed it to be more sensitive than the previous models. We carried out a sensitivity and spectral characterization, and compared it to our usual camera, the Watec 902 H2, that performed better.



Watec 910 HX and 902 H2 Ultimate response curve comparison [In press]



Watec 910 HX linearity test. Saturation is reached at approximately 200 ADUs (dark current subtracted) [in press]

The research in the instrumentation field has been also applied to the meteor detection in wide-field survey telescopes. In the new era of the time-domain astronomy, many telescopes will cover the whole sky with a cadence of a few days. These requirements lead to fast large telescopes with wide FOVs, like the Schmidt cameras that were widely used for meteor observing in the past. Our estimations show that meteor detection rates that will be achieved with the future wide-field survey telescopes are similar to the ones for current video networks. Therefore, meteors detected as by-products in these surveys will be a free source of meteoric data that could be easily exploited.