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SPACECRAFT MOLECULAR RETURN FLUX CONSIDERATIONS FOR MISSIONS TARGETING DETECTION OF ORGANICS WITH MASS SPECTROMETERS

Abstract

Science missions targeting the detection of organics from jet plumes originating from icy moons (i.e., Europa and Enceladus) will employ next-generation mass spectrometers to measure the composition of plume effluents and exospheres. During icy moon flybys, when mass spectrometers will be making measurements, molecular emissions from the spacecraft (from materials outgassing and thruster operations) interact with the local exosphere (and associated jet plumes from the sub-surface oceans of the icy moons). Spacecraft induced molecular effluents collide with molecules from the ambient exosphere and a fraction of the spacecraft emissions are returned to the spacecraft, and its complement of science instruments. The rate at which the emitted molecules are returned to the spacecraft by collisions with other molecules (in the exosphere) is known as the return flux. Return flux of molecular emissions from spacecraft sources (flight system and instruments) contribute to contaminant deposition on contamination sensitive instruments. Characterization of return flux is critical to the definition of requirements for materials outgassing (for the flight system and instruments) and for the definition of thruster operations. Typical spacecraft configurations have several sources of organic contamination. A major source of organic contamination is materials outgassing, which include: solar arrays (if solar powered), spacecraft bus, propulsion module, high-gain antennas, and science instruments. A second major source of organic contamination are thruster firings, if monopropellant or bipropellant systems are used. Analysis results using materials outgassing rate data from typical spacecraft materials demonstrate the magnitude of the molecular return flux to the spacecraft and science instruments. For solar powered spacecraft, solar arrays can represent the largest contributor to molecular return flux. The return flux is proportional to the ambient number density of the local exosphere; hence, the fly-by trajectory and proximity to the surface has a direct effect on the molecular return flux. The natural environment of icy moons produces combined effects that also impact return flux. For Europa, the high-energy radiation environment can significantly increase materials outgassing rates and produce ionization of molecular effluents. Spacecraft induced molecular return flux contributions to science instruments, in particular next-generation mass spectrometers, must be characterized and controlled to ensure that mission science objectives can be achieved. Combined effects from the interaction of the spacecraft and instruments induced environment with the natural environment further contributes to molecular return flux.