METEO IMPACT MEASUREMENT IN LABORATORY EXPERIMENT USING THERMAL INFRARED CAMERA

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Introduction: Since Apollo's mission, lunar inner structure models at the depth of <~1000 km have been proposed based on the observation of seismic signals caused by meteorite impacts [1]. This model depends on the accuracy of location and epoch of the seismic source identified by the observation. Ground based observations of impact flash with visible wavelength recently become valuable to identify its location and epoch precisely [2]. However, the visible observation cannot detect the direct flash except for the event occurring at the night side. When the thermal infrared emission from an impact is observed, coverage can be expanded not only to the nightside but also to the day-side. The thermal infrared observation also would detect residual hot spot after the impact event. When the temperature variation is derived from the continuous observation of the residual hot spot, thermal inertia, from which an energy budget correlated with size of the crater, would be obtained. Epoch of the impact and the temperature at that time may be estimated from the thermal relaxation profile even if the impact could not be directly detected. As a first step, we have measured artificial impact flashes using a thermal infrared camera in a laboratory experiment.

Experiment: The impact experiment has been carried out in a vacuum chamber. SiO_2 sand with ~345 μm diameter was set inside, and an uncooled microbolometer array (UMBA) camera detecting the thermal infrared wavelengths at 10 μm (8 -14 μm) was configured outside of the chamber. Thermal infrared images were continuously obtained with 30 Hz via a thermal transmission window. When a polycarbonate impactor with a size of 2 mm struck the sand with a speed of 6.6 km/s, the temperature distribution and profile of the crater created on the sand surface was obtained from brightness temperature distribution in the UMBA images.

Results: Fig. 1 shows an example image at the time of impact acquired by the UMBA camera. Since the maximum temperature the camera can obtain is 400 K, scattered particles seem saturated in this figure. The temperature of the sand surface gradually decreases after the impact, hence, temperature decreasing on the surface can be estimated in each pixel from

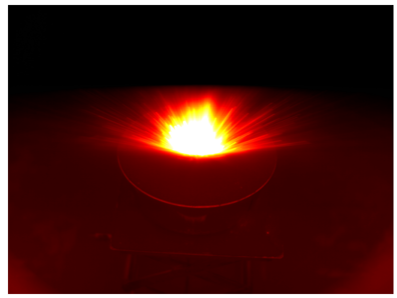

Fig.1. Representative thermal infra-red image at the time of impact

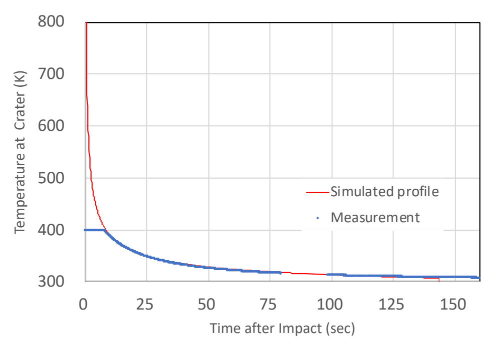

Fig.2. Temperature profile obtained from thermal infra-red measurement and simulation.

the images continuously obtained. Meanwhile, the temperature decreasing can be represented by

$$T(t) = T_0 + T_i e^{(\frac{H}{I})^2 t} erfc(\frac{H}{I}\sqrt{t})$$

where t is the time from the impact, $T(t)$ is the temperature at the surface at t, I is the thermal inertia, H is the thermal conductance, T_0 is the initial surface temperature, and T_i is the maximum surface temperature difference from T_0. When the thermal conductivity of the SiO_2 sand in the vacuum environment is experimentally estimated using the line heat source method [3], I can be derived and profile of $T(t)$ can be simulated (Fig. 2). The profile derives $T(0)$ which cannot be estimated from the laboratory measurements. $T(0)$ of each shot was roughly estimated as 1700-2600 K, from which an energy budget of the kinetic energy of the impactor to the sand surface would be discussed.

Further work: We propose a thermal infrared camera to be mounted to a future explorer to detect lunar impact flash. The UMBA camera is a potential thermal detector, which enable the lightweight and small camera without a cryogenic system. The UMBA for the ground telescope with high spatial resolution is applied to a pilot study. Ground observation of lunar impact flashes by the UMBA detects a hotspot with a size of subpixel. Detectable size of the hotspot primarily depends on the spatial resolution accompanying to focal length of an optical system [4]. When the telescope for the ground observation is suitably designed with the detector size and the focal length, the impact by the typical meteoroid which has the size of several ten mm [5] would be detected by the UMBA with the slight temperature difference. We are planning a ground observation in the dry weather condition site so that the observation does not disturbed by the thermal infrared absorber such as water vapor. The laboratory experiment in the present study will contribute to the insight discussion of the ground observation.

References:

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