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In-situ observations of the ablation processes of artificial shooting stars

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We studied the aerodynamic ablation processes of small bodies entered into planets and/or satellites with a thick atmosphere. The kinetic energy of a small body is parted into the thermal energy and the kinetic energy of a shockwave propagated into a surrounding air during an atmospheric passage. Active chemical reactions between a vaporized impactor and the surrounding air are driven by the kinetic energy of the impactor. Since the extraterrestrial material mixes with the atmosphere, the induced chemical reactions have never been driven in the mean-field on the planets/satellites. Such events are expected to frequently occur through the history of the Solar system and may affect the atmospheric evolution on the planets/satellites. The energy partitioning and chemical reactions as mentioned above, however, has not been investigated well because it occurs via a number of complicated physical and chemical processes.

We have made artificial shooting stars using a two-stage light gas gun at a new laboratory of Planetary exploration Research Center of Chiba Institute of Technology (PERC/Chitech). A flight tube for accelerated projectiles and a chamber were filled with N2 gas. Then, a plastic sphere was shot into the N2 gas. A high-speed imaging observation and a time-resolved spectroscopic observation of an artificial shooting star, observed from two directions perpendicular to the projectile trajectory, were conducted simultaneously. The distance between the projectile trajectory and the collecting optics of measuring instruments was ˜50 cm. We successfully resolved the spatial distribution of an artificial shooting star with the time and spatial resolution of 0.5 us and 100 um, respectively. The spatial structure of the shooting star, the distribution of produced gases, and the blackbody temperature along the trajectory were obtained. We are planning to investigate the elemental steps of the energy partitioning with the comparison between the experimental results and the prediction by a computational fluid dynamics.

Keywords: Small bodies, Shooting stars, Aerodynamic ablation, Two-stage light gas gun, High-speed imaging, Time-resolved emission spectroscopy