The Influence of Magnetospheric Plasma on Magnetic Sounding of Europa's Interior Oceans. J. H. Westlake[1], A. M. Rymer[1], J. C. Kasper[2,3], R. L. McNutt[1], H. T. Smith[1], M. L. Stevens[3], C. Parker[1], A. W. Case[3], G. C. Ho[1], D. G. Mitchell[1], [1]Johns Hopkins University Applied Physics Laboratory, [2]University of Michigan, [3]Harvard Smithsonian Center for Astophysics.

The strongest evidence for the existence of a liquid ocean at Europa has been provided via magnetic field measurements that support the existence of a subsurface conducting layer. This evidence was derived by comparing in situ magnetic field measurements with different induced magnetic field models, including different scenarios for the bulk composition and differentiation of Europa's subsurface region Khurana et al [1998] concluded that the most likely scenario was a fully conducting layer beneath Europa's water-ice surface. While the magnetic field signature could be due to a solid metal-rich layer, other data on the differentiation and average mass density of Europa effectively rule out this possibility [Anderson et al., 1998]. The most likely scenario is that the conducting layer is a liquid ocean between 100 and 170 km thick with the conductivity generated by dissolved salts such as sodium chloride and, especially, ammonia - that not only provide free ions to carry current but also acts as an anti-freeze allowing water to be in liquid form at low temperatures.

If Jupiter's magnetosphere were otherwise empty, de-convolving the induced field from Europa's interaction with the Jovian background field would be a non-trivial task. However Jupiter's magnetosphere is full of ionized plasma mostly from its volcanic moon Io, but also from Europa, the other Jovian satellites, and from Jupiter itself. In magnetohydrostatic equilibrium the magnetic field is coupled to the ambient plasma by the relation

$$\nabla p = j \times B + \rho g$$

where the gradient of the particle pressure (p) is balanced by the magnetic tension and gravity. This relation also gives the familiar concept of the plasma β. The in situ magnetic field measurements from any proposed Europa mission will be influenced by the multitude of plasma regions encountered resulting in the following sensitivities: 1) changes in the magnetic field to maintain pressure balance in the plasma; 2) the response of the magnetic field to currents in the plasma and 3) Europa's plasma exosphere and atmosphere. Estimates of the plasma pressure contribution to the magnetic field measurements range from ~20 nT in the magnetospheric lobes to over 200 nT within the plasma sheet. This contribution is substantial compared to Europa's induction response to Jupiter's cyclical field component due to its internal conductivity, which is about 250 nT near the surface [Kivelson et al., 2000; Khurana et al., 2009]. From this relation and the estimates of its contribution to the measurements it is clear that the particle pressure is the crucial measurement for correcting the magnetic field measurements.

The Europa Clipper mission will make repeated flybys of Europa at different altitudes and locations in order to characterize Europa's induced magnetic field. Observations of the variability of this field with Jupiter's 10 hour rotation period and Europa's 85 hour orbital period will be used to determine what ocean properties are consistent with the observations. The mission concept relies on observations of Europa's induction response over a variety of Jovian system III longitudes and true anomalies, and will therefore require plasma corrected magnetic sounding measurements for every flyby. In this paper we detail the crucial measurements of the Jovian and Europan plasma environments that are necessary to magnetically sound Europa. We specifically discuss the contribution of Jovian magnetospheric plasma and Europan ionospheric plasma to the precision of the subsurface magnetic sounding measurement. We introduce a candidate suite of instruments, consisting of two Faraday cups and a retarding potential analyzer, that can provide the high quality plasma measurements that are crucial to the success of a Europa magnetic sounding experiment.

References:

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