Locating the Earth's Magnetopause Through X-Ray Imaging

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Abstract

Despite the development of several empirical magnetopause models based on statistical analyses of in-situ crossings, capturing the global dynamics of the magnetopause remains a significant challenge. Current work discusses new steps in the modeling of the X-ray emission produced in the Earth's magnetosheath due to the Solar Wind Charge eXchange (SWCX) processes. Initially discovered and explained for comets [1], this emission, produced by highly charged solar wind ions (e.g. O7+), has also been observed from interplanetary gas, planets, terrestrial magnetosheath, etc.[2]. SWCX emission in the Earth's magnetosheath will be the target of the future joint ESA and CAS space mission called SMILE (Solar wind Magnetosphere Ionosphere Link Explorer). The goal of the current study is to develop a methodology that will probe the global dynamics of the magnetopause, by utilizing the remote sensing capabilities of the Soft X-ray Imager (SXI) onboard. In this light, the team has developed the LATMOS Test Particle (LaTeP) model, a Test Particle (TP) model with input electric (E) and magnetic (B) fields from MHD (OpenGGCM) simulations, that is capable of estimating the levels of X-ray flux in the Earth's magnetosheath. In the LaTeP model, we follow numerical test-particles, representing O7+ ions, solving their motion equation as they propagate in the MHD-computed E and B fields, and calculate the probability of them charge exchanging with hydrogen atoms from the Earth's exosphere. The produced X-ray emission cubes are being projected and integrated over the imager's Field of View (FOV) cone, returning the synthetic images of the SXI instrument. We propose a methodology for retrieving the instantaneous location and topology of the magnetopause from single SXI images. This approach assumes that the magnetopause's tangent direction coincides with the curve of maximum intensity in the image [3], a hypothesis we test against simulation inputs. A processing pipeline is developed to fit the empirical model tangent curves to the image-derived tangent directions, and performance is benchmarked both against the intensity maxima and simulation input. Assuming a given empirical model, this technique enables the retrieval of optimal model parameters and provides a quantitative assessment of model performance. From the fitted parameters we can reconstruct the surface, providing information about the location and shape of the magnetopause.

References

[1] Cravens, T. E., Comet hyakutake x-ray source: Charge transfer of solar wind heavy ions, *Geophysical Research Letters*, *24*(1), 105–108, doi:https://doi.org/10.1029/96GL03780, 1997.

[2] Robertson, I. P., and T. E. Cravens, X-ray emission from the terrestrial magnetosheath, *Geophysical Research Letters*, *30*(8), doi:https://doi.org/10.1029/2002GL016740, 2003.

[3] Samsonov, A., S. Sembay, A. Read, J. A. Carter, G. Branduardi-Raymont, D. Sibeck, and P. Escoubet, Finding magnetopause standoff distance using a soft x-ray imager: 2. methods to analyze 2-d x-ray images, *Journal of Geophysical Research: Space Physics*, *127*(12), doi:https://doi.org/10.1029/2022JA030850, 2022.