Spherical Spectropolarimetric Inversions with PINNs Enable Novel Magnetograms from SDO/HMI

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Spectropolarimetric inversions are fundamental for the inference of the solar magnetic fields. A set of assumptions used for inverting photospheric spectral lines is that they form under the Milne-Eddington (ME) conditions, which allow for fast spectropolarimetric inversions, nowadays used routinely in most inversion pipelines. Our method performs spectropolarimetric inversions of solar data under the ME approximation with Physics Informed Neural Networks (PINNs). Building on synthetic spectral line profiles, we demonstrate that our approach can reliably solve complex magnetic configurations in a computationally-efficient way. Our method intrinsically enables spatially and temporally coupled inversions that can improve the accuracy of the inferred plasma parameters. We apply our method to observations from SDO/HMI in a spherical geometry and compare our results the VFISV pipeline inversions. Our approach improves the accuracy of the magnetic field inversions by the implicit spatio-temporal regularization, and we present an outlook for reducing the noise levels in the faster cadence HMI magnetic field data products. The spherical projection inherent of the method reduces the projection effects close to the limb, which allows us to study the polar magnetic fields. This study highlights the ability of PINNs to smoothly integrate complex data products into a unified representation, achieving state-of-the-art magnetic field estimates and advancing our existing full-Sun observations.