Engineering and Physical Sciences Research Council Doctoral Landscape Award

PROJECT TITLE: Solar and space data analysis for major risk space weather forecasting

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Project details: The current suite of space missions provides continuous high-precision images of the Sun. The resulting big data are so large and complex that they pose significant challenges for their quantitative analysis using traditional processing tools. Robust detection of physical features and events in solar imagery is a vital contributor to understanding and predicting the risk posed by space weather on electronics, communication and space-borne technology. Space weather is recognised in the UK's 2023 risk register, which ranks it as having potentially significant impact and global repercussions. Since 2011 the Met. Office hosts an operational space weather prediction centre.

To address the solar data challenge, the project will be an interdisciplinary collaboration to adapt the recent developments in deep learning and computer vision and deliver a step-change in the automated analysis of solar imagery. The research project focused on the automated detection, tracking and analysis of oscillatory phenomena in coronal holes and solar filaments, which appear as regions of low emission in images of the corona. Coronal holes are regions of the Sun where the magnetic field reaches out into the heliosphere. Filaments are magnetic structures of dense, cool plasma. The high-speed solar wind streams from coronal holes and the coronal mass ejections associated with filament eruptions are major sources of space weather disruptions. Coronal holes and filaments exhibit a rich spectrum of oscillations that includes ultra-long period limit cycles, a nonlinear process where the exchange of energy and mass in the atmosphere is driven by thermal non-equilibrium. Such oscillations provide insight into local plasma conditions and are precursors to eruptions (Foullon et al. 2004).

For the systematic analysis of those features, the project will take advantage of deep learning tools being developed for the automated detection of coronal structures in solar imagery through an inter-disciplinary collaboration between Computer Science and Mathematics at Exeter and Physics at the University of Warwick. An automated coronal hole detection tool called Wavelet Watershed Based Coronal Segmentation (WWBCS) developed by Dr Erwin Verwichte and Dr Claire Foullon already exists and has been established to be internationally competitive in a recent comprehensive COSPAR review (Reiss et al. 2024). The addition of machine learning will make distinguishing between coronal holes and filaments robust. We will adapt tracking and wave analysis tools from Ramsey et al. (2023) to collect oscillatory information on a large data set of filaments. Machine learning will aid in determining the oscillatory precursor signatures of filament eruptions.

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Project specific entry requirements: Degree in a numerate discipline (2.2 at least)

Potential PhD programme of study: PhD Mathematics

Department: Mathematics and Statistics

Location: Laver building, Streatham campus

Please direct project specific enquiries to: Claire Foullon (c.foullon@exeter.ac.uk)

Please ensure you read the entry requirements for the potential programme you are applying for.

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