HDTV camera for meteor observation onboard the International Space Station

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Introduction: Meteor streams are derived from vaporization of ice from active comets or infrequent disintegrations of comet-asteroid transition bodies [1–3]. Possible parent bodies which are dynamically linked with major meteor showers are identified. Since the velocity of the meteoroids of each meteor shower is known, the size of the meteoroid can be estimated based on its flight path and lightcurve. Chemical composition of the meteoroid can be determined by the emission spectra. Thus, observation of meteor streams is important in understanding the physical and chemical properties of meteoroids and their parent bodies. Most meteor observations have been performed from the ground so far. They are weather dependent and limited to a narrow observation range. The International Space Station (ISS) is an ideal platform for continuous meteor observation without distortion caused by weather and atmospheric disturbances.

Mission overview: We will launch and install a meteor observation system (Chitech Observatory of METor on iSS: COMETSS) with a super sensitive color high-definition TV (HDTV) camera to the Window Observational Research Facility (WORF) rack in the pressurized US Lab module (Destiny) of the ISS to conduct continuous meteor observation through the window in Earth's orbit for two years. The reflective coating on the window absorbs UV radiation, but transmittance rises rapidly after 304 nm to > 90 % in the visible and into the near infrared. Due to the IR cut filter, the camera observes visible light up to 700 nm. We will install a transmission diffraction grating in front of the lens for spectral analyses of the meteoroids, to estimate meteors' elemental abundance. The atomic emission lines of major elements are located within the visible wavelength; Fe I (370 nm), Ca I (393 nm), Mg I (518 nm), Na I (589 nm). The flux data collected will allow better comparison of physical and chemical data among major meteor streams and their parent bodies.

Operation & system configuration: The ISS orbits the Earth with a period of 90 minutes at an altitude of 400 km with an orbital inclination of 51.6 deg. The ISS night time when the Sun is beneath the horizon viewed from the ISS is about 35 minutes in a single orbit. With the ISS orbiting the Earth sixteen times in one day, available night time for the meteor observation is about 560 minutes. The field of view (FOV) from the window is restricted due to other pressurized modules, robotic arms and docked launch vehicles. Because of the relatively narrow FOV of COMETSS (38.8 deg (H) $\times$ 22.8 deg (V) with wide-angle converter), it will be installed normal to the window with a distance of 2–3 inches between the bumper ring attached to the lens and the window glass. The COMETSS system consists of a Hyper bit CMOS sensor (HbCMOS) HDTV camera, a lens, an encoder, a power distribution box and a laptop PC. Except the focus adjustment which is supported by the ISS crew, all the operation is remotely conducted on the ground. Operation plan files are uploaded to the onboard laptop PC. The onboard software on the PC performs on/off of the camera and the encoder, and processing/analysis of the observation data, on the basis of the operation plan. Due to the shared operation timeframe with other payloads, observation targets are priotized: primary (periods around the peak of major meteor showers) and secondary (periods outside of the peak of major meteor showers, minor meteor showers, and periods with little or no regular meteor activity identified).

Data analysis & handling: Due to the constraint on the maximum downlinkable data volume of 200 MB per day from the ISS, all the acquired data can not be downlinked. A software is developed for autonomous detection of meteors in the acquired image data, and extraction of the data including meteor images, so that the image with meteors can only be downlinked and the downlinked data volume can be minimized. We may also lower the bit rate of the data to further decrease the downlikned data volume. The downlinked data will be analyzed for scientific interests, and will be openly distributed via internet for the purpose of education and public outreach.

Development status and future schedule. Both the COMETSS hardware and software are currently under development. Once the development and verification testing are completed in Japan, COMETSS will be delivered to the U.S. for final testing and crew training prior to the launch, which is currently scheduled to be late 2014. Calibration tests will be done using light sources and stars, to properly estimate physical properties from the luminosity of the meteoroid, and to correctly deduce elemental abundance from the visible spectra.

References: [1] P. Jenniskens (2006). Meteor Showers and their Parent Comets. Cambridge University Press, Cambridge, U.K. [2] D. Jewitt & L. Jing (2010) Ast J, 140:1519–1527. [3] D. Jewitt et al. (2013) Ast J Let, 771:L36 (5pp), doi:10.1088/2041-8205/771/2/L36.