



# First scientific results of the Fireball Detection Station at UCM Observatory



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guaix.fis.ucm.es/fireball/



## Abstract

Observatorio UCM is one of the nodes of the Spanish Meteor Network (SPMN), an interdisciplinary research project of interplanetary matter. Since 2008 we are operating a high sensitivity camera in double station with UCLM in Toledo, and since 2010 we are operating the full station with 12 additional cameras.

We present the scientific results of the UCM Fireball Detection Station during its 2 first years of operation. The main event was the observational campaign of the Draconids 2011 outburst with a mobile station and an stratospheric balloon.

This campaign join the general exploitation of the data generated continuously by the station in collaboration with SPMN. In addition to our outreach efforts in this field and the results obtained, the project has opened up itself even more to society and students of Bachelor Degree in Physics from the UCM who have participated in the reduction and analysis of the data, some graduations projects and collaborations.

Fireball Detection Station of the Universidad Complutense de Madrid is located at the terrace roof of the and is part of the Observatorio UCM (40° 27' 04" N 03° 43' 34" W).

It has 6 high sensitivity cameras covering the whole sky with a plate scale better than 10 arcmin/pixel. The project was funded by Spanish Science Ministry to monitor continuously the sky over the centre of Iberian Peninsula.



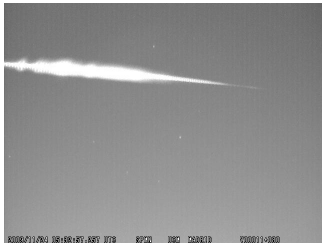
Madrid SPMN node is linked with several other stations: UCLM, UV, UHU, AAM and several amateurs.

### Stations operated by the SPMN-UCM group

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

## Large meteoroids on minor cometary streams

Meteoroids streams are mainly associated with comets. The classic mechanism is ejection from the comet surface by the drag of the sublimated gas. However it imposes certain restrictions to the lift off for massive particles. Other streams are formed by *catastrophic disruption*, and this process leads to some amount of large meteoroids. These big fragments are observed by the SPMN as large fireballs when they enter the atmosphere. The records of these events allow us to calculate its orbit and parent body.



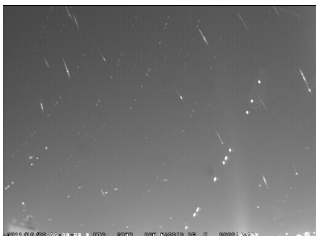
The Valhermoso bolide (SPMN 241109) was an Earth-grazing event imaged from high-resolution video cameras in the UCM station in Madrid and UCLM station in Toledo. The estimated absolute magnitude was -10. [Moreno-Ventas J., et al 2010]



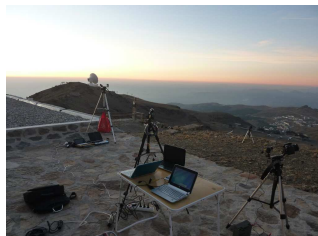
The SPMN310711  $\alpha$ -Capricornid fireball imaged from Madrid (Observatorio UCM). Our data are consistent with the recently established idea that minor planet 2002 EX12 is the parent body of the  $\alpha$ -Capricornid meteoroids stream. [Zamorano J., et al, 2012]

## Outburst Draconids 2011

The 8th of October took place an outburst of Draconids, with the maximum at ~20hTU as forecast. GUAIX (UCM group of Extragalactic Astrophysics and Astronomical Instrumentation) prepared a dedicated observing campaign to complement the continuous monitoring at Observatorio UCM.



Composed image with all the Draconids detected in 1h30m by one of the cameras of the Fireball Video-Detection Station at Observatorio UCM. The 'jet of light' is caused by the Torre Picasso illumination.



Part of the group went to Sierra Nevada Observatory (OSN) of the Instituto de Astrofísica de Andalucía (IAA) at 2900m high. More than a hundred of Draconids were recorded. Some fireballs were observed in multiple station by several nodes of the Spanish Meteor Network.

The highlight was the launch of a high altitude helium balloon with a scientific payload for recording the Draconids. It was done in collaboration with Proyecto Daedalus that had launched successfully others balloons. The payload consisted of a netbook recording the signal coming from a Wattec high-sensitivity video camera.

The balloon was launched in Daimiel, Spain and it landed 200km away, after a 4h flight. It reached the 29km level, and descended slowly to a place close to Jaén. The probe was recovered just before the astronomical twilight (as seen in the picture on the left). Unfortunately the computer stopped working after 45 minutes, when it was at ~11000m high.



## Fireballs and the Solar System

As fireballs are caused by material from several bodies of the Solar System, their study is extraordinary valuable. In fact, the brightest fireballs announce the fall of meteorites, that are indispensable to understand the formation processes of asteroids, comets and planets.

Recording fireballs from several stations allows the calculation of the atmospheric trajectory and the meteorite fall places. The SPMN is monitoring now almost all the atmosphere volume above the Iberian Peninsula.

Moreover we are measuring its speed while entering the atmosphere to determine the orbit in the Solar System and the subsequent provenance.

Meteoroid flux arriving to Earth each year versus their masses. Over 10 kg are able to survive the atmospheric pass and fall as meteorites

## Undergraduate Research Projects

**Dungeons and Draconids (& Fellows!):** The GUAIX group conducted an observing campaign of the Draconids 2011 meteor shower, motivated by the predictions of a historic high activity. More than 50 GB of data were collected and taken to the dungeons of the Faculty of Physical Sciences of the UCM, where they are being analyzed by some students in an undergraduate collaboration project.

**Spectracolour:** Spectracolour is a project to study light emission from fireballs and meteors. Our goal is to present an alternative narrow-band photometric system against spectroscopy.

**MetCode:** MetCode es un sistema automático de eliminación de falsos positivos en la detección de meteoros. Permite mejorar la capacidad de detección sin disminuir la sensibilidad del software específico.

**Radianes UCM:** Radianes UCM is an undergraduate students' project of the Fireball Research Group. The main goal of the project is introducing young students into modern day investigation and help the group to exploit the large meteor database. Two years ago, the group set up a six camera system in order to record every meteor above Madrid. Since its installation over ten thousand events have been detected.

## Photometric system for fireball observation

We have designed a photometric system to measure several meteor properties more efficiently than others spectroscopic methods using prisms or gratings. Using photometric filters improves the detection of fireballs and meteors, especially under skies with heavy light pollution like at the Observatorio UCM.

We have developed a simulation and pipeline software, and tested the feasibility of this technique. We are currently using the Spanish VO service to analyze our experimental data.

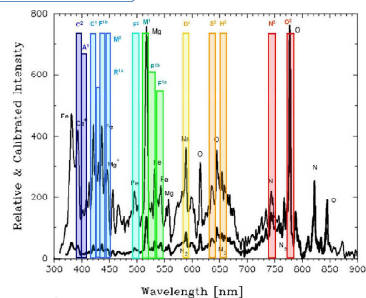
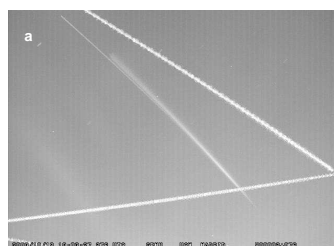


Figure shows a typical spectrum of a fast fireball and the photometric bands of the system proposed overlaid.

## Space Surveillance Educational Outreach – Video monitoring

Satellites in Earth orbit could be monitored using different techniques. Video monitoring has been proven to be successful for optical ground tracking allowing high temporal resolution (equivalent to good astrometric precision for these moving objects). It is feasible to use this technique at Secondary School and University levels to increase the Educational Outreach of the space activities. Ground optical and radar tracking suffer from some difficulties that can be overcome by a network of low cost cameras spread throughout Europe. From continuous monitoring at UCM Observatory we have recorded satellite reentries, fuel dumps, and several satellites flashes. [Ocaña F. & Zamorano J., 2011]



(a) On 18th October 2009 the detection station recorded an object surrounded by a relatively bright halo. Several other stations and amateur observers around the world observed this phenomenon. The object was lately identified by several sources as a Centaur stage dumping the remaining fuel after inserting into orbit the F18 US Military Weather Satellite.



(b) Observatory UCM has collaborated with Simone Corbellini (Politecnico di Torino) in satellite surface modelling. Composite image shows our first successful observation. It was done for the pair NOSS 3 4(A) and NOSS 3 4(C) on the 17th February 2007.