Particle-based ablation model for faint meteors

E. Stokan[1] and M. Campbell-Brown[1]

[1]Department of Physics and Astronomy, University of Western Ontario, Canada

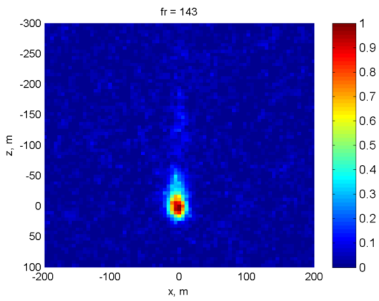
Modeling the ablation of meteoroids as they enter the atmosphere is a way of determining their physical structure and elemental composition. This can provide insight into the structure of parent bodies when combined with an orbit computed from observations.

The Canadian Automated Meteor Observatory (CAMO) is a source of new, high-resolution observations of faint meteors [1]. These faint objects tend to have pre-atmospheric masses around 10^{-5} kg, corresponding to a radius of 1 mm. A wide-field camera with a 28° field of view provides guidance to a high-resolution camera that tracks meteors in flight with 1.5° field of view. Meteors are recorded with a scale of 4 m per pixel at a range of 135 km, at 110 frames per second, allowing us to investigate detailed meteor morphology. This serves as an important new constraint for ablation models, in addition to meteor brightness (lightcurves) and meteoroid deceleration.

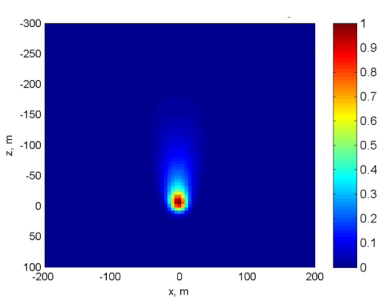
High-resolution observations of faint meteors have revealed that contemporary ablation models are not able to predict meteor morphology, even while matching the observed lightcurve and meteoroid deceleration [2]. This implies that other physical processes, in addition to fragmentation, must be considered for faint meteor ablation. We present a new, particle-based approach to modeling the ablation of small meteoroids. In this model, we simulate the collisions between atmospheric particles and the meteoroid to determine the rate of evaporation and deceleration. Subsequent collisions simulated between evaporated meteoroid particles and ambient atmospheric particles then produce light that would be observed by high-resolution cameras.

Preliminary results show simultaneous agreement with meteor morphology, lightcurves, and decelerations recorded with CAMO. A sample comparison of simulated and observed meteor morphology is given in the attached figure. Several meteoroids are well-represented as solid, stony bodies, but some require modeling as a dustball [3]. Large trail widths in faint meteors observed with CAMO are also explained by the collisional light production emphasized with this model [4].

Ultimately, improving models of meteoroid ablation, such that they are able to satisfy more constraints simultaneously, will provide a better understanding of the composition and structure of objects throughout the Solar System. Particularly, we hope to use this model in the future to quantify meteoroid density and the distribution of particle sizes present in dust-ball bodies.



(a) Observed meteor



(b) Simulated meteor

Figure: Meteor observed with the CAMO high-resolution tracking camera (a) and simulated with the particle model (b). Color scale corresponds to normalized pixel brightness.

References: [1] Weryk, R. J. et al., 2013. Icarus 225, 614–622. [2] Campbell-Brown, M. D. et al., 2014. A&A 557, A41, 13pp. [3] Hawkes, R. L., Jones, J., 1975. MNRAS 173, 339–356. [4] Stokan, E. et al., 2013. MNRAS 433 (2), 962–975.