Improved Characterization of Meteor Luminous Efficiency through Laboratory Experiments

Robert A. Marshall, Liane K. Tarnecki, Zoltan Sternovsky, Tobin Munsat, Michael DeLuca

The total mass flux of micrometeoroids entering the Earth's atmosphere remains an open question, largely because the relationships between meteor observables and the parent meteoroid properties are not well established. In particular, the observables of meteor luminosity and radar cross section do not easily map to the parent properties of mass and composition. For the luminosity in particular, the luminous efficiency - the relationship between the meteoroid kinetic energy and the luminous energy produced - is very poorly understood [e.g., Subasinghe et al, 2018, Figure 9].

Laboratory experiments to characterize the luminous efficiency were last conducted in the 1970s; those experiments were also primarily restricted to iron particles. In this talk we present the design of a new experiment to more accurately assess the luminous efficiency of micrometeoroids. Our experiment is centered around the dust accelerator at the Institute for Modeling Plasma, Atmospheres and Cosmic Dust (IMPACT) at the University of Colorado Boulder, and in particular the ablation target chamber [Thomas et al, 2016] used to simulate the ablation of particles in various gases, including air. To this facility we are adding an advanced optical detection system designed to better characterize meteor properties. This optical system uses four 16-channel photomultiplier tube arrays with 5 MHz bandwidth, whose signals are fed to a 64-channel data acquisition system sampling at 100 MS/s per channel simultaneously. The system will increase the light measured by a factor of ten over the previous system from Thomas et al [2017], and will further measure the velocity and deceleration of particles directly. In the near future, we plan to add spectral capabilities to this system, in order to characterize the wavelengths produced by ablating particles. Future experiments will include ablation of iron and aluminum, but also new particles including olivine and others, providing the first measurements of the luminous efficiency for relevant particle compositions.

References:

Subasinghe, D., & Campbell-Brown, M. (2018). Luminous Efficiency Estimates of Meteors. II. Application to Canadian Automated Meteor Observatory Meteor Events. The Astronomical Journal, 155(2), 88.

Thomas, E., Horányi, M., Janches, D., Munsat, T., Simolka, J., & Sternovsky, Z. (2016). Measurements of the ionization coefficient of simulated iron micrometeoroids. Geophysical Research Letters, 43(8), 3645-3652.

Thomas, E., Simolka, J., DeLuca, M., Horányi, M., Janches, D., Marshall, R. A., Munsat, T., Plane, J.M., & Sternovsky, Z. (2017). Experimental setup for the laboratory investigation of micrometeoroid ablation using a dust accelerator. Review of Scientific Instruments, 88(3), 034501.