In Situ Characterization of Elemental Compositions for Small Bodies Throughout the Solar System

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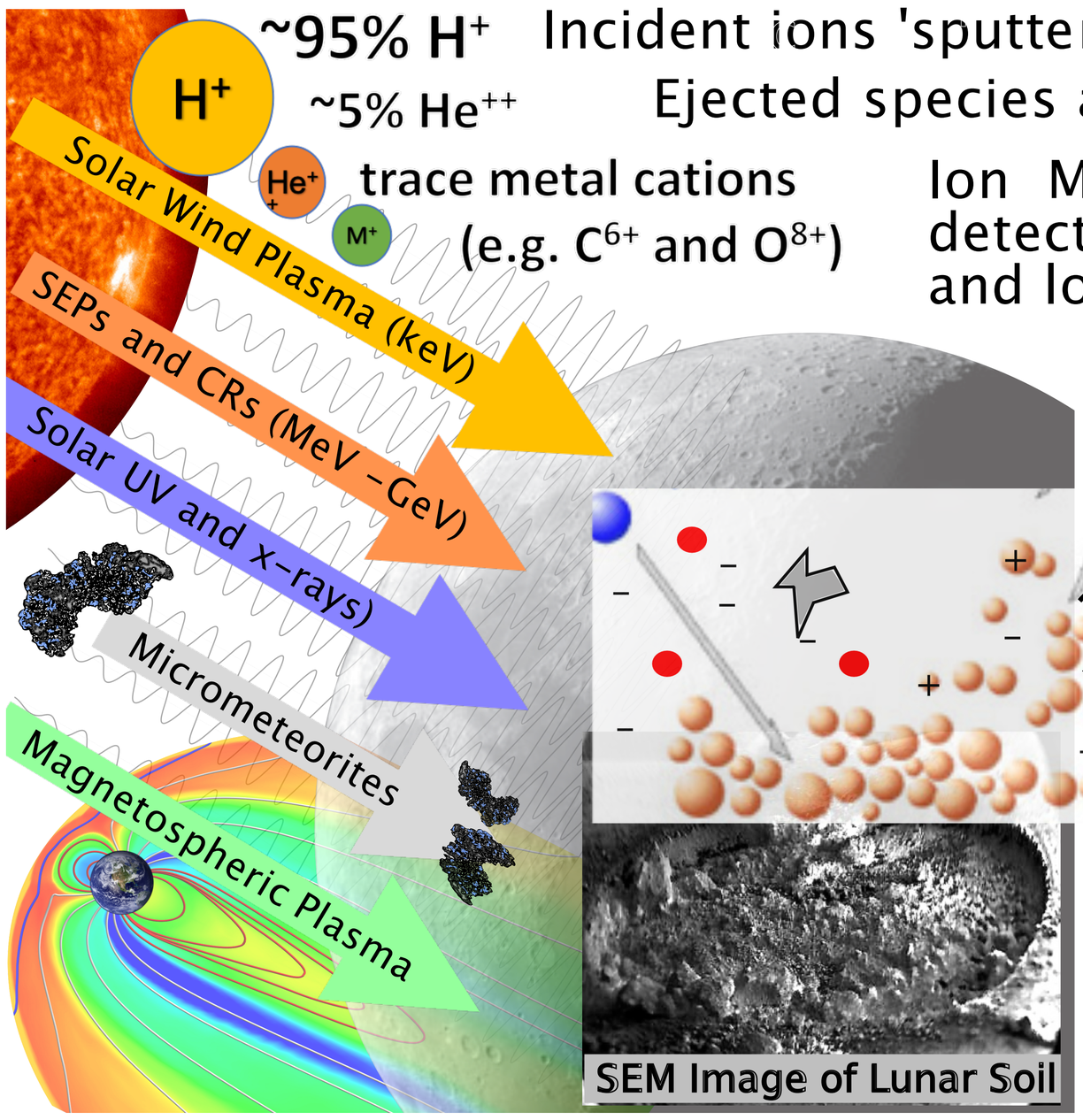
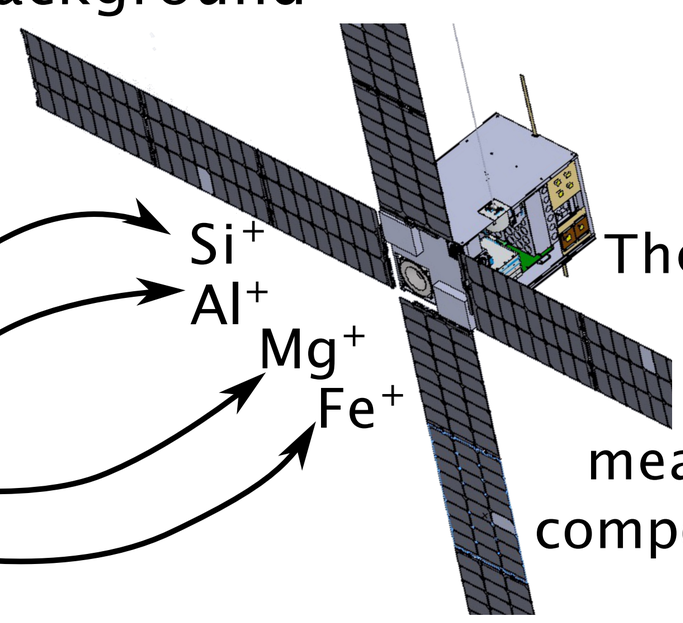
Goals: Determine composition, formation conditions, and materials resource potential for small, airless bodies



Incident ions 'sputter' the surfaces of airless bodies

Ejected species are related to the elemental composition

Ion Mass Spectrometry (IMS) can be used to detected secondary ions with high sensitivity and low background

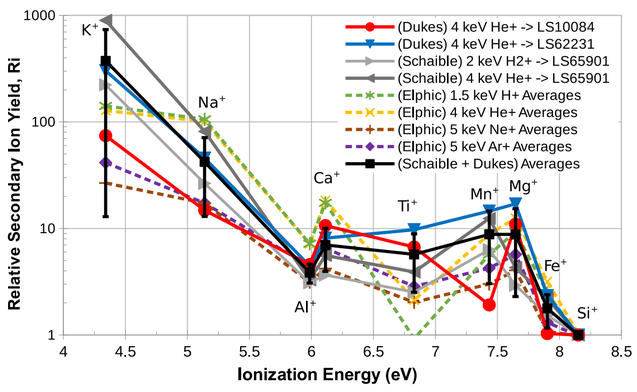


PRISM

The PRISM SmallSat mission concept utilizes an IMS to measure the surface composition of Phobos and Deimos

Environment Dependent Sputtered Secondary Ion Flux Estimates

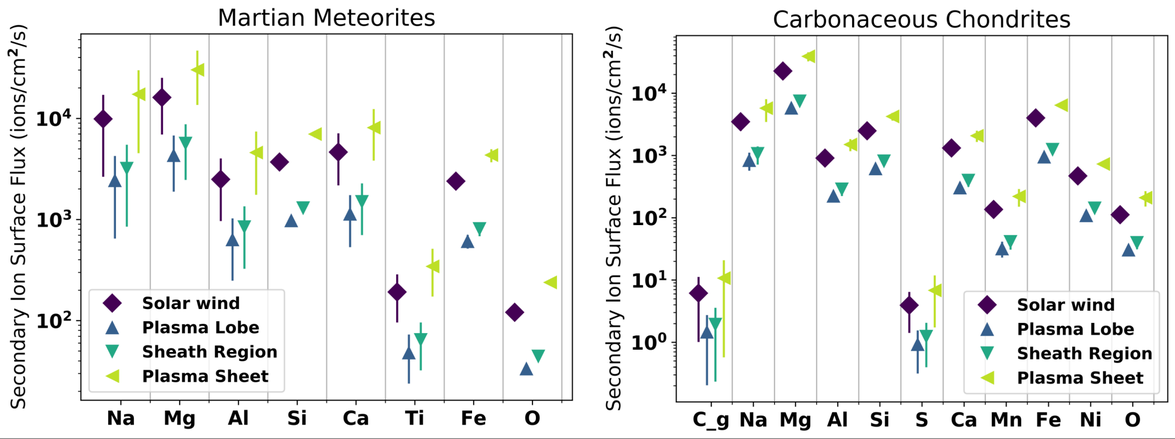
Computational total sputtering yields, experimental relative ion yields, and measured incident ion fluxes can be combined to predict sputtered ion fluxes for small bodies exposed to both solar wind and magnetospheric ions



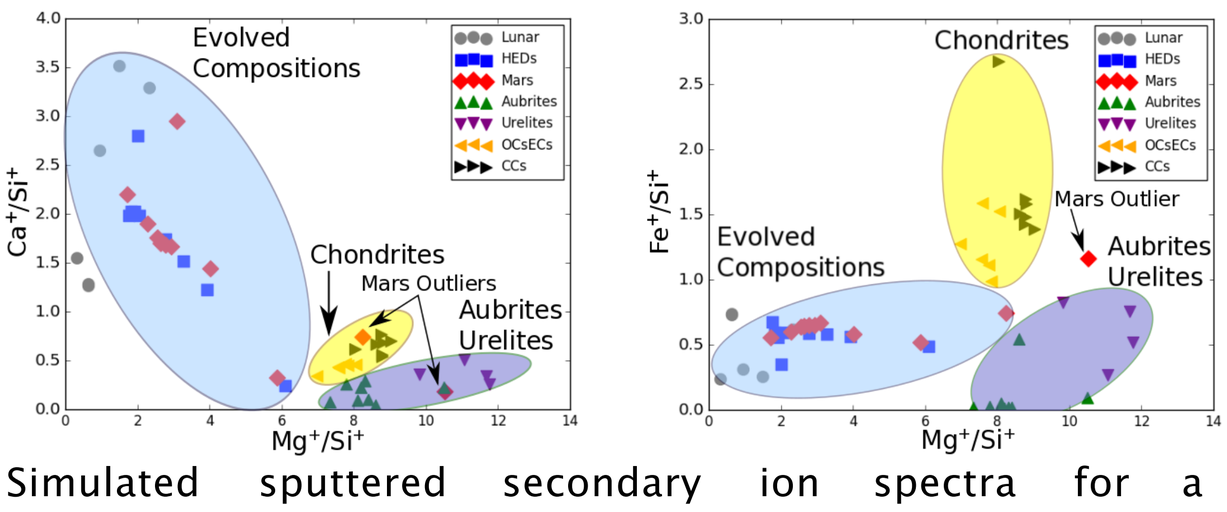
Relative secondary ions yields depend on the elemental ionization energy

$$R_i = \left(\frac{Y_i^+}{Y_{Si}^+}\right)\left(\frac{C_{Si}}{C_i}\right)$$

Easily ionized elements are more readily detected!!



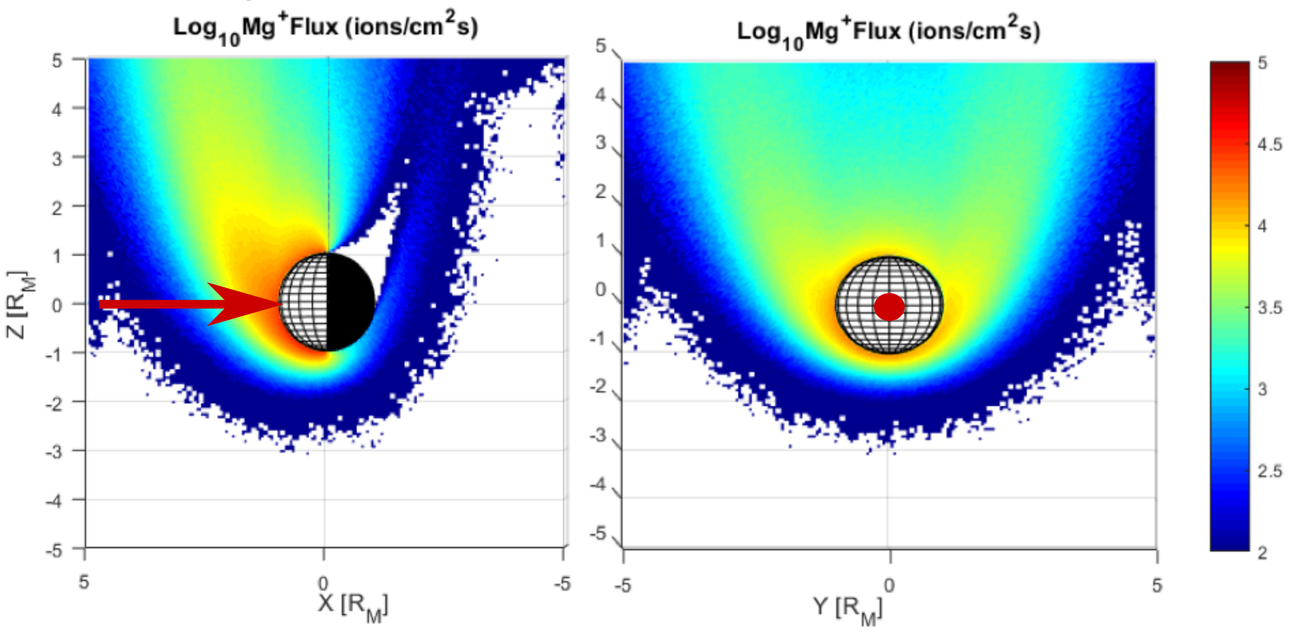
Relative elemental abundance used to determination of small body origins



Simulated sputtered secondary ion spectra for a representative distribution of meteorite compositions shows that relative abundances of major metal species can be used to roughly distinguish the origins of the target bodies.

Monte Carlo Computational Ion Transport Modeling and Sputtered Flux Estimates

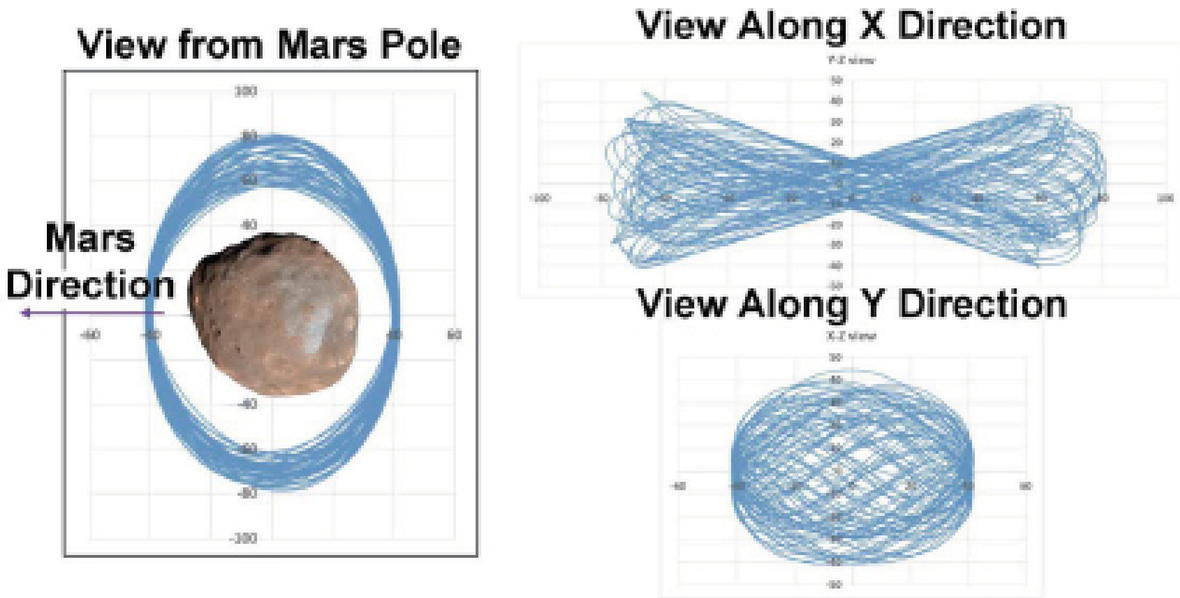
Using experimentally measured sputtered secondary ion velocity distributions and computationally determined sputtering yields under solar wind conditions, the sputtered ion density around small bodies can be calculated.



Simulated ion trajectories calculated for a distribution of ejection angles yields an average flux of secondary ions around a small (~10 km) body exposed to solar wind irradiation conditions.

PRISM Orbital Design: Weakly Stable Phobos Co-fly Retrograde Orbit

PRISM simulated mission trajectories carried out by the Goddard flight dynamics group showing weakly stable retrograde orbits allow > 90 days prime science period



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