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First lunar flashes detected from Morocco at AGM observatory of Marrakech

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Abstract

When a projectile at hypervelocity impacts the Moon a transient luminous phenomenon occurs (impact flash). Here we report some results of the analysis of the two first lunar flashes detected from an astronomical observatory based in Morocco.

1. Introduction

Impact cratering is an important geological process, and the Moon is, among solid bodies, the most accessible one from which to document the cratering history in our Solar system. This topic is part of new research programs developed at Oukaimeden observatory (OUCA) and at the AGM observatory of Marrakech [1], [2]. The monitoring and scientific analysis of the meteoroid impacts on the Moon is a collaboration between the University Cadi Ayyad, (Marrakesh, Morocco), Uranoscope of Ile de France, Paris observatory, and Midi-Pyrénées Observatory (Toulouse) [3],[4]. On February 6, 2013, at 06:29:56.7 UT and April 14, 2013, 20:00:45.4 we observed two flashes produced by kilogram-size meteoroids striking the lunar surface.

2. Methods and instruments

Our observations are taken when sunlight illuminates between 10 and 50% of the lunar disk. We use medium size telescopes adapted for such observations with focal reducers. Images are recorded using a high speed Watec camera leading to a 20 arcmin horizontal field of view, covering $\sim 4 \times 10^6$ km ^{2} on un-illuminated portion of the Moon. The video signal is digitized and recorded to the hard-drive. The impact flashes were identified using LunarScan software developed for Lunar Impact detection [5]. The two impacts are shown in Figure 1 and the characteristics of each flash are given in Table 1.

3. Characteristics of detections

Impact flashes that are less than two video frames must be confirmed by at least two different observatories to discriminate between impact flashes and other transient phenomena (e.g., specular reflection of artificial debris in terrestrial orbits, cosmic rays hitting the sensor of the camera). However, our impact flashes appear in more than two video frames and show an adequate brightness change at the same pixel area.

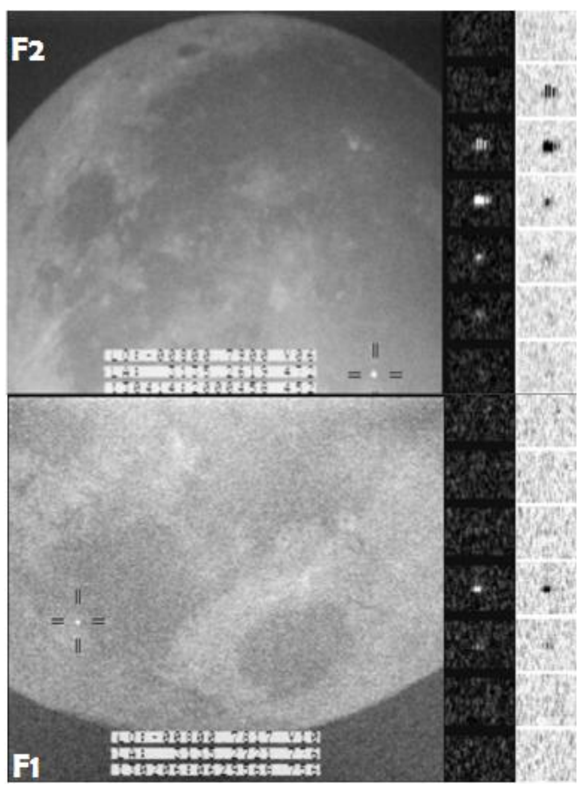

Figure 1: lunar impact flashes detected with LunarScan (© LunarScan Peter Gural [5]) with a multi-frame subimage of the raw imagery for each event (in positive and negative)

Table 1: Characteristics of lunar impact flashes

	Flash 1	Flash 2
Duration (ms)	80	240
Estimated Peak magnitude	9.4	7.7
Energy generated by impact	6.17×10^4 J	42.1×10^4 J
Estimated mass of impactor	0.3 kg	2.2 kg
Estimated diameter of impactor	7-8 cm	14-15 cm
Estimated crater diameter	2.5 m	4.4 m

4. Analysis

The characteristics of the flash in terms of magnitude and duration showed a consistency on the trend revealed in the work of [3]. The peak intensity of each flash is shown in the figure 2. Using a meteoroid speed of 16 $km.s^{-1}$ typical for sporadic event and a luminous efficiency η = 1.510^{-3} [6],[7], the conversion from kinetic to optical energy yields meteoroid masses of the 0.3 kg and 1.8 kg, and meteoroids sizes of 7-8 cm and 14-15 cm for Flash 1 and 2, respectively. In addition the diameter of the crater formed on the lunar surface can be estimated using Gault’s formula for craters of less than 100 m in diameter, The results show that the meteoroids are likely producing craters of about 2.5 m and 4.4 m in diameter for Flash 1 and 2, respectively. The parameters used in the calculation are the projectile density (1.5 $\mathrm{g.cm^{-3}}$), the target density (2.2 $\mathrm{g.cm^{-3}}$).

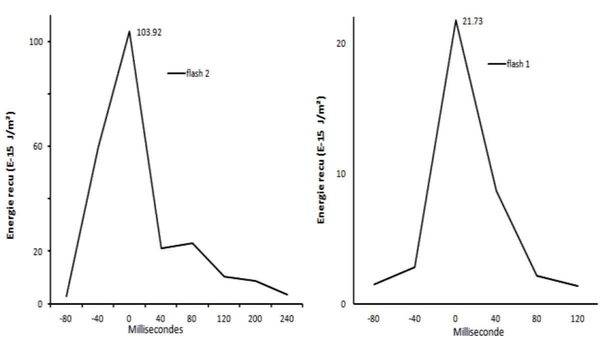

Figure 2: (Left) Light curve of flash recorded on April, 14, 2013. (Right) Light curve of flash recorded on February, 6, 2013

5. Search for associated lunar craters

Lunar flashes present an excellent natural process for study of hypervelocity impact and thermal evolution of ejected matter emitting radiation. This improves theoretical models and numerical simulations devoted to describe impact ejecta evolution [8], [9], [10]. Also, new small craters identified by high-resolution images from LRO spacecraft could be matched to lunar flashes detections, may be used to improve our knowledge of the formation crater process.

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