**“Raise Shields, Scotty”: Initial Experimental Results of a Laboratory “Mini-Magnetosphere” for Astronaut Protection**


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**Introduction**

Following NASA’s lead, the European Space Agency’s (ESA) AURORA Programme aims to land a man or woman on the Moon then Mars in the next few decades. This makes the health risks much more of an issue than it has been for 40 years.

**Mini-Magnetospheres**

The mini-magnetosphere is one possible solution: to create a small, portable, electromagnetically confined plasma “bubble” around the spacecraft that could act in a similar way as the natural magnetosphere does around the Earth. It was first suggested in the 1960s but dismissed for power reasons mostly. But power estimates were based on either the electric, magnetic or plasma particles creating a shield separately. In fact all the forces are used when the plasma physics of two interacting plasmas is considered on the kinetic level. Here computer simulations combined with laboratory experiments have been used to re-examine the feasibility of mini-magnetospheres for astronaut protection.

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**Plasma shield in operation. Stage 1: Magnetic “piston”**

A permanent magnet with NO internal plasma source (yet) creates a “mini-magnetosphere” away from the magnet. These results show the action of one component of the shield “the magnetic piston”.

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**Modelling**

Computer simulations of mini-magnetospheres are very sensitive to the boundary physics. MHD-fluid approximation is not appropriate as it doesn’t distinguish change species. Previous simulations have shown that finite ion Larmor radius effects are important especially where the ion Larmor radius can be comparable to the size of the mini-magnetosphere, only a fully kinetic treatment of the ions can properly take into account these effects.

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**Summary & Conclusions**

In light of the ESA AURORA goals, the physics behind mini-magnetospheres as an active shield for astronaut protection is being re-examined using plasma physics of transport barriers, incorporating particle kinetics. This involves computer simulations and laboratory experiments. The initial results shown here are very promising.

An established hybrid code (dHybrid) previously validated on AMPTE simulations (Gargate et al 2004) and has now been used to simulate the laboratory re-creations of the “magnetic piston” component of a mini-magnetosphere shield for astronaut protection.

Both model and laboratory confirmed the creation of an electrodynamic cavity in the solar wind plasma in which a space craft would be protected from the energetic particles of a solar event. The very narrow transport barrier created by both simulation and experiment, showed that the important scale size is the electron Larmor radius and not the ion Larmor radius. This illustrates how the microphysics dominates and MHD is not an appropriate model for this application (Gargate et al submitted to Special Issue of Plasma Phys & Cont. Fus. 2007).

These initial model and experimental results suggest that small artificial magnetospheres may be practical - the shield is more effective and would require much less power than previously thought.

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**Measurement**

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**Figure Legend**

[A photograph of deflected “solar wind” plasma](#)

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No astronauts have been outside the protection of Earth’s magnetosphere since the Apollo Moon landings. Even then their stay was never for extended periods of time. This makes the health risks much more of an issue than it has been for 40 years.

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**The laboratory experiment**

The solar wind in a bottle (below). The linear device (originally built for fusion edge physics studies), produces the laboratory “solar wind” magnetized beam which magnetises target represents the dipole field of a mini-magnetosphere on a spacecraft.

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**The luck of Apollo**

The Earth’s magnetosphere is made visible in miniature – such as field aligned (Birkeland) currents and the ring current. On the movies Alfvén or ion-acoustic waves can be seen.

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**A permanent magnet with NO internal plasma source (yet) creates a “mini-magnetosphere” away from the magnet.**

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**Model - Measurement comparisons**

Both show how the diamagnetic cavity, a region free of “solar wind” plasma, is created.

Langmuir probe data provides an in situ measurement of the “solar wind” plasma, is created.

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