Cosmic dust demystified

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Credit: NASA/MSFC/MEO/Bill Cooke

The solar system is a dusty environment, with trillions of cosmic dust particles left behind by comets and asteroids that orbit the sun. All this dust forms a relatively dense cloud through which the Earth travels, sweeping up the interplanetary dust particles very effectively.

Besides providing substantive information about the atmospheres of other planets, these particles can impact radio communications, climate and even serve as fertilizer for phytoplankton in the oceans. Studying them can help answer questions like "Is there (or was there) extraterrestrial life?" and "How did life start on Earth?," and unlock unexpected practical solutions for air travel.

A team of researchers at the University of Leeds in Great Britain led by John Plane, professor of atmospheric chemistry, has developed a new experimental Meteoric Ablation Simulator (MASI) that can help answer questions about cosmic dust and how it impacts Earth and everything on it. The researchers describe their work in this week's *Review of Scientific Instruments*.

The study of the evaporation of cosmic dust particles in the upper atmosphere has, until now, relied heavily on theoretical calculations. Evidence provided by field radar and optical observations of meteoroids is contradictory in relation to the height where each of the metals in the particles will ablate as they fall through the atmosphere. The model developed in Leeds is the only model capable of simulating the evaporation of each important elemental constituent (silicon, iron, magnesium, sodium, calcium) from cosmic dust particles. To put the model calculations on a solid experimental basis and settle the question about when each metal ablates, they designed the MASI, where particles with similar composition to cosmic dust are flash-heated to simulate atmospheric entry while simultaneously monitoring the evaporating metals.

"Only relatively recent advances in computing hardware and software have allowed us to address the precise timing and substantial computational requirements needed for MASI," said David Bones, a member of the Leeds research team working on the project. "During a particle entry simulation that lasts about 12 seconds, we want to take 6,000 measurements while we are rapidly changing the temperature of the filament to flash-heat the particle with real-time feedback."

The Meteoric Ablation Simulator is the first ablation experiment capable of simulating detailed mass, velocity and entry angle-specific temperature profiles while simultaneously tracking the resulting gas-phase ablation products. This results in elemental atmospheric entry yields that consider the mass and size distribution of interplanetary dust particles.

So what are we learning from MASI? While the measurements for sodium and iron ablation agreed reasonably well with the model, the calcium ablation measurements did not, suggesting that we need a more sophisticated ablation model that can take into account factors like the particles breaking up into smaller bits in the atmosphere and the fact that these particles are not uniform in composition but are aggregates of different types of minerals stuck together.

Perhaps surprisingly, understanding interplanetary dust particles and using tools like the Meteoric Ablation Simulator have value beyond the obvious. Besides providing a better understanding of the upper atmosphere and the metal layers present there, the simulator offers other utility from industrial applications to understanding the formation of planets.

"An example of an area where small particles can be rapidly heated is jet turbines," Bones said. "By better understanding the melting and ablation processes we can design ash-resistant jet engines that could fly without disruption through an ash cloud similar to that created when the volcano Eyjafjallajökull erupted in 2010."

More information: "A novel instrument to measure differential ablation of meteorite samples and proxies: the Meteoric Ablation Simulator (MASI)," by D.L. Bones, J.C. Gómez Martín, C.J. Empson, J.D. Carrillo Sánchez, A.D. James, T.P. Conroy and J.M.C. Plane, *Review of Scientific Instruments*, September 27, 2016. scitation.aip.org/content/aip/ … /9/10.1063/1.4962751.

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