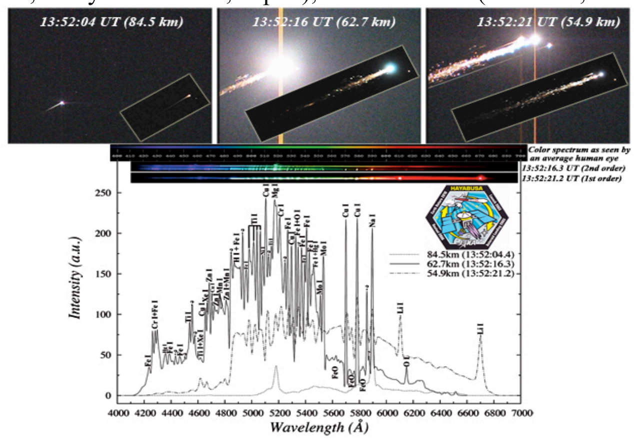
SPECTROSCOPY AND TRAJECTORY OF HAYABUSA SPACECRAFT REENTRY AS AN ARTIFICIAL EARTH IMPACTOR. S. Abe[1], K. Fujita[2], J. Borovička[3], P. Spurný[3], D. Tholen[4], K. Ohtsuka[5] and M. Yoshikawa[6]. [1]Institute of Astronomy, National Central University (300 Jhongda Road, Jhongli, Taoyuan 32001, Taiwan; shinsuke.avell@gmail.com), [2]JAXA (Chofu, Tokyo 182-8522, Japan), [3]Astronomical Institute of the Academy of Sciences (Ondřejov Observatory, Czech Republic), [4]Institute for Astronomy, University of Hawaii (Honolulu, HI 96822-1839, USA), [5] Tokyo Meteor Network (Setagaya-ku, Tokyo 155-0032, Japan), [6]ISAS/JAXA (Chuo-ku, Sagamihara 252-5210, Japan).

Introduction: On June 13, 2010, the HAYABUSA spacecraft (S/C) returned to the Earth with the reentry capsule containing asteroid samples. The sample return capsule was separated at 10:51 UT, which was just 3 hours before the atmospheric reentry. Due to the failure of all bi-propellant thrusters for orbital maneuvering, the HAYABUSA S/C could not escape from its Earth collision course. The sample return capsule and the spacecraft entered the atmosphere at 13:51 UT directly from an interplanetary transfer orbit with a velocity over 12 km/s. The spacecraft disintegrated in the atmosphere, and the capsule flew nominally and landed approximately 500 m from its targeted landing point. The ground observation teams were organized by JAXA and NAOJ [1,2].

Spectroscopy of HAYABUSA Reentry: Spectroscopic observation was carried out in the near-ultraviolet and visible wavelengths between 300 and 750 nm at 0.3-2.0 nm resolution [3]. Approximately 100 atomic lines such as Fe I, Mg I, Na I, Al I, Cr I, Mn I, Ni I, Ti I, Li I, Zn I, O I, and N I were identified from the spacecraft. Exotic atoms such as Cu I, Mo I, Xe I and Hg I were also detected. The effective excitation temperature as determined from the atomic lines varied from 4,500 K to 6,000 K. A strong shock layer from the HAYABUSA S/C was rapidly formed at heights between 93 km and 83 km, which was confirmed by detection of N_2^+(1-) bands with a vibration temperature of ~13,000 K. Gray-body temperature of the capsule at a height of ~42 km was estimated to be ~2,400 K which is matched to a theoretical prediction.

Trajectory of HAYABUSA Fireball: Photographically and photoelectrically observations of the HAYABUSA reentry from two JAXA temporary stations and four stations of the Desert Fireball Network located in Southwestern Australia were carried out using wide-field (fish-eye) lenses and sheets of films [4]. The capsule trajectory was observed within a few hundred meters of the trajectory predicted by JAXA prior to reentry. The spacecraft trajectory was about 1 km higher than the capsule trajectory.

Meteorite-Fireballs and NEOs: The extrapolated interplanetary orbit was computed by using the HAYABUSA fireball trajectory obtained from our ground-based observation. On the other, HAYABUSA S/C (pre-impact orbit) was observed by four ground-



(pre-impact orbit) was observed by four ground-based optical observatories during 3:41-6:13 UT (10-8 hours before the reentry) using Tenagra-II Observatory & Mt. Lemmon Survey in Arizona, and Subaru & Canada-France-Hawaii Telescopes on Mauna Kea in Hawaii [5]. The comparison of the pre-impact orbit with its fireball orbit provides us the first index of the 'asteroid-meteorite' orbital association. Since there is no meteorite orbit whose parent body was identified, the orbital similarity between HAYABUSA S/C and its fireball would shed light on searching meteorite associations among Near-Earth Objects (NEOs) population. Though the Almahata Sitta meteorite is the first case of recovered meteorite originating from an asteroid (2008 TC_3) that was detected in near Earth space shortly before entering the Earth's atmosphere, the fireball trajectory couldn't be obtained [6]. Note that a most likely meteorite-fireball associated with the asteroid Itokawa was identified, but the estimated ~1kg meteorite was not recovered [7]. Here we used the orbital similarity *D*-criteria [e.g., 8,9] to check the orbital match between current known ~8,700 NEOs and ~5,500 fireballs compared with the case of the HAYABUSA impactor, which will be discussed in detail.

References:

[1] Fujita et al. (2011) *PASJ 63*, 961-969. [2] Watanabe et al. (2011) *PASJ 63*, 955-960. [3] Abe et al. (2011) *PASJ 63*, 1011-1021. [4] Borovička et al. (2011) *PASJ 63*, 1003-1009. [5] Yamaguchi et al. (2011) *PASJ 63*, [6] Jenniskens et al. (2009) *Nature 458*, 485-488. [7] Ohtsuka et al. (2011) *PASJ 63*, L73-L77. [8] Southworth & Hawkins (1963) *Smithson. Contr. Astrophys. 7*, 261-285. [9] Valsecchi et al. (1999) *MNRAS 304*, 743-750.