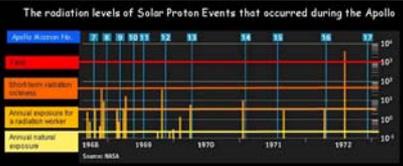


Return to the Moon, and on to Mars

- NASA committed to Return to the Moon.
- And a manned mission to Mars.
- European Space Agency (ESA) is following suit with the 'AURORA Programme'.
- To land a European on Moon/Mars.

The problem of Astronaut protection

- Radiation from Sun and other Cosmic sources are hazardous to the astronauts.
- None have been outside the protection of Earth's Magnetosphere since Apollo..... and never for extended periods of time.



The luck of Apollo



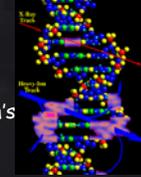
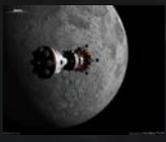
- If man is to go into space to stay then it is essential some means of protection from radiation is developed.
- The Earth is protected from much of the hazardous radiation by the action of the magnetosphere.

Finding a solution

- Why not borrow an idea from nature and bring a magnetosphere with you?
- A small artificial magnetic "bubble" around the space craft could act in the same way as the natural one around the Earth.
- But if it is small can we still get it to work?
- Is the engineering feasible?

Modelling the physics

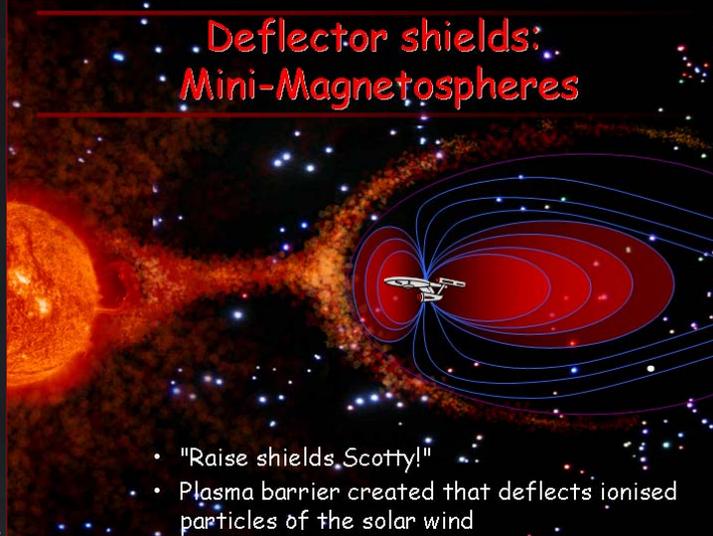
- MHD -plasma is just a magnetised fluid
 - Rather like liquid mercury
- Great at big picture but misses kinetics
- For boundary interaction on scale of electron skin depth (kms in space) have to use particle kinetics.
- Computationally demanding
- d-Hybrid - is a PIC code & has both hybrid of fluid and particle code.



Shields for the Starship Enterprise
The Mini Magnetospheres Program

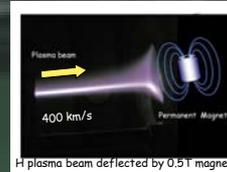
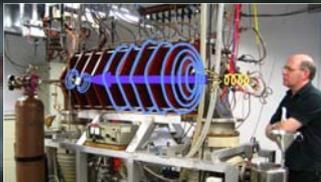
Ruth Bamford*, Bob Bingham*, Mike Haggood*, John Bradford*, Richard Stamper*, Luis Gargate†, Luis Silva‡, Carol Norberg*, Kieran Gibson‡, Tom Todd§, Howard Wilson‡

*Space Science & Technology Dept, Rutherford Appleton Laboratory, Chilton, Didcot, OX11 0QX
†Centro de Física dos Plasmas, Instituto Superior Técnico, 1049-001 Lisboa, PORTUGAL.
‡Umea University, Box 812, 981 28 Kiruna, Sweden.
§University of York, Heslington, York, YO10 5DD
¶University of Manchester, Sackville Street Building, Manchester, M60 1QD
§ EFDA-JET, Culham Science Centre, Abingdon, Oxfordshire, OX14 3DB, U.K.



- "Raise shields Scotty!"
- Plasma barrier created that deflects ionised particles of the solar wind

Experiments in the lab



- The technology being development for magnetically confined fusion can be used to develop a plasma shield.

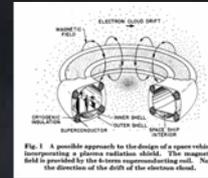
- Above is a photograph of the plasma beam being deflected asymmetrically by the magnetic field of a magnet.

Plasma shield

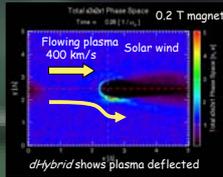
A plasma has very high conductivity.

The electrons and ions of the plasma 'barrier' react to the impinging electric field to try to cancel the field out.

By nature, plasmas behave collectively and only relatively small adjustments by many individual particles are needed to cancel the impinging electric field.



Simulations

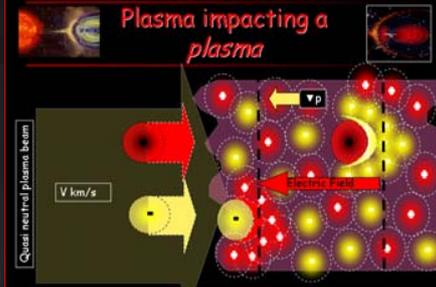


- Above is the results from the d-Hybrid computer simulation of a permanent magnet producing a diamagnetic "cavity" of excluded solar wind plasma.
- A space craft in this cavity would be shielded from the hazardous radiation of space.

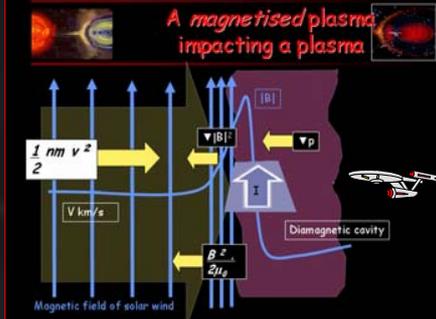
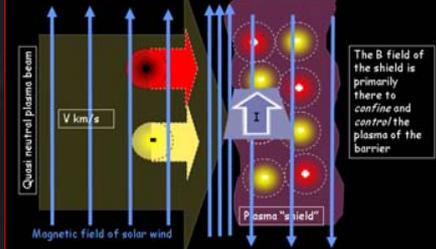
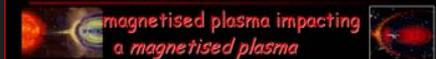
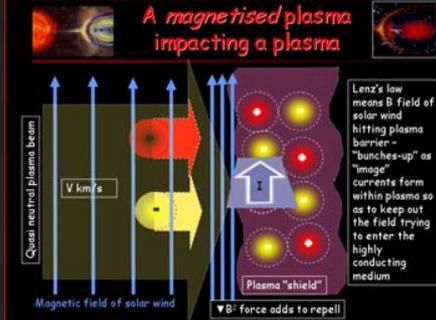
In summary

- This is perhaps THE big problem for man to 'boldly go' into the solar system. It is a show stopper if not solved.
- The idea of using an artificial magnetosphere around a space craft is not new
- But only now is the technology to make a mini-mag becoming a practical possibility.
- Time to step up the pace and put computer model and experiment together.
- The primary aim of the RAL project is to determine the physics & engineering feasibility of a space craft sized plasma shield.
- A secondary question is the possibility of mini-magnetosphere plasma propulsion to the outer planets....But that is another story...

How does it work?
The physics behind the plasma shield

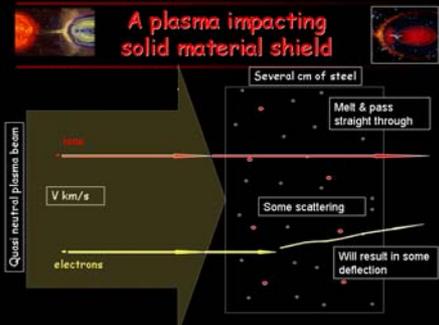


Ions & electrons have same charge but very different mass
Ions are stopped by the ELECTRIC field created by charge separation



For more information
Contact: R.Bamford@rl.ac.uk 01235 44 6517

Why not use a metal shield?



Why not use a magnetic barrier?

