Low-dispersion spectra of lunar impact flashes in 2018 Geminids

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In the collisions in the solar system, there are many cases where the collisions occur at speeds exceeding 10 km/s, which are difficult to reproduce in laboratory experiments. In such a collision, melting, evaporation, and ionization of silicate, iron, etc. which do not occur at a speed lower than this occur. Understanding of high-speed collisions accompanying such processes is an important issue for planetary sciences. However, it is not clear yet what kind of phenomenon actually occurs. We can approach this problem from the observation of lunar impact flashes.

Several research results have been reported on the occurrence frequency and brightness of lunar impact flashes and their time variations. However, there are few reports on their spectra. As part of the SAKURA Japan-France joint observation project, that is, the joint observation of meteoroids' impacts as lunar seismic sources, we observed the flashes due to the collisions of December Geminids' meteoroids by simple spectral cameras for visible wavelength (Fig. 1) [1]. At the University of Electro-Communications (Chofu-shi, Tokyo), observations were made with two spectral cameras attached to a Newtonian telescope with an aperture of 450 mm and a focal length of 2015 mm and a Schmidt–Cassegrain telescope with an aperture of 280 mm and an effective focal length of 920 mm. At Nihon University (Funabashi-shi, Chiba Prefecture), observations were carried out mainly with an ordinary movie camera attached to a telescope with a 400 mm aperture.

Thirteen flashes were detected by the observations at the University of Electro-Communications on 15th December, 2018 (JST) and nine of them were detected simultaneously at Nihon University. For those that were not detected at the same time, it is conceivable that there are differences in the sensitivity of the observation devices and temporary interruptions of observation, but the examination in detail is a future task. We named these 13 events from A to M. Their locations on the lunar surface are shown in Fig. 2 [2]. Their spectra were obtained by comparing their spectral images with those of comparison stars which were observed every 30 minutes [2, 3]. An example is shown in Fig. 3. Most of the flash spectra can be approximated well by the blackbody radiation spectrum of about 3000 K, but some are not. For the former, they would be due to the blackbody radiations from micro-droplets of melted rocks generated at the impacts. On the other hand, there is a possibility that the latter may be reflection of sunlight by space debris.

References (in Japanese): [1] Kakinuma, F., A spectral camera for observing lunar impact flashes, Master thesis, the University of Electro-Communications, 2016, http://id.nii.ac.jp/1438/00008427/. [2] Uchida, Y., Low-dispersion spectra of lunar impact flashes I, Master thesis, the University of Electro-Communications, 2018. [3] Kurihara, S., Low-dispersion spectra of lunar impact flashes II, Master thesis, the University of Electro-Communications, 2018.

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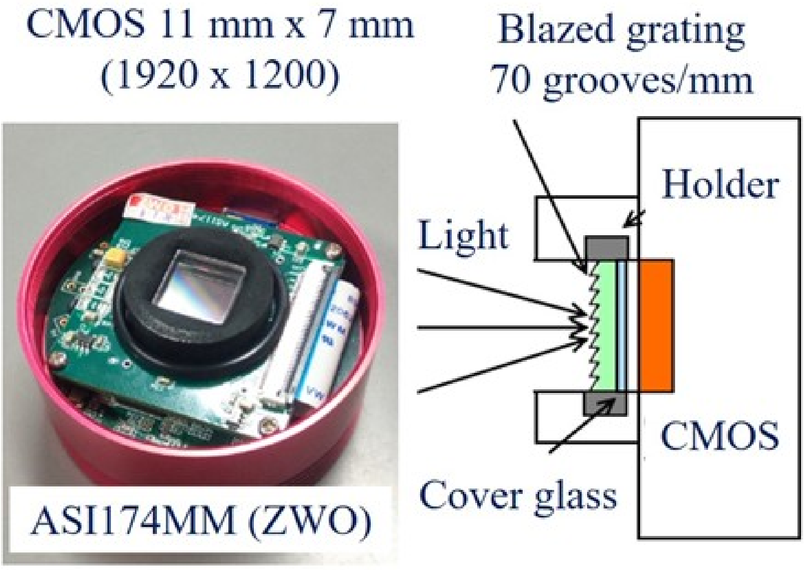

Figure 1. A simple spectral camera [1]. A grating is glued on the cover glass of a CMOS image sensor.

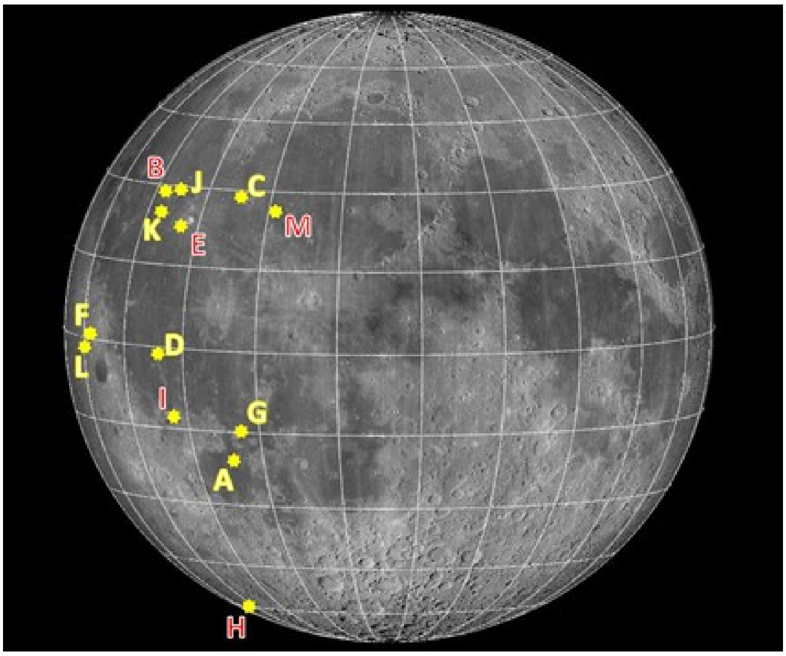

Figure 2. Locations of impact flashes (A-M) observed on December 15, 2018 [2].

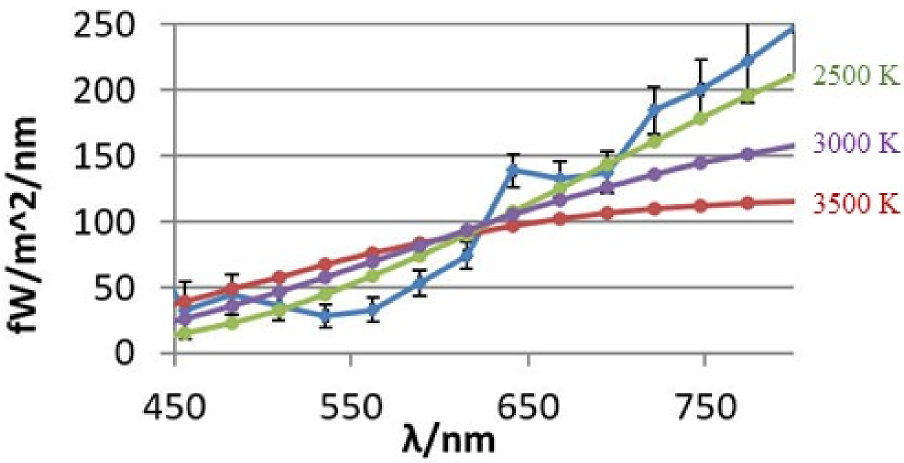

Figure 3. The spectrum of H impact flash. Black body spectra are shown with smooth lines [2].