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Active shield technology for space craft protection revisited in new laboratory results and analysis

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Energetic ions in the solar wind plasma are a known hazard to both spacecraft electronics and to astronaut's health. Of primary concern is the exposure to keV–MeV protons on manned space flights to the Moon and Mars that extend over long periods of time. Attempts to protect the spacecraft include active shields that are reminiscent of Star Trek "deflector" shields. Here we describe a new experiment to test the shielding concept of a dipole-like magnetic field and plasma, surrounding the spacecraft forming a "mini magnetosphere". Initial laboratory experiments have been conducted to determine the effectiveness of a magnetized plasma barrier to be able to expel an impacting, low beta, supersonic flowing energetic plasma representing the Solar Wind. Optical and Langmuir probe data of the plasma density, the plasma flow velocity, and the intensity of the dipole field clearly show the creation of a narrow transport barrier region and diamagnetic cavity virtually devoid of energetic plasma particles. This demonstrates the potential viability of being able to create a small "hole" in a Solar Wind plasma, of the order of the ion Larmor orbit width, in which an inhabited spacecraft could reside in relative safety. The experimental results have been quantitatively compared to a 3D particle-in-cell 'hybrid' code simulation that uses kinetic ions and fluid electrons, showing good qualitative agreement and excellent quantitative agreement. Together the results demonstrate the pivotal role of particle kinetics in determining generic plasma transport barriers. [1]

[1] R Bamford et al., "The interaction of a flowing plasma with a dipole magnetic field: measurements and modelling of a diamagnetic cavity relevant to spacecraft protection." 2008 Plasma Phys. Control. Fusion 50 124025 (11pp) doi: 10.1088/0741-3335/50/12/124025