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ABLATION AND HEATING DURING ATMOSPHERIC ENTRY AND ITS EFFECT ON AIRBURST AND IMPACT RISK

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ABSTRACT

Large meteoroids and asteroids entering the atmosphere endure tremendous heating from the shock heated air, and thereby lose a significant fraction of their mass during atmospheric entry – a process known as *ablation*. The predicted evolution of the asteroid's mass as it passes through the atmosphere can affect both the predicted energy deposition profile relevant to an airburst event, and/or the residual mass that strikes the ground in the case of an impact event.

This presentation is divided into two parts. In the first part, an overview of traditional models for heat transfer and ablation that are historically used in the meteor physics community is presented, and the validity in the asteroid entry regime

discussed. Sensitivity analyses performed using the recently developed Fragment-Cloud Model (FCM)[1] will be presented which illustrate the range of sizes and entry parameters for which the predicted asteroid threat is most sensitive to the models for ablation and heat transfer.

The second part of the presentation shall focus on recent work done under NASA's Asteroid Threat Assessment Project (ATAP) to develop new models for heat transfer and ablation using high-fidelity numerical simulation in concert with state-of-the-art experiments. Coupled computational fluid dynamics (CFD)/radiation transport simulations preformed using the state-of-the-art entry modeling tools at NASA show that, for large meteoroids and asteroids, there can significant attenuation of the heat transfer to the surface (>95% in some cases) by the products of ablation. This finding is reinforced by the presentation of data from recently performed laser ablation testing of chondritic material.

In addition to the heat transfer, new models for the material response and ablation of asteroidal material have been developed[2]. In the current work, we present findings from recent novel experiments performed in the arc jet facility at NASA Ames, which allow us to, in part, simulate the extreme environment experienced by the asteroid during entry. Briefly, the experimental set-up was comprised of a 1.5" conical article of machined H5 chondrite, which was exposed to a high-enthalpy flow resulting in approximately 4 kW/cm^2 of heating to the surface. A still frame capture from high-speed video taken during this experiment can be seen in Figure 1. In this figure, we can observe some of the major mechanisms for meteoroid ablation, such as melt flow, spallation (mechanical removal of material), and vaporization. Major findings from this, and other experiments will be discussed, as well progress on utilizing the data from the experiments to inform and develop improved models for ablation.

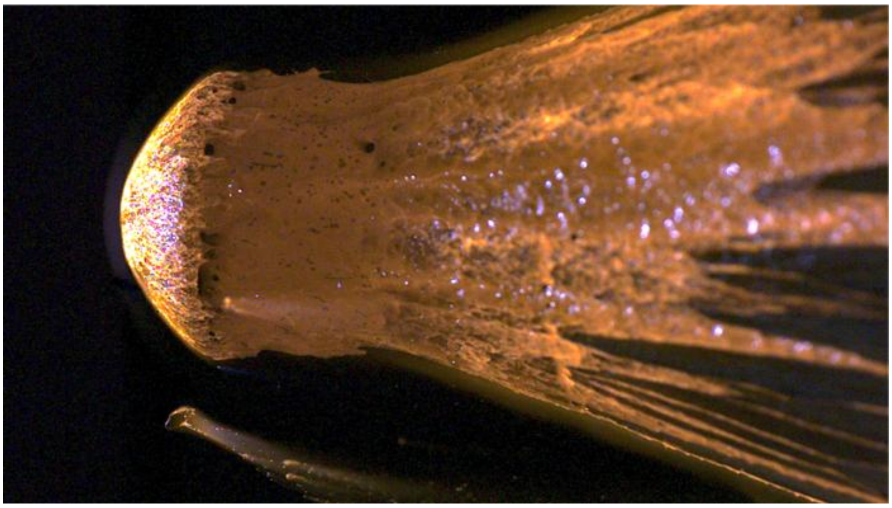

Figure 1: Still frame capture from arc jet experiment showing widespread melt flow, and spallation/ablation of meteorite fragments.

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[1] Register, P. J., Mathias, D. L., & Wheeler, L. F. (2017). Asteroid fragmentation approaches for modeling atmospheric energy deposition. *Icarus*, *284*(C), 157–166. http://doi.org/10.1016/j.icarus.2016.11.020

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