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Magnetic fields in the vicinity of Europa: Distinguishing an internal, induced signal from the magnetospheric interaction signature

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Magnetic field measurements by the Galileo spacecraft show that there is a sub-surface ocean within Europa. The time-varying component of Jupiter's magnetic field induced electric currents in the ocean, which in turn generate an oscillating, dipole magnetic field outside the satellite. The interaction between Europa and Jupiter's magnetosphere also generates magnetic field perturbations in the vicinity of the satellite. Kivelson et al. (2000) fit the Galileo magnetic field measurements from each encounter with a dipole. The effect of the interaction field on these fits was discussed qualitatively. Further analysis by Zimmer et al. (2000) suggest that the interaction field's was 0—30% (i.e. that neglecting it results in a 15% uncertainty in the induced field's amplitude.) Fitting the data with an approximate "wire frame model" of the interaction field as well as the induced field [Shilling et al. 2007] yields a statistical uncertainty of $\sim$4% but with unknown systematic uncertainty due to the assumptions of the model. More realistic simulations of the interaction (e.g. Shilling et al. 2008) agree with the measurements reasonably well, but do not lend themselves to fitting of the measurements due to the large number of free parameters and the computational time required for each simulation.

We present an approach involving running many numerical simulations of the interaction in order to quantify the effects of the interaction with the atmosphere/ionosphere on the best-fit internal dipole. This approach allows us to estimate the uncertainty due to the interaction magnetic fields and the accuracy to which they are calculated. In addition, we can systematically investigate the sensitivity of the results to various uncertainties (e.g. uncertainties in measured, upstream plasma conditions, uncertainties in the details of Europa's ionosphere, and of differences between various models.)