Experimental simulation of the atmospheric ablation of cosmic dust particles

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The ablation of meteoroids entering a planetary atmosphere is the critical process which produces layers of metal atoms and ions, as well as the meteoric smoke particles which act as condensation nuclei for middle atmospheric clouds. Ablation has been modelled in the past by coupling the classical equations of meteor physics to a thermodynamic model of a high temperature silicate melt, and assuming Langmuir evaporation of the constituent elements into a vacuum. A current example of such a model is the Chemical Ablation Model (CABMOD), developed at the University of Leeds [*Vondrak et al.*, 2008]. Although CABMOD successfully predicts the differential ablation which is inferred from the relative abundances of the layers of Na, Fe and Ca atoms in the terrestrial mesosphere [*Carrillo-Sanchez et al.*, 2015], and the time-resolved variation of radar head echoes [*Janches et al.*, 2009], the underlying assumptions of this type of model have never been tested.

We have therefore recently constructed at Leeds the Meteoric Ablation Simulator (MASI). In this apparatus, meteoritic analogues of cosmic dust are flash heated to over 2800 K in a few seconds, inside a vacuum chamber. A fast time response pyrometer coupled to a temperature controller is used to match the particle heating profile to that which a meteoroid of specified mass, entry angle and velocity would experience. The evaporation of metals is measured in real time by time-resolved laser induced fluorescence spectroscopy using a very high repetition rate YAG laser pumping two dye lasers, so that the ablation of a pair of metals can be studied simultaneously.

Results have been obtained for a variety of particle sizes (20 – 150 µm), types (carbonaceous and chondritic), and entry velocities (14 – 40 km s^{-1}). Although CABMOD correctly predicts the order of evaporation of Na, Fe and Ca, there are significant differences with the observed ablation onset temperature and duration over which each element ablates. This has important consequences for the height ranges over which elements ablate, as well as the rates of ablation which determine the production of electrons and hence the detectability of a meteoroid by radar. In this presentation, the implications of the experimental results for the interpretation of radar observations, mass flux estimates and the modelling of metal layers will be discussed.

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