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Magnetic Moons

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Abstract. Measurement of the magnetic fields around solar system bodies can tell us a great deal about their interior structure. Very often these fields have the form of a dipole field, which has been taken to indicate that some form of 'permanent magnet' is located within the body. However, here we suggest another possibility which deserves further examination.

A dipole in a uniform external field

1. Suppose the body in question is a good electrical conductor, and lies in a region of flowing magnetised plasma, such as the Earth's moon in the solar wind, or the moons Ganymede and Europa in Jupiter's magnetosphere. In this situation the plasma flow is wholly deflected around the body. The magnetic field is "frozen-in" into the plasma flow, and is hence deformed as it passes round the body, being exactly excluded from its interior.

2. It seems possible that the perturbations in the field outside the body in the above case might also have the form of a dipole field. We suggest that this possibility can be examined by deducing the overall structure of a field which consists of the combination of a uniform magnetic field $\boldsymbol{B}$ (representing the uniform field in the plasma), and a magnetic dipole of moment $\boldsymbol{M}$ which is directed exactly opposite to $\boldsymbol{B}$ (potentially representing the external field perturbations due to the moon). We further suggest that looking for null points in the field is a good starting point in examining the structure. A rough sketch that we have made indicates that the radial field could be zero on a spherical surface centred on the dipole that passes through the null points, a fact likely to be of significance to this problem, if it can be proved.

3. We point out that if it proves correct that 'induced' dipole perturbation fields can indeed be produced by the deflection of magnetised plasma around a conducting moon, we are then faced with the dilemma of distinguishing between this effect, and the effect of 'permanent magnets' located within the body. How will it then be possible to tell the difference?