Material strength and the Rayleigh-Taylor instability in the atmospheric breakup of meteoroids

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When meteoroids enter a planetary atmosphere, the breakup process is governed by the Rayleigh-Taylor instability, mitigated by the strength of the meteoritic material. Particle sizes in the breakup cascade depend on the perturbation length scales exhibiting growth. The physics of meteoroid entry is thus related closely to high-pressure strength experiments using lasers, where strength is inferred by studying the Rayleigh-Taylor growth of perturbations. There are significant discrepancies between predicted and observed breakup altitudes of meteoroids, which in turn reduce the accuracy of assessments of the impact threat from asteroids. Simulations validated by laboratory experiments of instability growth can play a role in understanding the breakup of meteoroids and thus the threat from asteroids. Continuum dynamics simulations also provide more rigorous calculations of the stress distribution driving deformation than are usually used in breakup analyses, and can be used to calibrate compact expressions describing the breakup conditions.