LABORATORY SIMULATION OF SHOOTING STARS BY USING A TWO-STAGE LIGHT GAS GUN.

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Introduction: A shooting star is caused by an entry of a cosmic dust particle into the atmosphere on Earth. The entry speed of a cosmic dust particle is higher than the escape velocity from the Earth's gravity, which far exceeds the sound velocity of the upper atmosphere. The atmospheric gas in front of the dust particle strongly compressed, a shockwave is then formed. Accordingly, the dust particle suffer an intense aerodynamic heating.

A shooting star is observed as a bright object moving in the sky. The light from a shooting star is composed of a thermal radiation and emission lines from both of the compressed gas and the vapor from the dust particle. Spectroscopic observations of a shooting star allow us to obtain an information about the composition and the physical properties of the dust particle. However, since a shooting star is one-time event and the dust particle is expected to be burned out in the sky, the original composition of the dust particle is inaccessible. There are empirical equations which describes a relationship between the luminosity of a shooting star and the size and velocity of the dust particle. But it is unclear whether or not the equations are applicable for both of a carbon-bearing dust particle and an iron-rich metal particle. There is also an ambiguity on the efficiency of translation from the kinetic energy to the thermal energy. To clarify them laboratory experiments under controlled condition are needed.

We are constructing a laboratory experimental system to simulate shooting stars by using a two-stage light gas gun at Planetary Exploration Research Center, Chiba Institute of Technology [1]. This gun shoot a 4.8 mm sized projectile at the velocity of about 6 km/s. It can also launch smaller (~2 mm) projectile using a nylon-slit sabot [2]. We experimentally simulate a shooting stars by shooting a projectile in to a observational chamber which is filled with gas in advance. In this paper we will present preliminary results by using the experimental system.

Method: Fig. 1 shows our experimental system to simulate shooting stars. An observation chamber was installed at the downstream of the projectile's trajectory. The observational chamber is 1200 mm in length and has 750 mm x100 mm windows on the top and sides. The trajectory of the projectile can be observed through the widows.

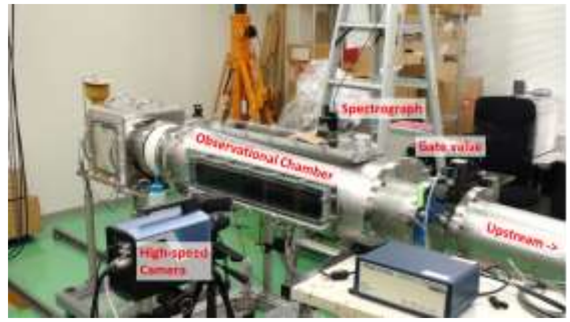


Fig. 1: laboratory experimental system to simulate shooting stars

The observational chamber had been filled with 10 kPa dry argon gas. The observational chamber was sealed from the gun chamber by a gate valve. The gate valve between the gun chamber and the observational chamber was ϕ30 mm and opened in 400 msec. After the open of the gate valve, the gas pressure in the observational chamber decayed with a time scale of 600 msec. On the other hand the projectile reached the observational camber immediately (<4 msec) after the gun fired. We shot a projectile with known composition 420 msec after the open of gate valve. The gas pressure in the observational chamber was still about 9.4 kPa at the entry of a projectile.

The image of the projectile was taken by high-speed camera (Shimadzu, HPV-X) with 10^6 fps. The width of the field of view was about 100 mm. The spectrum of the light from the projectile was taken by using spectrometer from the top of the observational chamber. The spectrometer was composed of a streak camera (Hamamatsu, C7700) and a spectrograph (Acton SpectraPro 300i) to obtain the time-resolved spectrum. The spectrometer covered 360-730 nm with the resolution of 5.7 nm. The field of view of the spectrometer was about 7 mm x 18 mm.

Projectiles: We carried out seven experiments and obtained valid data from five of them. The composition and the velocity of projectiles are compiled in Table 1.

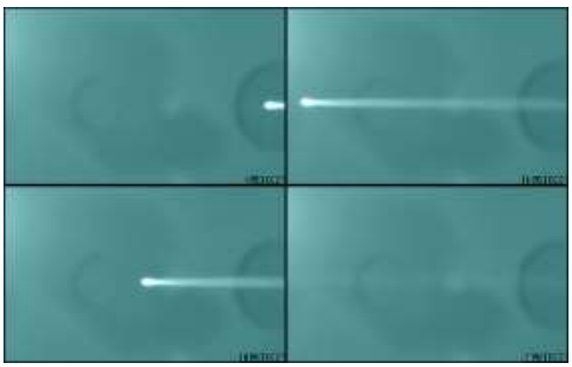
Table 1: Projectiles and their velocities

Shot #	Composition	Size	Velocity
141	Al	2 mm	5.92 km/s
142	Al_2O_3	2 mm	6.20 km/s
145	Al_2O_3	2 mm	6.30 km/s
146	SUS 304	2 mm	5.87 km/s
147	Polycarbonate	4.8 mm	6.59 km/s

Results: Fig. 2 show the resulting snapshots for shot #141 (Al), #142 (Al2O3) and #147 (polycarbonate). In all of these cases the leading side of projectile shine brightest. Neck structure formed 1-2 diameters behind the projectile and long tail (>50-100 diameter) follow the neck.

The time-series spectrum for each shot is shown in Fig. 3. As is shown in these figures the heads are far brighter than the necks and the tails. The light from tails contain emission line spectra and their shape depend on the composition of projectile. This means that the information on the composition of projectile can be obtained not only by a direct observation of the head part but also by an observation of tail part, whoes cross section is larger than the cross section of the head part.

(a)



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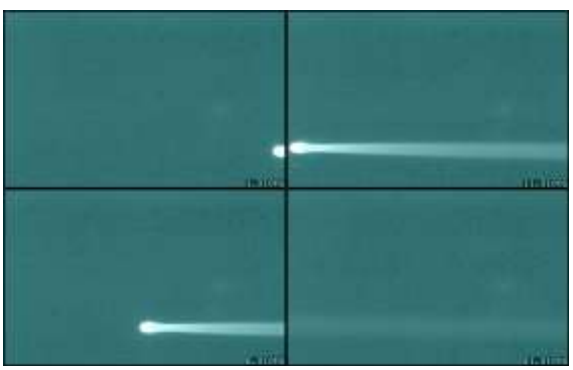

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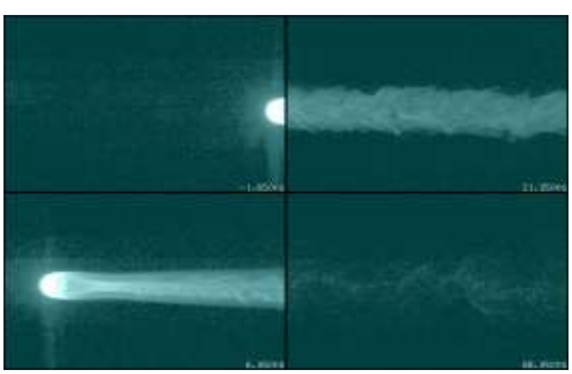
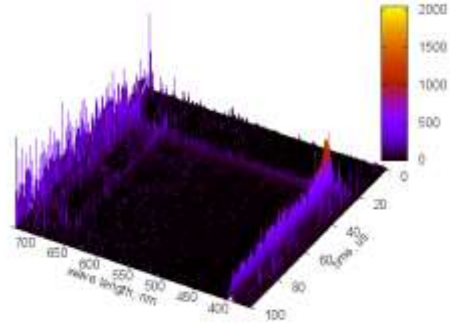


Fig. 2: snapshots of (a) shot #141, (b) shot #142, and (c) shot #147

(a)



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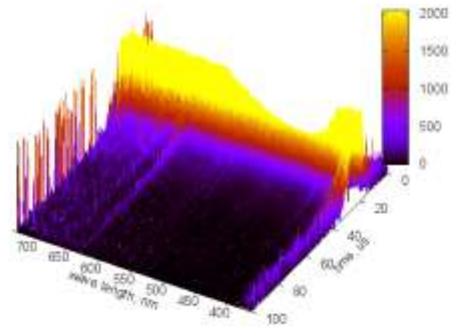

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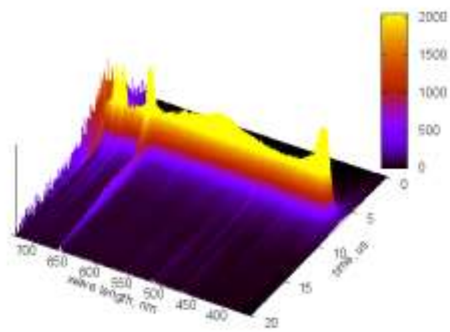

Fig. 3: Time-resolved spectra of (a) shot #141, (b) shot #142, and (c) shot #147.

Conclusions: We conducted a experimental study to simulate shooting star by using two-stage light gas gun. The spectra of shooting star depend on the compositions of the dust particle. A parameter study on composition and velocity of projectiles is needed to establish the method to obtain the physical properties of original dust particle from ground observation.

References: [1] Kurosawa, K. et al. (2015) *LPSC* 46th, Abstract #2766. [2] Kawai, N. et al. (2010) *RSI*, **81**, 115105.

Additional Information: This work is partly supported by JSPS KAKENHI Grant No. 26610184.