METEOR: TWO-YEAR METEOR OBSERVATION FROM THE INTERNATIONAL SPACE STATION.

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Introduction: Meteor showers occur when the Earth crosses streams of dust derived from specific comets or asteroids. Based on the dynamical link, parent bodies of major annual meteor showers are specified. Since velocity of dust for meteor showers are known, the size of dust can be estimated from the brightness and light curve of meteors. Major element composition of the dust can be constrained from the visible emission spectra of meteors. Photometric and spectroscopic observations of meteor showers provide clues to understand physical and chemical properties for the meteoroids and their parent bodies. METEOR is two-year meteor observation project onboard the International Space Station (ISS) [1], conducting photometric observation for the first year and spectroscopic observation for the second year. ISS is an ideal platform for continuous meteor observation without distortion caused by weather and atmospheric disturbances. The flux data collected allow better comparison of physical and chemical data among major meteor showers and their parent bodies. After two launch failures in October 2014 and June 2015, METEOR was delivered to the ISS in March 26, 2016 and started nominal operation on July 7, 2016. Since planned photometric and spectroscopic observation was not complete in the nominal two-year period due to variable constraints, such as the Moon condition, the ISS high-beta condition, hardware failures, and etc., extra observation was conducted for another half year. All the observation was complete on March 5, 2019 and the METEOR instruments were de-installed on March 31, 2019. Initial results were presented [2, 3] and further data analyses are currently underway.

Method: The ISS orbits the Earth at the altitude of about 400 km, while meteors generally starts to illuminate at the altitude of 100 km. Because a distance to a meteor is three time greater from the ISS than from the ground, a meteor looks darker by one order of magnitude on the ISS than on ground. METEOR consists of a high sensitive, high definition TV (HDTV) color camera equipped with a wide-angle, extremely bright lens (F0.95, f=10.5mm, diagonal FOV=57.8 deg) [2]. METEOR is installed in the Window Observational Research Facility (WORF) rack of the US Lab module (Destiny). It observes meteors through the US Lab window facing toward the Earth during orbital night when the Sun is beneath the horizon viewed from the ISS. The ISS orbits the Earth for 90 minutes and each orbital night is about 35 minutes except high beta periods when orbital night is shorter. Observation schedule is uploaded to the onboard PC one or two weeks in advance of observation based on the orbital prediction using two-line elements. Activation/deactivation of the camera and the encoder, data recording and processing are autonomously conducted with uploaded batch file commands. Observation is done in visible wavelength, as the METEOR camera has an IR cut filer, allowing visible light only, up to 700 nm. A transmitted blazed diffraction grating (300 grooves/mm) is used for spectroscopic observation. It is manually installed by ISS crew in front of the lens. Target atomic emission lines are Fe I (370nm), Ca I (393nm), Mg I (518nm), Na I (589nm), which are key elements of dominant silicate minerals, such as olivine, pyroxene and plagioclase in meteorites and interplanetary dust. A software to detect meteors in the recorded video data and extract the portion including meteors was developed utilizing deep learning, in collaboration with the Software Technology and Artificial Intelligence Research Laboratory of Chiba Institute of Technology.

Results: Video data for a single orbital night recorded at 20 Mbps is about 5.5 GB. With allowable data downlink rate (max. 4 Mbps) and 9 hours' daily command window, 6-9 GB is the maximum downlinkable data volume per day. All the recorded data of 20 Mbps are stored in a 750 GB HDD installed in the onboard PC. Thirty five HDDs were launched with METEOR in March, 2016 and another ten HDDs were delivered to ISS on Dec. 17, 2017. The used HDD is swapped with a new HDD by the ISS crew and periodically returned by Space-X Dragon vehicles. The HDDs used for the observation in 2019 and the METEOR instruments will be returned by Space-X #17 Dragon by June this year. Photometric and spectroscopic data for twelve meteor showers were successfully captured. Photometric data are analyzed to study the number of meteors, the luminosity variation, and the arrival direction, in order to understand the dust flux for each meteor shower. Spectral data of meteor showers are analysed to understand compositional variation within each meteor shower and among meteor showers, and thus their parent bodies. Some of the captured meteor images are available at the METEOR project website: http://www.perc.it-chiba.ac.jp/project/meteor/.

References: [1] Arai T. et al. (2014) LPSC 45th abstract #1610. [2] Arai T. et al. (2017) LPSC 48th, abstract# 3034 [3] Arai T. et al. (2018) LPSC 49th, abstract# 2525.