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HEMISPHERIC AND TOPOGRAPHIC ASYMMETRY OF MAGNETOSPHERIC PARTICLE IRRADIATION FOR ICY MOON SURFACES. J. F. Cooper[1] and S. J. Sturner[2], [1]Heliospheric Physics Laboratory, Code 672, NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD 20771 (John.F.Cooper@nasa.gov), [2]CRESST/UMBC, Astroparticle Physics Laboratory, Code 661, NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD 20771 (sturner@milkyway.gsfc.nasa.gov).

Introduction: All surfaces of icy moons without significant atmospheres, i.e. all except Titan in the giant planet systems, are irradiated by hot plasma and more energetic charged particles from the local magnetospheric environments. This irradiation can significantly impact the chemical composition, albedo, and detectable presence of signs of life on the sensible surfaces, while also limiting lifetimes and science operations of orbital spacecraft for extreme radiation environments as at Europa. Planning of surface remote sensing and lander operations, and interpretation of remote sensing and in-situ measurements, should include consideration of natural shielding afforded by the body of the moon, by any intrinsic or induced magnetic fields as at Ganymede, and by topographic structures.

Moon Body Shielding: The physical presence of the moon produces perturbation of flows for hot plasma and more energetic charged particles corotating with the magnetic field of the central planet. The particles gyrate around local magnetospheric field lines, move up and down along these field lines between magnetic mirror points, are carried past the moon by corotation with the planetary magnetic field, and undergo gradient-curvature drift, either in the prograde orbital direction for protons and positive ions or retrograde for electrons and negative ions. Since these multiple kinds of motions are involved, the interaction and impact distributions at the moon surface are complex. In the case of Europa, electrons below 10 MeV preferentially impact the trailing hemisphere, higher energy electrons above 20 MeV impact the leading hemisphere, and large gyradius ions have more global impact distributions. The electron impact distribution is consistent with radiolytic sulfate distributions on Europa, concentrated on the trailing hemisphere, and may also account for CO_2 distributions on Callisto. Overall, irradiation fluxes and dosages are much lower on the leading hemisphere of Europa, an important consideration in the search for chemical composition of internal origin and for any organic signs of life. For a low-altitude orbiter, the leading hemispheric orbital segments offer lower radiation levels from electrons and facilitate the more radiation-sensitive observations while also extending the lifetime of spacecraft systems, a critical consideration for currently envisaged Europa orbit missions.

Magnetic Shielding: The intrinsic dipole magnetic field of Ganymede offers a refuge from surface and orbital spacecraft irradiation by Jovian magnetospheric electrons and lower energy (< 10 MeV) protons. This natural magnetic shielding is most effective within several hundred kilometers of the surface and within the region of closed dipolar field lines. Regions associated with open field lines in the polar hemispheres of Ganymede are relatively unshielded. Differences in color and CO_2 abundance between the open and closed field line regions of the moon surface are suggestive of magnetic shielding effects. Induced magnetic fields from subsurface conducting layers, e.g. salty oceans, would shift the position of the open/closed field line boundary on Ganymede and produce periodic perturbations of surface irradiation distributions on other moons without intrinsic dipole fields.

Topographic Shadowing: The diurnal shadowing of solar illumination by topographic structures, e.g. crater walls and cliffs, is familiar to planetary geologists, but more continuous shadowing effects arise for energetic particle irradiation from gyration motions. This effect becomes particularly strong when the particle gyroradiusis is comparable (high energy heavy ions) or much smaller (electrons and lower energy protons) than the curvature scale of the surface. At Europa the gyroradii of the dominant radiation dosage components, keV to MeV electrons, is comparable to the sub-km scale of topographic relief, so surface topography becomes an important factor in surface irradiation dosage distributions. Near the equator of Europa, the irradiation flux from the zenith direction, e.g. as would be relevant at the bottom of a deep crevice otherwise exposed dirurnally to solar illumination, would be zero. Since particles of one charge, positive or negative, move in only one respectively opposite direction of gyration around the local magnetic field line, there are east-west asymmetries in surface irradiation fluxes. Thus an east-facing cliff face could be shielded on one side by the cliff mass and on the other by gyration.

Conclusion: Remote sensing and landed observational strategies should exploit the natural physical and magnetic shielding afforded by the global hemispheric and surface topographic structures of icy moons imbedded in planetary magnetospheres, e.g. for separation of internal and external sources of composition.