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Impact flashes on the Moon.

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Abstract

Using telescopic observations in R and I band, for a first time impact flash temperatures are derived. Flash temperatures can now be used to calculate, with better accuracy, the luminous energy of the events. The masses are found to range between a few grams to kilograms and the derived sizes are just a few centimetres.

1. Introduction

The idea to monitor the lunar surface using photomultipliers was already introduced since the beginning of 90s, when it was modelled that impact flash events can be recorded on the lunar surface using modest telescopes [1]. However, it was not until the 2000 when the first impact flash was recorded [2]. The initial purpose of this research was to measure the flux of impactors on Earth. The advantage is that the lunar surface provides an extended area for numerous detections, whereas the Earth-based sky monitoring systems searching for bolides does not have such a large detection area. Additionally, the Moon represents a better impact target as it lacks atmosphere, therefore an impact occurs without the influence and the filter of an atmospheric medium. Several surveys have been started monitoring the lunar surface, however all are equipped with one camera detector operating in the visible wavelength [3]. Here, will be presented the analysis of observations that were performed for a first time in two different wavelengths, in the framework of NELIOTA project.

2. Data

The project up to now has released 33 publicly available validated flashes. The link of an impact event with a specific meteor shower or the sporadic population has a fundamental role in the further analysis of the impact characteristics. The assumption of the impact speed, together with the measurement of the flash temperature, is essential in the calculation of the mass of the impacting body and, moreover, the assignment to a meteor shower (or not) provides an estimate of the impactor's bulk density which enables the calculation of their sizes.

3. Method and Results

Here is followed a numerical way, advanced from the previous version [4], to calculate the temperatures of the impact flashes which were observed in two different wavelength ranges, under the assumption that it is a black body radiation. The theoretical expression of the colour index $R - I$ of a flash is given by:

$$R - I = 2.5log\frac{F_I(T)}{F_R(T)} \tag{1}$$

where the fluxes $F_I(T)$ and $F_R(T)$ are calculated using:

$$F(T) = \frac{\int_{\lambda_1}^{\lambda_2} B(\lambda, T) f(\lambda) d\lambda}{\int_{\lambda_1}^{\lambda_2} f(\lambda) d\lambda} \tag{2}$$

where λ_1 and λ_2 the initial and final transmitted wavelength from each system and $f(\lambda)$ the filter response curve for a wavelength λ as it is provided by the quality tests. The calculated temperatures range between 1,770 and 3,730 K which is in agreement with the aforementioned estimated range for the Moon between the melting point of the lunar regolith at 1,725 K and the vaporization at 3,776 K [5].

Assuming that the impact flash forms a spherical surface, the photon flux f that is received at the telescope corresponds to the radiation of a projected area. The radius r of the radiating area can be easily then calculated from:

$$f = \frac{B(\lambda, T)\epsilon\pi r^2}{D^2} \tag{3}$$

where D the Earth-Moon distance when the flash was recorded and $\epsilon = 1$ the emissivity assuming, as a first

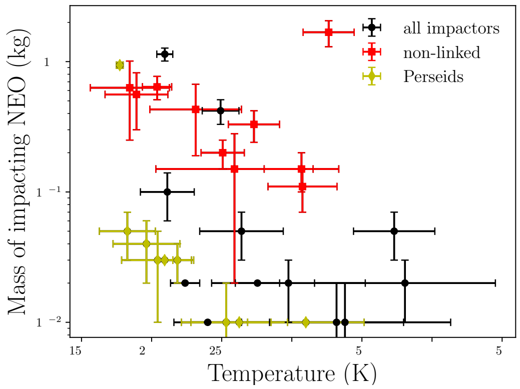

Figure 1: For a given mass of the impactors the temperature appears to have a large dispersion in values and therefore there is no obvious correlation. However, for a given impact speed and material density there is an anti-correlation between temperature and mass.

approximation, a black body radiation. During the partitioning of the impactor's kinetic energy, KE, a fraction η (luminous efficiency) is transformed to luminous energy L. With the help of the measured T, L is estimated and thus the impactor's mass is derived from the KE. Masses are found to be between a few grams and a few kilograms and are strongly affected by the selection of η, by an order of magnitude.

Having a measurement for the impacting mass and assuming spherical-shaped objects it is also possible to estimate their size. The important parameter in this calculation is the choice of the impactor's bulk density which is determined by the origin of the impactor. In our sample the bulk densities are 0.9-2.9 g/cc. The combination of the derived mass with the appropriate density results in small impactor sizes which are between 1-15 cm.

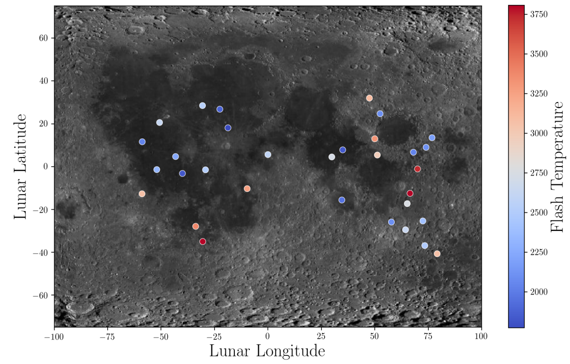

Figure 2: Locations where the impact flashes were detected along with the measured temperature.

References

[1] Melosh H. J., Artemjeva N. A., Golub A. P., Nemchinov I. V., Shuvalov V. V., Trubetskaya I. A.: Remote visual detection of impacts on the lunar surface, Lunar and Planetary Science Conference, 1993.

[2] Ortiz, J. L., Sada, P. V., Bellot Rubio, L. R., Aceituno, F. J., Aceituno, J., Gutierrez, P. J., Thiele, U.: Optical detection of meteoroidal impacts on the Moon, Nature, 405, 921, 2000

[3] Suggs, R. M., Moser, D. E., Cooke, W. J., and Suggs, R. J.: The flux of kilogram-sized meteoroids from lunar impact monitoring, Icarus 238, Supplement C, pp. 23–36, 2014.

[4] Bonanos, A. Z., Avdellidou, C., Liakos, A., Xilouris, E.M., Dapergolas, A., Koschny, D., Bellas-Velidis, I., Boumis, P., Charmandaris, V., Fytsilis, A., Maroussis, A.: NELIOTA: First Temperature Measurement of Lunar Impact Flashes, A&A, 612, 2018.

[5] Cintala, M.: Impact-Induced Thermal Effects in the Lunar and Mercurian Regoliths, Journal of Geophysical Research, vol. 97, p. 947-973, 1992.