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PROBING SOLAR POLAR MAGNETIC FIELDS: A SPATIALLY-COUPLED APPROACH WITH DISAMBIGUATION

Đ. Mijović[1], I. Milić[1,2,3] and R. Centeno[4]

[1]*Faculty of Mathematics - University of Belgrade, Department of Astronomy, Studentski trg 16, 11000 Belgrade, Serbia*
[2]*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*
[3]*Institute for Solar Physics, Georges Khöler Allee 401a, 79110 Freiburg, Germany*
[4]*High Altitude Observatory, Center Green Drive 3090, CO 80301 Boulder, USA*

E-mail: djordje.mijovic@matf.bg.ac.rs

Accurate determination of photospheric magnetic fields is crucial for deciphering solar atmospheric dynamics, particularly in the polar regions, where projection effects and geometric complexities significantly challenge conventional analyses. In this study, we address the biases introduced by limited spatial resolution in spectropolarimetric data via an advanced, spatially coupled inversion method and subsequent magnetic field disambiguation.

We generate realistic observations by calculating synthetic Stokes profiles from an MHD atmosphere model, and by applying spatial degradation to mimic the effect of a telescope PSF. We then apply both traditional pixel-to-pixel inversion and the spatially-coupled approach. By comparing (i) the "true" magnetic field and line-of-sight (LOS) velocity from the original data $(\vec{B}, v_{\rm LOS})^O$, (ii) the results from spatially-coupled inversion of the convolved data $(\vec{B}, v_{\rm LOS})^{S\text{-}c}$, and (iii) the outcomes of pixel-to-pixel inversion $(\vec{B}, v_{\rm LOS})^C$, we quantitatively assess the improvement in recovering underlying magnetic structures. Furthermore, we implement a robust disambiguation procedure (minimum-energy method) to resolve the inherent 180° ambiguity in the transverse magnetic field components. Our results indicate that, within specific ranges of magnetic field strengths

and LOS velocities, the spatially coupled inversion significantly outperforms traditional methods, yielding a more accurate reconstruction of both magnetic and velocity fields. These findings underscore the potential of advanced inversion techniques and magnetic field disambiguation for polar observations.