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Simulations of Magnetospheric Tomography

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Over the past decade, radio tomographic techniques have seen increasing use within space science, both in practice, with ionospheric reconstruction, and theoretically as a tool for remote sensing magnetospheric plasmas. The promise of this technique for use in the magnetosphere was greatly enhanced with the idea of combined Faraday rotation and phase or group delay radio tomography. As measurables, these techniques provide distributions in space and time of electron density n_e and magnetic field $\vec B$. Given these measured quantities we present a theoretical framework for further derivation of parameters, such as plasma temperature, based upon MHD relations. Additionally, we show how using the physical constraint $\nabla \cdot \vec B = 0$ to regularize the reconstructions of magnetic field yields superior reconstructions with fewer measurements, and provides a physical and effective method for incorporating in situ magnetometer measurements. Specifically, we find that including this regularization often reduces RMS errors in magnetic field reconstructions by a factor of three. This simple regularization, especially when combined with in situ measurements is so powerful that it may influence future designs of a magnetospheric tomography mission.

We also present simulations of the techniques of combined phase delay and Faraday rotation tomography first proposed by Ganguly et al. [JGR 2000] using realistic satellite orbits and spatial distributions of magnetic field and plasma density derived from LFM MHD simulations. We show that using only a 5-6 satellites, that radio tomography can reliably image large swaths of the magnetosphere under quite different yet realistic conditions.