AbeLab related presentations at Meteoroids 2019 International Conference

2 Orals+4 Posters+3 other Orals = 9 presentations

Lunar impact flash observation of Geminids and application to lunar impact monitoring from deep space

Shinsuke Abe, Ryota Fuse (Nihon University), Masahisa Yanagisawa (University of Electro-Communications), Tetsuya Fukuhara (Rikkyo University), Ryuhei Yamada (University of Aizu), Keisuke Onodera, Satoshi Tanaka, Hajime Yano (ISAS/JAXA), Ryu Funase (University of Tokyo/ISAS)

[Oral] Meteoroid Impact Physics

A Lunar Impact Flash (LIF) can be detected as a short duration luminous phenomenon in VIS and NIR wavelength regions when a meteoroid impacts on the night side of the moon. The LIF provides absolutely essential for understanding the Earth-Moon meteoroid environment, especially centimeter to sub-meter sized impactors, which is as a bridge between visual meteors and small asteroids. Here we report a tremendous impacting rate of Geminids, a dozen LIFs in 2-hours, which were observed on Dec 15 2018 from Nihon University and the University of Electro-Communications simultaneously. Derived physical parameters will be discussed. We will also introduce DELPHINUS (DEtection camera for Lunar impact PHenomena IN 6U Spacecraft), one of the scientific instruments onboard the world's smallest spacecraft EQUULEUS (EQUilibriUm Lunar-Earth point 6U Spacecraft) to explore the Earth-Moon Lagrange point which will be launched by NASA/SLS in 2020.

Reentry physics and upper atmospheric sciences derived from artificial meteors

Shinsuke Abe (Nihon University), Hironori Sahara, Makoto Abo (Tokyo Metropolitan University), Masa-yuki Yamamoto (Kochi University of Technology), Jun-ichi Watanabe (NAOJ), Toshinori Kuwahara (Tohoku University), Koh Kamachi, Adrien Lemal, Lena Okajima (ALE Co., Ltd.)

[Poster] Future Methods and Techniques

A meteoroid or reentry object interaction with the atmosphere described as a meteor phenomenon is a complex physics depending on many variables such as entry velocity, entry angle, composition, shape, density, atmospheric conditions and so on. Artificial meteors are the best known way to test and calibrate theoretical models of meteoroid ablation, and has capabilities to investigate upper atmospheric conditions. In 1960s, the first artificial meteor experiments were accomplished by using sounding rockets with entry velocities from 8 to 16 km/s, which provided very important luminous efficiencies parameters. In 2019, Astro Live Experiences (ALE Co., Ltd.), Tokyo-based startup company, has developed a small-satellite "ALE-1" which was successfully launched by JAXA's Epsilon-4 rocket in January. The ALE-1 started descending the orbit altitude from 500 to 400 km until below the International Space Station using DOM (De-Orbit Mechanism), and "a whole new level of entertainment" through the Sky Canvas project will be held in Spring 2020 over Hiroshima area. We will discuss reentry physics and upper atmospheric sciences which can be derived from ground-based observations of controlled artificial shooting stars.

Spectroscopic Study of Luminous Efficiency using Hypervelocity Impact Experiment toward understanding Lunar Impact Flash Phenomena

Ryota Fuse, Shinsuke Abe (Nihon University), Masahisa Yanagisawa (University of Electro-Communications), and Sunao Hasegawa (ISAS/JAXA)

[Oral] Meteoroid Impact Physics

When a meteoroid impacts on the Moon, a brief flash phenomenon, called as a lunar impact flash, is observed by ground-based telescope. Its statistical detections can efficiently evaluate the meteoroid size frequency distribution in Cis-lunar space. Luminous efficiency that is a ratio of impactor's kinetic energy to luminous energy is the most important parameter for the precise meteoroid size estimation. Thus, it is necessary to understand the impact flash mechanism and luminous efficiency in various conditions. We performed hypervelocity impact experiments at JAXA, and measured interactions between luminous efficiency and ambient atmosphere in various vacuum level. Based on the obtained high-speed spectra (1Mfps: 1µs), it is found that the flash sources are blackbody radiation from hot ejecta and molecular bands (and atomic lines) from vapor cloud. The spectrum analysis results reveal that luminous efficiency of µs order depends on ambient pressure, whereas that of ms order does not.

Rotationally resolved visible spectroscopy of (3200) Phaethon and (155140) 2005 UD

Kohei Morita, Shinsuke Abe, Ryo Kato, Kyosuke Sawai (Nihon University), Nicholas Moskovitz (Lowell Observatory), Fumi Yoshida, Tomoko Arai (PERC, Chiba Institute of Technology), Katsuhito Ohtsuka (Tokyo Meteor Network,), Takashi Ito (National Astronomical Observatory of Japan), Daisuke Kinoshita, Wen-Ping Chen (National Central University)

[Poster] Meteoroid Sources

(3200) Phaethon classified as B-type spectral taxonomy is known as a parent of Geminid meteor shower and is thought to be a Comet-Asteroid Transition object (CAT). It is also shown that (155140) 2005 UD has similar orbital evolution and same B-type spectral taxonomy which suggests a break-up pair. To investigate surface heterogeneity caused by break-up process, rotationally resolved visible spectroscopic observations for Phaethon in 2007 and that in 2017 were carried out using 1.0 m Cassegrain telescopes at Lulin observatory in Taiwan and Kawabe Space Park in Japan, respectively. The same rotationally resolved observation of 2005 UD spectra were obtained by using 4.1 m SOAR telescope at Chili in 2018. To conclude, Phaethon has C-like positive slope in the visible wavelength range between 500 and 850 nm which can be seen around equator and southern hemisphere terrains. On the other, spectral heterogeneity was not identified for 2005 UD which shows B-type negative slope. In this paper, we will discuss possible hypothesis of break-up mechanism.

Meteor ablation experiments using arc-heated wind tunnel

Atsuki Miyashita, Shinsuke Abe, Homare Matsuyama, Kosuke Ohki, Takumi Ogawa (Nihon University), Hironori Sahara (Tokyo Metropolitan University), Lemal Adrien Lemal (ALE Co., Ltd.), Takayuki Shimoda (JAXA)

[Poster] Meteor Physics

The meteoroid ablation process is a complex phenomenon depending on many variables such as entry velocity, entry angle, composition, shape, density and atmospheric conditions. Meteor ablation tests were carried out using JAXA's arc-heated wind tunnel with artificial samples. With changing distance from the nozzle, we demonstrated several heating rates between 10.8 and 14.1 MW/m2. NUV-VIS video rate spectroscopy ranging 250 - 1000 nm and the ultra-high-speed imaging with 1μs exposure time. These experiments gave results on time series of atomic emissions, gray body temperatures and luminous efficiencies of samples. In this paper, we will discuss meteor ablation processes for low velocity meteors such as meteorite and ALE's artificial meteor ablations.

Spectroscopy of Geminid meteor shower

Takumi Ogawa, Shinsuke Abe (Nihon University), Koji Maeda (Miyazaki University/NMS)

[Poster] Composition and Physical Properties

The Geminids is the most active annual meteor shower whose parent body is a near-Earth active asteroid (3200) Phaethon. Since there still remains considerable controversy about how to generate the Phaethon–Geminid complex, JAXA's flyby mission DESTINY+ is scheduled to be launch in 2022. The sodium depletion in Geminid meteoroids has been identified which suggested smaller grains deplete sodium during their close encounter with the Sun. In order to investigate variations of the amount of sodium in Geminids' spectra, approximately 100 low-resolution spectroscopic observations were carried out using 4K high-resolution high-sensitive color camera SONY α7s during 2016 - 2018 in Japan. We will discuss Geminids' spectroscopy in a Mg-Na-Fe ternary graph.

Radar and optical simultaneous observations of faint meteors with MU radar and Tomo-e Gozen

Ryou Ohsawa, Akira Hirota, Kohei Morita, Shinsuke Abe, Daniel Kastinen, Johan Kero, Yasunori Fujiwara, Takuji Nakamura, Koji Nishimura, Shigeyuki Sako, Yuto Kojima, Jun-ichi Watanabe

[Oral] Future Methods and Techniques

The Earth is surrounded by small dust grains produced by comets and asteroids, parts of which plunge into into the Earth's atmosphere, causing meteor phenomena. A simultaneous radar and optical observation is promising to constrain a meteor motion and a meteoroid mass at a time. We've started a project to observe faint meteors with Middle and Upper Atmosphere Radar (MU radar), which is operated by Kyoto University, and a wide-field CMOS mosaic camera Tomo-e Gozen installed on the 105 cm Kiso Schmidt telescope, which is in Kiso Observatory, the University of Tokyo. The observations were carried out in 18--21, April, 2018. From tons of the detected meteors, the simultaneous detections were extracted in terms of the times, loci, and velocities of the meteors. Finally, we identified 894 meteor events simultaneously detected in the both sites. The optical absolute magnitudes of the simultaneous meteors ranged from about 3--11 mag in the V-band. We confirmed a clear correlation between the meteor brightnesses and the radar cross sections, and derived a conversion function from a radar cross section to an optical brightness. The mass and size distributions of meteors detected by MU radar are compared to literature. The MU and Tomo-e Gozen collaboration will provide statistical properties of meteoroids in the range of 0.1--1 mg.

Low-dispersion spectra of lunar impact flashes in 2018 Geminids

Masahisa YANAGISAWA, Yuki UCHIDA, Seiya KURIHARA, Shinsuke ABE, Ryota FUSE, Keisuke ONODERA, Ryuhei YAMADA

[Oral] Meteoroid Impact Physics

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. 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 [1]. At the University of Electro-Communications (Chofu, Tokyo, Japan), observations were made with two spectral cameras attached to a Newtonian telescope with an aperture of 450 mm and a focal length of 2025 mm and a Schmidt-Cassegrain telescope with an aperture of 280 mm and an effective focal length of 920 mm. At Nihon University (Funabashi, Chiba Prefecture, Japan), 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 [2, 3] 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.

For the bright flashes, their spectra were obtained by comparing their spectral images with those of comparison stars which were observed every 30 minutes. Our preliminary results are as follows. Some of the flash spectra could be approximated by blackbody radiation spectra of about 3000 K. They would be due to the blackbody radiations from micro-droplets of melted rocks generated at the impacts. On the other hand, there are also spectra that may be consistent with the higher temperature black bodies, e.g. 6000 K. There is a possibility that they may be reflections of sunlight by space debris.

It should be noted however that it is not easy to derive reliable spectra because of atmospheric scintillations and the non-uniform spectral sensitivity over a frame obtained by the simple spectral movie cameras. Final results will be presented at the Meteoroids 2019 meeting.

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, http://id.nii.ac.jp/1438/00008961/. [3] Kurihara, S., Low-dispersion spectra of lunar impact flashes II, Master thesis, the University of Electro-Communications, 2018, http://id.nii.ac.jp/1438/00008962/.

Observation of Impact flash at the wavelength of 10 μm using Thermal infrared camera

Tetsuya Fukuhara, Shinsuke Abe, Masahisa Yanagisawa, Ryota Fuse

[Oral] Meteoroid Impact Physics

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. Accuracy of the 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. However, the visible observation cannot detect the direct flash except for the event occurring at the night side. Meanwhile, thermal infrared observation, which detects thermal infrared emission from the target, can observe the impact not only at the nightside but also at the dayside, by which coverage can be expanded. The thermal observation also would detect residual hot spot caused by the impact. 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 may be estimated from the thermal relaxation profile even if the impact could not be directly detected. We propose a thermal infrared camera to be mounted to a future explorer to detect lunar impact flash. The uncooled microbolometer array (UMBA) detecting the thermal infrared wavelengths at 10 μm (8 -14 μm) 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, which will be carried out next year at the observatory located at the dry region to avoid the thermal infrared emission being disturbed by the water vapor. A laboratory experiment for the artificial impact has been carried out in the vacuum environment, and the temperature variation at the crater has been obtained from the continuous measurement. Thermal inertia preliminary obtained from the experiment contributes to the insight discussion of the ground observation.