Progress Toward Electrostatic Radiation Shielding of Interplanetary Spacecraft

Particle radiation remains a significant obstacle to human exploration of space. The sources of this radiation differ in variability, predictability, fluency, and isotropy. Because the most hazardous radiation is isotropic, it has been assumed that radiation shields must also be isotropic to protect the crew. Passive (materials-based) shielding technology has made significant progress but continues to be a costly in-flight option due to the required mass. Magnetic shielding has not come of age because it requires superconducting coils that are not only heavier than passive shields but contain single-point failure mechanisms and remain a technological challenge. However, electrostatic shielding has been largely overlooked because isotropic repulsion of the protons would attract a cloud of electrons, neutralizing the shield, whereas concentric shells of protection to repel both electrons and protons would require large voltages over short radial distances and exceed our current technology.

In this paper we review the history of electromagnetic shielding and advocate an overlooked alternative: anisotropic electrostatic fields, which leverage the asymmetries inherent in the physics so that nearly isotropic protection may be obtained without radial symmetry of the fields. This has the potential to dramatically reduce the mass of the shielding while increasing its effectiveness.