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Heliosheath Space Environment Interactions with Icy Bodies in the Outermost Solar System

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The Voyager 1 and 2 spacecraft are exploring the space environment of the outermost solar system at the same time that earth-based astronomy continues to discover new icy bodies, one larger than Pluto, in the transitional region outward from the Classical Kuiper Belt to the Inner Oort Cloud. Some of the Scattered Disk Objects in this region periodically pass through the heliosheath, entered by Voyager 1 in Dec. 2004 and later expected to be reached by Voyager 2, and out even beyond the heliopause into the Very Local Interstellar Medium. The less energetic heliosheath ions, important for implantation and sputtering processes, are abundant near and beyond the termination shock inner boundary, but the source region of the more penetrating anomalous cosmic ray component has not yet been found. Advantageous for modeling of icy body interactions, the measured heliosheath flux spectra are relatively more stable within this new regime of isotropic compressional magnetic turbulence than in the upstream heliospheric environment. The deepest interactions and resultant radiation-induced chemistry arise from the inwardly diffusing component of the galactic cosmic ray ions with significant intensity modulation also arising in the heliosheath beyond Voyager 1. Surface gardening by high-velocity impacts of smaller bodies (e.g., fragments of previous KBO collisions) and dust is a further space weathering process setting the time scales for long term exposure of different regolith layers to the ion irradiation. Sputtering and ionization of impact ejecta grains may provide a substantial feedback of pickup ions for multiple cycles of heliosheath acceleration and icy body interaction. Thus the space weathering interactions are potentially of interest not only for effects on sensible surface composition of the icy bodies but also for evolution of the heliosheath plasma. energetic ion, and neutral emission environment.

The heliosheath ion interactions with planetary material may produce background emission for Interstellar Boundary Explorer (IBEX) observations from discrete large body, associated neutral cloud, and diffuse dust sources. Bodies in the Pluto size class, like Pluto, may have substantial atmospheres from outgassing and surface sputtering sources, the surfaces potentially being constantly refreshed (consistent with higher albedo required for detection of the more distant objects) by internally-driven activity. The atmospheres would be heated and expanded by heliosheath plasma charge exchange interactions, similarly to cometary comae in the inner heliosphere and to the Cassini-detected neutral gas tori of Europa and Titan. The apparent sizes for neutral emission potentially detectable by IBEX could therefore be much larger than the body diameters. Sudden changes in neutral emission by orders of magnitude would be expected for termination shock crossings and for comparably large flux increases from interplanetary transients of solar origin. Heliosheath objects of interest particularly include 2003 UB_{313},

discovered in July 2005 at 97 AU with a newly-reported diameter of 3000 km, as compared to Pluto with diameter 2000 km at 40-AU average heliocentric distance. These two bodies both move less than one degree in heliocentric angle over six-month resampling periods and would therefore fall within the same IBEX pixels, also accounting for Earth orbital motion, over two or more consecutive samples. Continuous-mode tracking observations of neutral emissions for large distant objects like 2003 UB_{313} could provide remote determination of termination shock crossings and ion flux structure within the heliosheath.

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