THE UNIVERSITY OF CHICAGO

Computational and Applied Mathematics & Statistics Student Seminar

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Learning Coronal Nonlinear Force-Free Magnetic Fields Through Differentiable Rendering

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12:30 PM
Jones Laboratory,
Jones 226

ABSTRACT

We consider the ill-posed problem of computing the 3D magnetic field above the surface of the sun (the corona) from the vector magnetic field on the surface (the photosphere) and 2D optical projections of plasma flowing through magnetic field lines in the corona. We approximate the coronal magnetic field using the commonly-used nonlinear force free field (NLFFF) model. Traditional iterative numerical PDE methods have struggled with this problem, leading us to take a deep learning approach. Using a parameterized NLFFF approximation by Aschwanden (2012), we build a differentiable renderer that is able to synthesize vector magnetograms and images of magnetic field lines. Since we wish to be able to compute the coronal magnetic field from real solar data (for which there is no ground truth), we take an unsupervised learning approach by using our differentiable renderer in an autoencoder designed to learn the underlying NLFFF parameters. In particular, our loss function operates only on the rendered magnetograms and field line images; our training routine does not access the ground truth NLFFF parameters. We believe that the coupling of simple physical models with differentiable rendering provides a valuable and novel way of solving ill-posed inverse problems.