A new way to measure Earth's magnetosphere

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US researchers have demonstrated the potential use of a new way to measure properties of Earth's magnetosphere, the magnetic bubble that surrounds the planet.

Zhai et al. used a property known as Faraday rotation for radio tomographic imaging of the magnetosphere.

Faraday rotation occurs when a linearly polarized light wave travels through a magnetized medium such as the magnetosphere. The magnetic field causes the plane of polarization to rotate, and the amount of rotation is directly proportional to the electron density in the medium and to the magnetic field. Therefore, because Earth's magnetic field is known, researchers can use measurements of Faraday rotation to reconstruct electron density in the magnetosphere.

Using receivers on the Wind spacecraft, the researchers measured the polarization of radio signals transmitted by the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) spacecraft. They used the polarization data to reconstruct a two-dimensional electron density image of Earth's magnetosphere in the north polar region.

The researchers find that the electron density determined by this method agrees well with empirical models of electron density. Such measurements could lead to improved understanding of large-scale processes in the magnetosphere.

More information: Magnetospheric radio tomographic imaging with IMAGE and Wind, *Journal of Geophysical Research-Space Physics*, doi:10.1029/2011JA016743 , 2011

Abstract
Recent theoretical studies have shown the feasibility and potential scientific value of radio tomographic imaging of Earth's magnetosphere by measuring Faraday rotation and phase difference (or group delay) of coherent radio wave signals. On 15 August 2000, a 6 W linearly polarized 828 kHz signal transmitted by the Radio Plasma Imager (RPI) on the IMAGE spacecraft was clearly detected by WAVES X and Z antennas on Wind spacecraft. Following our previous analysis of the path-integrated product change of the magnetic field and plasma density based on the spin rate measurement, we report here Faraday rotation measured from absolute antenna orientation using the phase difference between the spin-phase modeled RPI signal and the WAVES X- and Z-antenna received RPI signals. The new approach gives Faraday rotation without the mod (π) ambiguity. The average electron density extracted along a typical signal propagation path over a 1 hour measurement window agrees well with empirical models of the northern polar region derived from years of measurements. Finally, we demonstrate preliminary 2-D radio tomographic imaging of magnetospheric plasma density using the Faraday rotation measurement.

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