BOSTON UNIVERSITY

Boston University College of Arts & Sciences
Center for Space Physics

2024—2025 SPACE PHYSICS SEMINAR SERIES

Cosmic Dust in Planetary Atmospheres

Cosmic dust particles are produced from the sublimation of comets and by collisions between asteroids. Because the particles enter the atmosphere at hypersonic velocities, collisional heating with air molecules causes a fraction of them to melt, leading to vaporization of their metallic constituents. The injection of these elements causes a wide variety of atmospheric phenomena in the terrestrial atmosphere, including the formation of global layers of metal atoms between 80 and 105 km; airglow emissions; layers of metallic ions which affect radio communications; and the production of meteoric smoke particles which enable the nucleation of mesospheric ice clouds and the freezing of polar stratospheric clouds. Certain metal atoms can be observed very precisely by ground-based lidar and from satellites, providing an excellent tracer of dynamics and chemistry at the edge of geospace.

The input rate of cosmic dust to the atmosphere has been very uncertain. A new estimate of around 27 tonnes per day globally will be discussed; this was obtained using an astronomical dust model to provide the size and velocity distributions of dust in the inner solar system, combined with the Leeds Chemical Ablation Model (CABMOD) to determine the rate of injection of metals into the atmosphere. CABMOD is itself benchmarked using a novel meteoric ablation simulator to measure the evaporation rates of metals from meteoritic particles that are flash heated, simulating atmospheric entry. Recently we have examined the pyrolysis of the organic fraction of cosmic dust particles, and the potential role of this process in fragmentation of meteoroids during atmospheric entry.

Atmospheric models of 11 meteoric elements – Li, Na, Mg, Al, Si, P, S, K, Ca, Fe and Ni (in order of increasing atomic number, not abundance!) – have been constructed from laboratory measurements of the rate coefficients of over 200 individual reactions involving neutral and ionized species. This chemistry, together with the relevant metal injection rates as a function of height, location and time, has been inserted into global chemistry-climate models of Earth, Mars and Venus. Model simulations compare well against pertinent observations of metal atoms/ions from ground-based lidar, rocket-borne mass spectrometry and satellite remote sensing. Topics that will be discussed include: meteoric fragmentation; sporadic E layers; vertical transport by gravity waves; ice nucleation; the increasing injection of metals from space vehicle re-entry; the Mars ionosphere; and the mystery absorber in the Venusian clouds.

Thursday, September 26th

3:30-4:30 p.m.

725 Commonwealth Ave | Room 502

John Plane

School of Chemistry at Leeds