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The Perseids: Results from 7 years of observations with the SPOSH camera

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Abstract

We will provide a full characterisation of the Perseid meteoroid stream using meteor observations acquired between 2009-2016 by the SPOSH camera systems. The image data will be reduced using a sophisticated software package developed to exploit the high performance of the imager.

1. Introduction

The Perseids is one of the most prominent meteor showers which can be observed from the Northern hemisphere. The stream is formed from accumulating dust particles originating from comet 109P/Swift-Tuttle. The Earth reaches the core of the stream particles around the 12^{th} of August each year when more than 100 meteors per hour can be seen visually under favorable observing conditions. Although, a high number of Perseid meteors is expected every year, variations in meteor activity do occur when freshly ejected material -usually a few revolutions old- intersects Earth's orbital path. Meteor observations during exceptionally high meteor rates are of great interest, since they hold important information regarding the stream formation and the evolution of the comet.

2. Method

2.1 The SPOSH camera

The SPOSH camera was designed to image faint short-lived phenomena, such as meteors or impact flashes on dark planetary hemispheres from an orbiting platform [4]. The camera is equipped with a highly sensitive back-illuminated 1024×1024 CCD chip and has a custom-made optical system of high light-gathering power with a wide field of view of $120\times120°$. For the determination of the meteor velocity, a mechanically rotating shutter with a known frequency is mounted in front of the camera lens. The shutter consists of two rotating blades and has a frequency of 250 rpm resulting in an exposure time of 0.06 sec for every shutter opening. Due to the camera's all-sky coverage and excellent radiometric and geometric properties, a large number of meteors can be obtained for reliable event statistics.

2.2 Observing campaigns

We have been monitoring the Perseid meteor activity every year since 2009 by operating a set of two SPOSH cameras in southern Greece. The observing stations were deployed in remote areas at altitudes of 1400-1600m above sea level ensuring ideal observing conditions during the night. The observations cover a time period starting from late July (λs $\sim$120) to mid-August (λs $\sim$145) covering the pre-maximum as well as post-maximum activity of the shower. While our principal aim is to monitor recurrent annual shower activity, we aso observed significantly enhanced Perseid meteor rates in 2009 and in 2016, in agreement with predictions of the arrival of Perseid grains ejected at 1862, 1479, 1079 and 441 (Vaubaillon, in [2]; [3]). Overall, we estimate that several thousand Perseids have been recorded by our observing setup, not including meteors belonging to other showers that are active during the same period.

2.3 Data reduction

A sophisticated data processing pipeline has been developed to reduce the meteor image data acquired by the SPOSH camera system. The meteor detection algorithm is based on the Hough Transform technique for extracting linear features in images. The inner and outer orientation of the camera is determined by using the known positions of the stars depicted in the images. On a clear sky, the camera typically captures > 2000 stars on each frame. The reconstruction of the meteor trajectory is performed using the plane-line intersection method. The meteor speed is determined in a two-step process: first, the image is normalized for distance and aspect angle so as to create a new image of the meteor as it would appear if it was travelling parallel to the ground and passing through the local zenith point of each station. A search algorithm compares this image to a pre-computed database of synthetic images with the same geometry travelling at different speeds. The extraction of the meteor lightcurve is performed by applying a technique developed specifically for SPOSH image data [1]. It employs time-domain deconvolution to increase the temporal resolution in meteor lightcurves recorded simultaneously by two SPOSH cameras. Photometric calibration of the images is performed providing the correction parameters which will be applied on the measured instrumental magnitudes of the meteors. The software package has been validated using synthetic images, generated for a certain observing geometry, radiant, speed and brightness. These synthetic images were then used as input to the software package and the resulting meteor properties were compared against the given values.

3. Results

The data acquired during the observing campaigns will be processed using software developed at the Technische Universität Berlin (TUB) and the German Aerospace Center (DLR). A classification algorithm based on the meteor's radiant position, speed, time of occurrence and orbital elements will be applied in order to identify meteors belonging to the Perseid meteoroid stream. Other meteors will also be analysed searching for meteor showers active at the time of the observations. Flux estimates of the Perseid stream will be obtained by applying corrections accounting for the camera's observing area, radiant position and geometry between camera, meteors and radiant for certain time intervals. Magnitude population indices will be determined as a function of time by using the photometric properties of each Perseid meteor.

4. Summary and Conclusions

We have developed a software package for the reduction of meteor image data acquired by the SPOSH cameras. The precision and accuracy of the software package was verified with the help of simulated meteor images. We will provide a full characterisation of the Perseid meteoroid stream based on the large dataset acquired by the SPOSH cameras during the observing campaigns. Predicted outbursts for the Perseids from theoretical models will be compared against the observations and thoroughly investigated. We will investigate the association between sub-families identified within the Perseid meteoroid stream and different perihelion passages of the parent comet with the help of existing dust models.

References

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