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Unveiling the Global Magnetic Topology with Physics-Informed Neural Networks

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The 3D coronal magnetic field is the decisive component to understand the formation and eruption of flux ropes in the solar corona. Non-linear force-free magnetic field extrapolations are a frequently applied method to provide a realistic estimate of the coronal magnetic field from photospheric vector magnetograms but are typically limited to small simulation volumes.

We present a novel approach based on Physics-Informed Neural Networks, to perform force-free magnetic field extrapolations of the global solar magnetic field. Our method uses full-disk vector magnetograms from SDO/HMI, and directly models highly twisted quiet-Sun filaments, coronal holes, and complex active region fields, that are in agreement with observations from SDO/AIA in extreme ultraviolet.

We use our method to study the eruption of a trans-equatorial filament on February 5th 2016 and its connection to a quiet-Sun filament eruption. The global extrapolation reveals the magnetic connectivity across the solar equator and interaction with an open-flux region. Furthermore, our model shows the large-scale connectivity that could link to a sympathetic filament eruption. These findings highlight the importance of the global magnetic topology, both for small scale reconnection and large topological reconfigurations. We conclude with an outlook, where we apply this approach to estimate the open magnetic flux and show that highly twisted field configurations play a significant role for the formation of open flux regions.

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