

Synthesis and inversion of Stokes parameters in the solar context applying Deep Learning Techniques

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The solar photosphere is the optical limit for which we can observe the sun at a greater depth. It is here where the structures generated by plasma convection to the solar interior are evident. The study of the photosphere allows us to analyze the emergency zones of magnetic fields, whose evolution can generate highly energetic phenomena such as flares, and turbulent movements that can be one of the causes of nanoflare generation. Although observations of the Sun are limited by the resolution of telescopes, during the last two decades an increasing number of realistic simulations of the configuration of the solar interior and atmosphere have been developed, which employ the equations of the magnetohydrodynamics and various other conditions, depending on the particular characteristics and activity in each zone of the sun, whereby the physical properties and details of the structure of various solar zones can be studied. In this work, the MURaM code is used to generate simulated physical parameters such as plasma density, temperature and velocity, including also the magnetic field, at different optical depths in the convective zone and the solar photosphere. The main objective, based on the simulations, is to train a 1D convolutional neural network, which takes the values of density, temperature, magnetic field and speed, the latter two in the line of sight, along a column. The trained network is capable of generating the corresponding Stokes parameters. Based on this model, another version is created which has an inverse functionality such that now having the Stokes parameters as inputs, the corresponding physical parameters of the plasma and the magnetic field in the same domain can be recovered.

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The effect of cross-section expansion on the evolution of coronal loops

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Solar coronal dynamics is strongly dominated by the magnetic field. The presence of loop structures, observed in Extreme Ultraviolet and X-ray images of active regions, are the most conspicuous manifestations of this. The “frozen-in” condition of the coronal plasma obliges it to flow along magnetic field lines making magnetic strands and loops the basic blocks of the coronal structure. This led, in recent decades, to a growing interest in studying the geometric and dynamic properties of these loops, in particular, in relation to the problem of coronal heating. In this work, we use a one-dimensional hydrodynamic code to analyze how the loop geometry, determined by the expansion factor of its cross-section, affects the evolution of the plasma contained in them. For that, we apply different geometries and heating regimes to modeled loops for later comparison with actual observations. Our preliminary results show that the evolution of the plasma parameters, mainly the density, are remarkably affected by different schemes of cross-section variation along the loops. This, in turn, produces clearly identifiable differences in the observational signatures of the parameters, as can be deduced from the analysis of synthetic spectral lines obtained from the models.

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Intermittent features in the solar wind: a case study

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The solar wind (SW) is a natural scenario to study intermittency in magnetohydrodynamic (MHD) turbulence for systems with low dissipation rates. These intermittent structures can be characterized by computing the degree of phase correlation of the magnetic field. In this work, we study in situ observations of magnetic field intensity, velocity, and proton density from the Advanced Composition Explorer spacecraft ACE, which is located near one astronomical unit from the Sun, in the SW near Earth. We obtained spectral indices and flatness scaling exponents of the studied fields characterizing their intermittent features.

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Assessing the predictability of solar active regions using helioseismic holography: An exploratory data analysis

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For solar astrophysics and space weather, deepening our understanding of the relationship between solar Active Regions (ARs) and solar flares is essential to predict and mitigate their effects on our planet. This study focuses on assessing the possible connection between ARs on the far side of the Sun, identified through holographic helioseismology techniques, and the ARs that rotate onto the visible side of our star, the near side. Using Doppler observations from the Solar Dynamic Observatory (SDO), the Northwest Research Associates (NWRA), in collaboration with Stanford University, regularly generates acoustic maps of the far side of the Sun (one map every 12 hours), allowing us to analyze non-visible ARs from Earth. This poster will present exploratory data analysis of ARs in the identifiable regions on both the far and near sides of the Sun, covering the period from April 25, 2010, to July 31, 2023. The list and characteristics of active regions on the visible solar disk are taken from standard catalogs compiled by the National Oceanic and Atmospheric Administration (NOAA) for this purpose. The analysis aims to assess the existence (or lack thereof) of a relationship between active regions on the far side of the Sun and those that become visible due to the rotation of our star. We analyze key parameters such as acoustic intensity and morphological evolution of active regions, to then visualize them and carried out descriptive statistical techniques to evaluate potential statistical correlations among them. This exploratory data analysis is the first step of a broader project that seeks to use the acoustic characteristics of the Sun's far side as predictors of subsequent solar flares on the visible side of our star.

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Terrestrial influence of solar activity: The September 1941 solar storm and its relationship with unexplained terrestrial events

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Solar activity refers to the various phenomena that occur on the Sun, including sunspots, solar flares, and coronal mass ejections (CMEs), mainly driven by the highly dynamic and complex Sun's magnetic field. The influence of the Sun on our planet is a fascinating and relevant topic, as solar activity can have significant effects on our environment and many technologies of our contemporary society. In this research work, we explore the relationship between solar activity and various events that occurred on Earth, focusing on the solar storm that took place in 1941. This research focus on preliminary findings and discuss the implications and prospects for future investigations in this field. Our research delves into the intriguing possibility that the intense solar storm of September 1941 may have played a pivotal role in triggering unexplained terrestrial events, including some mysterious explosions. By exploring this hypothesis, we aim to uncover new insights into the complex interplay between solar activity and its terrestrial impacts, particularly in the context of historical events that have remained enigmatic for decades. Central to our hypothesis is the concept of Faraday induction, whereby changes in the local magnetic flux during the geomagnetic storm could have induced currents in the wires connected to dynamite blasting caps. The exact magnitudes of magnetic flux changes capable of potentially triggering the detonation of the explosives during the geomagnetic storm are not definitively established. While our preliminary investigations suggest a potential connection between the solar storm and the unexplained terrestrial events, further in-depth research is needed to solidify the precise link.

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Study of magnetic field variations in high-cadence vector magnetograms during solar flares

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During a flaring event, the magnetic field topology changes rapidly, abruptly, and significantly. Some of these eruptive events inject enough energy into the photosphere and sub-photosphere to generate acoustic responses observed as sunquakes. The precise physical mechanism causing the acoustic source of a sunquake is still a topic of debate. A number of authors agree that magnetic field restructuring must play a fundamental role in causing such acoustic drivers. Previous studies have mainly probed the line-of-sight component of the magnetic field in such scenarios. In this work, we investigate the temporal and spatial evolution of the permanent changes in the magnetic field during 4 flares from high-cadence vector magnetograms (135 to 720 s) of the imaging system (dopplergrams and magnetograms) of the SDO/HMI instrument, which are suitable for investigate the phenomenon. These highly energetic events occurred during the current solar cycle 24, in a range of high and low energy, according to the GOES classification. Changes of tens of degrees in the magnetic field inclination are present in the studied flaring events displaying sunquakes. The acoustic wave is produced in the lower atmosphere by the ponderomotive force in the Alfvénic front associated with the magnetic variation. The analysis carried out represents a crucial input for the investigation of sunquake's origin and dynamics. We conclude that permanent changes in the magnetic field with values greater than 10 degrees in a kernel, are likely to induce sunquake signatures. Injection of particles seems not to take place when the field lines do not display the correct direction (downwards). Our results are in agreement with previous theoretical approaches. Sunquakes offer an opportunity for studying the interaction of acoustic waves with magnetic fields and flows in flaring active regions.

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