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Monitoring and analysis of flashes produced by meteoroids impacting on the lunar surface

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Abstract

Our team is currently performing a monitoring of the night side of the Moon in order to identify flashes produced by the impact of meteoroids on the lunar surface. For this purpose we employ several telescopes equipped with high-sensitivity CCD video cameras. Software development plays an important role in our project, and as a result of this our detection and analysis package has been improved. Some of the results obtained so far are presented here.

1. Introduction

The first attempts to identify impact flashes produced by large meteoroids on the lunar surface by means of telescopic observations date back to 1997 [1]. Thus, impact flashes have been unambiguously detected during the maximum activity period of several major meteor showers by using this technique, and flashes of sporadic origin have been also recorded [2-9]. This method can be employed when the illuminated fraction of the lunar disk varies between 10 and 60 %, during the first and last quarters. At least two telescopes must operate in parallel imaging the same area on the Moon in order to discard false detections produced by other phenomena such as, for instance, cosmic rays. This technique can be useful to estimate the flux of incoming bodies to the Earth, with the advantage that the area covered by one single detection instrument is much larger than the atmospheric volume monitored by meteor detectors on Earth. With this aim we are currently performing a continuous monitoring of the night side of our natural satellite from Sevilla, in the south of Spain. This location provides us with a very favorable statistics of clear nights per year.

2. Instrumentation and methods

Our observatory in Sevilla currently employs a 11" and two 14" Celestron SC telescopes, all of them endowed with f/3.3 focal reducers and monochrome high-sensitivity Watec 902H Ultimate CCD video cameras operating in PAL mode (25 frames per second) and with a resolution of 720x576 pixels. With this configuration the limiting stellar magnitude is of about 12 and we approximately monitor about $5.8 \cdot 10^6$ km^2 ± 10% on the lunar surface. Large enough lunar features are easily visible in the earthshine and these can be used to determine the selenographic coordinates of impact flashes. In order to improve our detection system we are currently setting up a 40 cm telescope in central Spain. This system, that will be operated remotely, is planned to be operative during summer 2012.

The interlaced images taken by the cameras are stored and digitized on multimedia hard disks as AVI compressed? video files. GPS time inserters are used to stamp time on every video frame with a precision of 0.001 seconds. The video files are analyzed with our MIDAS software (Moon Impacts Detection and Analysis Software). This is Microsoft Windows application developed under C++ computer language that automatically detects flashes produced by the impact of meteoroids on the lunar surface [10]. For every telescope MIDAS creates a database with potential impact candidates. These databases are automatically compared by the software to establish which events are produced by the impact of meteoroids and which of them are related to other phenomena (cosmic rays, etc.). For confirmed impacts a photometric analysis is performed and the software also establishes their likely origin by trying to link them to a given known meteoroid stream or to a sporadic source.

3. Preliminary results

The results obtained so far are summarized in table I. Magnitudes range from 8.0 to 9.8 and, as can be noticed, these flashes are short in duration (about 0.05 s in average). No clear meteoroid swarm could be assigned to most of them and for this reason the majority of the detections have been associated to sporadic sources. However, the events recorded on February 26, 2012 and March 27, 2012 took place near of the maximum peak of the δ-Leonids (DLE) and the Virginids (VIR), respectively. In both cases the geometry was favorable and the selenographic coordinates of the flash are compatible with these radiants. Impactor masses have been inferred by calculating the radiated energy for every event and then by estimating the kinetic energy of the meteoroid by using a value for the luminous efficiency of $\eta=6\cdot10^{-3}$ [1]. For sporadic flashes we have used an average value of 17 km/s for the velocity of the meteoroids [1]. For the δ-Leonids and the Virginids we have considered a velocity of 29km/s and 30 km/s, respectively. According to this, the impactor mass would range between 5 and 101 g.

Table 1: Characteristics of the main impact flashes detected and confirmed so far.

Date and time (UTC)	**Selenographic coordinates**	**Dur. (s)**	**App. mag.**	**Mass (g)**	**Source**
9/Apr/2011 20:38:08	Lat: 24.4º Lon: -64.2º	0.080	8.0	101	SPO
9/Apr/2011 20:52:44	Lat: -26.7º Lon: -45.0º	0.040	8.5	32	SPO
11/Apr/2011 0:05:06	Lat: -12.4º Lon: -55.9º	0.040	8.2	41	SPO
30/Dec/2011 21:00:30	Lat: 12.8º Lon: -28.4º	0.040	8.5	35	SPO
26/Feb/2012 21:40:10	Lat: -23.3º Lon: -28.6º	0.040	8.8	9	DLE
27/Mar/2012 20:47:16	Lat: -24.4º Lon: -69.6º	0.060	9.8	5	VIR

4. Summary and Conclusions

We are operating a system that monitors the night side of the Moon in order to detect flashes produced by the collision of meteoroids on the lunar surface. A software package has been developed to automatically identify and analyze these flashes. Significant improvements will be performed in a near future, as we are currently setting up a new telescope in central Spain. The detection algorithm in the MIDAS software is currently being improved. As a result of this we expect to identify more efficiently flashes in future, but also among images recorded so far.

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