Cosmic Dust in Planetary Atmospheres

What happens to the cosmic dust that enters the atmosphere of a planet, such as Earth, Mars, or Venus? The fate of this cosmic dust influences the chemistry of different levels of the atmosphere all the way to the surface.

Scientists from the School of Chemistry at the University of Leeds, UK and international partners have been studying the fate of cosmic dust particles that enter and move through planetary atmospheres. Using a combination of computer modeling and experiments they are able to better understand how ionization and ablation (loss of mass due to vaporization) of the cosmic dust injects elements into planetary atmospheres causing some atoms and ions to linger in concentrated layers.


Earth's Atmospheric Layers from NASA / JSC Astronaut Photography of Earth

Previous work has made important discoveries, including 1) Jupiter-Family comets are the major cosmic dust source in the atmospheres of the terrestrial planets, 2) the composition of most of the cosmic dust entering Earth's atmosphere is similar to that of ***CI chondritic*** meteorites.

Recently published work by Juan Diego Carrillo-Sánchez (University of Leeds and currently at NASA Goddard Space Flight Center) and an international team of coauthors focused on the chemical ablation of both bulk silicate and Fe-Ni metallic grains in cosmic dust that enter the atmospheres of Earth, Mars, and Venus.

They used a combination of the Chemical Ablation Model (***CABMOD 3***, a high-fidelity chemistry-physics-based model) and the Zodiacal Cloud Model (ZoDy, an astronomical model of dust in our Solar System) to estimate the cosmic dust fluxes of Fe-Ni metals and organics to the atmospheres of Earth, Mars, and Venus. Then they tested their results experimentally in the University of Leeds' Meteoric Ablation Simulator (***MASI***). In this ingenious apparatus, they measure evaporation rates and study ablation of meteoritic particles that are flash heated under vacuum conditions fine tuned to simulate atmospheric entry of cosmic dust at specified angles and velocities.

Carrillo-Sánchez and colleagues found that the CABMOD-ZoDy-model predictions of the ratio of Fe^{+}:Ni^{+} in Earth's atmosphere are in good agreement with data from sub-orbital rockets but ground-based lidar measurements show a differnt ratio due to Ni depleted with respect to Fe. The ratio of Fe^{+}:Ni^{+}

measured in the Martian ionosphere during orbits of NASA's MAVEN spacecraft also show Ni more depleted with respect to Fe than predicted by the models. These results suggest to the team that nickel is converted into permanent reservoirs in the atmospheric layers more efficiently than iron. The researchers also considered the results of their modeling on pre-biotic organics in the Martian atmosphere and surface, since cosmic dust contains carbon. They report that the CABMOD-ZoDy-model predicts 97% of the unaltered carbon-bearing cosmic dust particles at Mars are smaller than 48 μm radius, the fraction of intact carbon relative to the total unmelted influx would be about 1%, and the amount of intact carbon finally touching down would be 0.04 kg/meter^2 with the (difficult-to-measure) average concentration of about 10 ppm in the top meter of the Martian surface. More measurements *in situ* and from orbit and more experimental data from the laboratory will further refine the models and our understanding of the effects of the remarkable cosmic dust on atmospheric cosmochemistry.

See Reference:
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See also:
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Written by Linda Martel, Hawai'i Institute of Geophysics and Planetology, for ***PSRD***.

April 2020
http://www.psrd.hawaii.edu
psrd@higp.hawaii.edu