Augustin André-Hoffmann (**ESR1**)

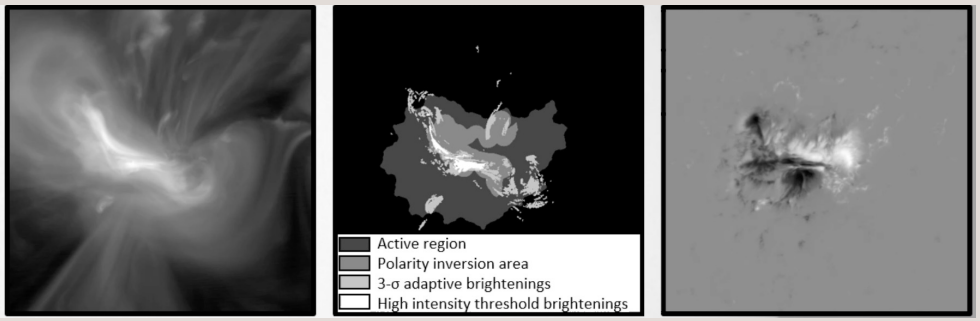
Host: University of Ioannina/Academy of Athens, Greece
Secondment Host: University of Sheffield, UK
Supervisors: Manolis Georgoulis, Spiros Patsourakos, Alexander Nindos, Robert Erdelyi
Industrial training: AstroTech, Hungary
Project: Pre-eruption magnetic configuration and eruption forecasting

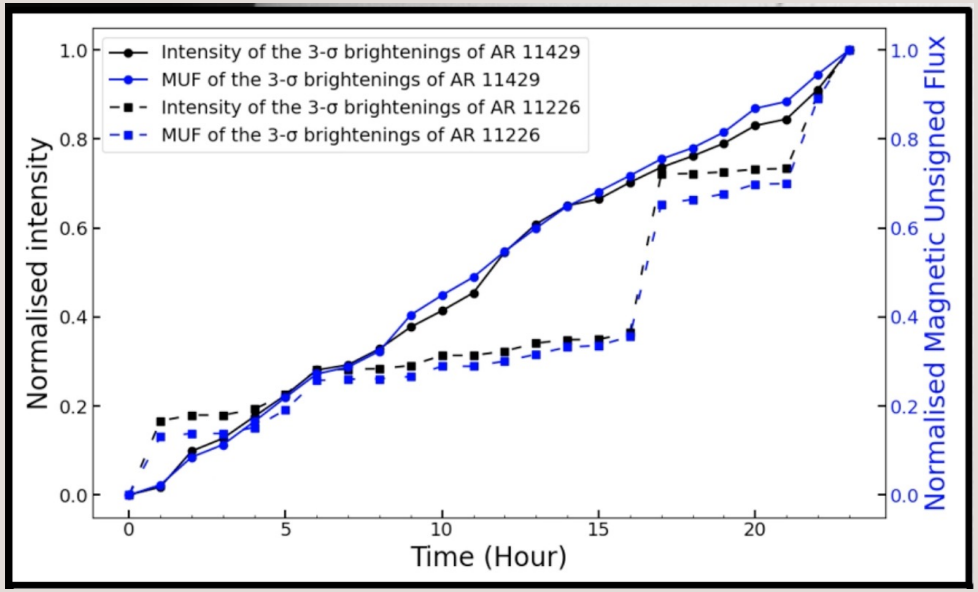
<u>Question</u>: Can transient small-scale brightenings predict major solar eruption?

<u>Methods</u>: Transient brightenings identified from active region light curves and correlated with local evolution of the magnetic field

<u>Outcome</u>: Clear differences between eruptive and non-eruptive active regions (linear versus step-like progression) → promising proxy for solar eruptions

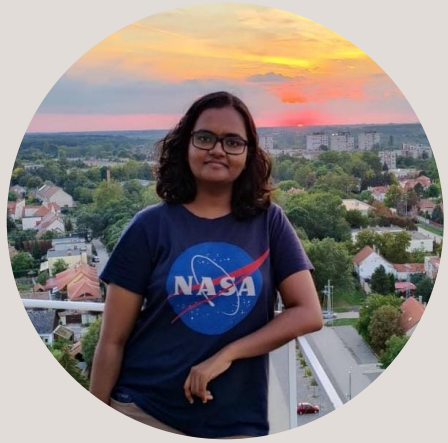
Eruptive Active Region 11492 (6 March 2012)





Shifana Koya (**ESR2**)

Host: University of Ioannina/Academy of Athens, Greece
Secondment Host: Maria Curie-Skłodowska University, Poland
Supervisors: Manolis Georgoulis, Spiros Patsourakos, Alexander Nindos, Kris Murawski
Industrial training: Instituto Pedro Nunes IPN, Portugal
Project: Assessment of the Near-Sun CME Magnetic Field

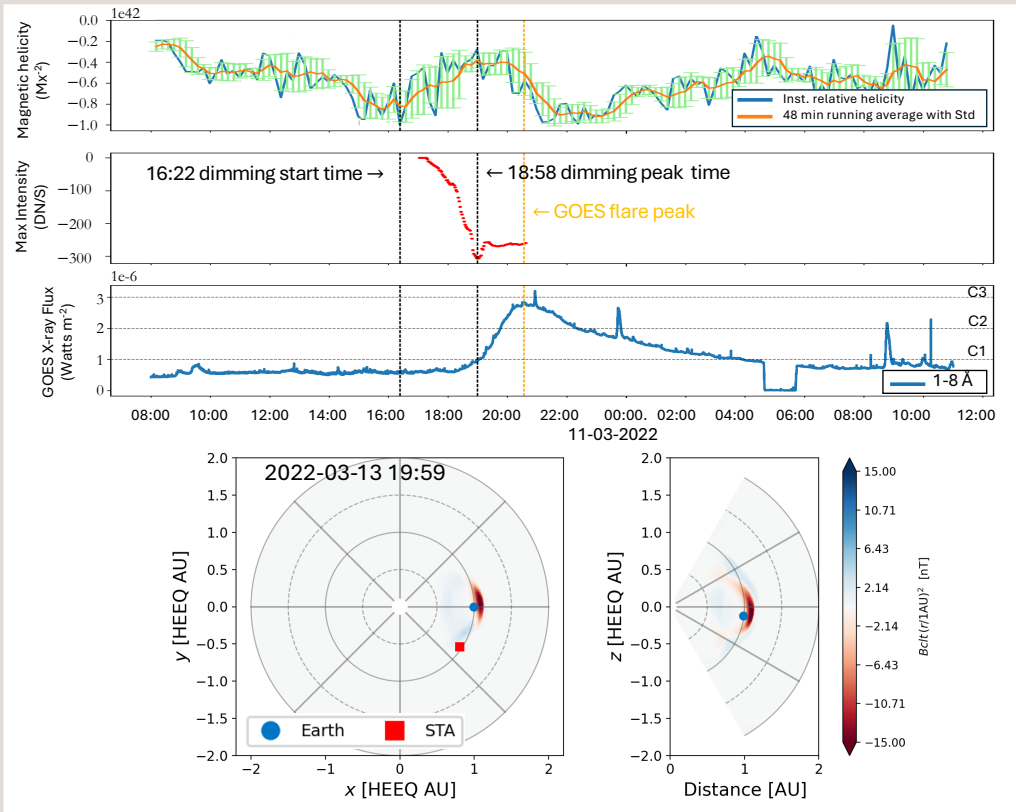


Question: How to estimate near-Sun CME magnetic field from source active region (AR) helicity?

Methods: Combine magnetic helicity in the lower solar atmosphere with outer coronal geometric CME modelling to estimate near-Sun CME magnetic field.

Outcome: Refined methodology to assess near-Sun CME magnetic field strength using the source helicity budget, enabling quantitative determination of CME chirality and magnetic flux for propagation models. The estimated power-law index for magnetic field evolution aligns well with near-Sun observations (e.g. PSP).

Top) temporal evolution of helicity budget of AR12962
Bottom) Evolution of Bz component of CME in EUHFORIA



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Shreeyesh Biswal (**ESR3**)

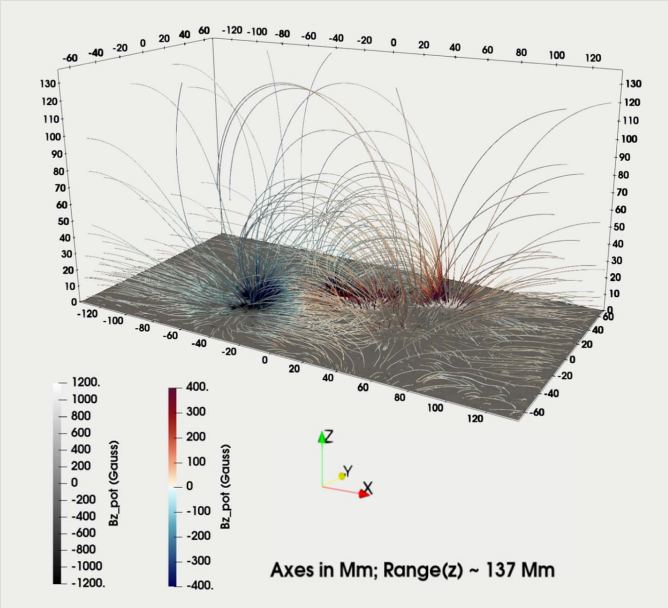
Host: University of Sheffield, UK
Secondment: University of Ioannina/Academy of Athen, Greece
Supervisors: Robert Erdelyi, Manolis Georgoulis, Spiros Patsourakos, Alexander Nindos
Industrial training: AstroTech, Hungary
Project: Three-dimensional solar flare forecasting

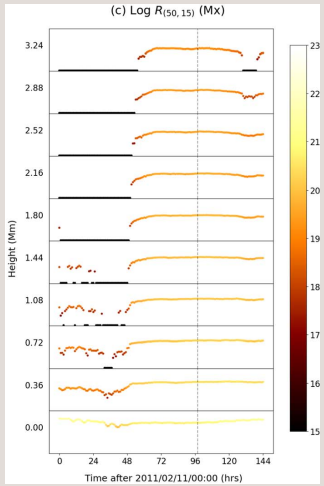
<u>Question</u>: How can we provide early warnings of solar flares?

<u>Methods</u> Analysis of R-value - a flux-based parameter in the lower solar atmosphere - after extrapolation of photospheric magnetic field.

<u>Outcome</u> R-value behaves differently for flaring and non-flaring ARs, could spike 48-68 hrs before a 'flux emerging' flaring AR → advance warning

Extrapolated coronal fileds and jumps in the R-value before the X-class flare (dashed line) for AR 11158





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Guilherme Nogueira (**ESR4**)

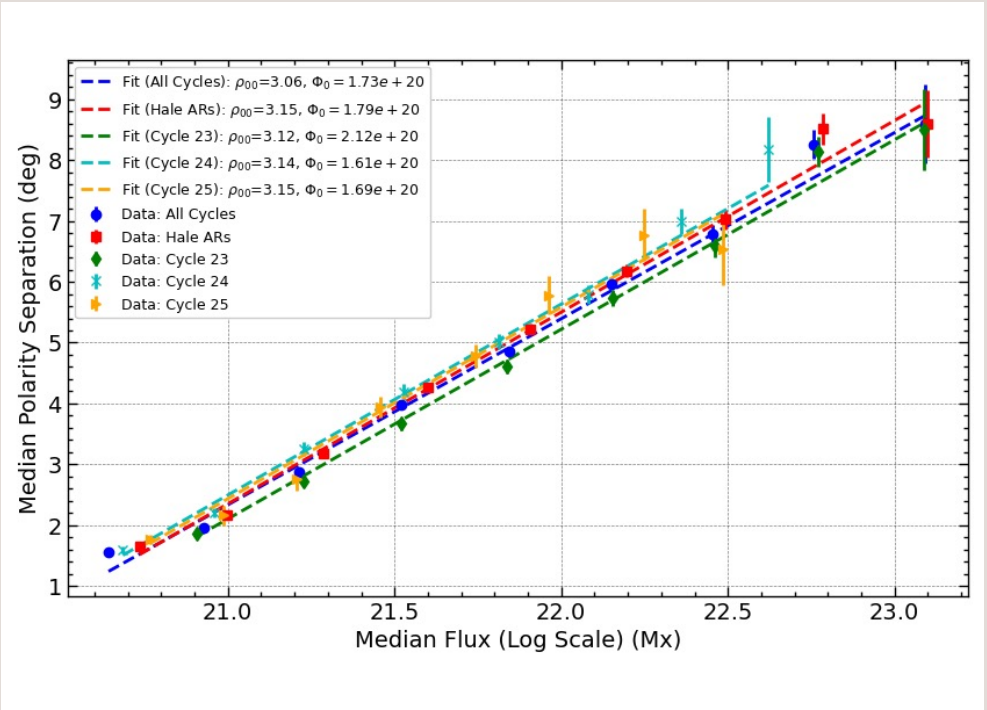
Host: Eötvös Loránd University, Hungary
Secondment Host: University of Sheffield, UK
Supervisors: Kristof Petrovay, Robert Erdelyi
Industrial training: AstroTech, Hungary
Project: Modelling periodic and quasi-periodic variations in solar activity

Question: How solar active region parameters can be used to enhance understanding of active region formation and intercycle variations of solar acticity?

Methods: Statistical analysis of data from Solar Cycles 23, 24 and 25 provided by SOHO/MDI and SDO/HMI.

Outcome: Polarity separation and magnetic flux of active regions follow a log-normal distribution, differing from the commonly observed log-log pattern → refine the source term in surface flux transport models, → improving solar cycle forecasting.

Log-Normal Relationship Between Polarity Separation and Magnetic Flux in Solar Active Regions Across Multiple Solar Cycles



Mayank Kumar (**ESR5**)

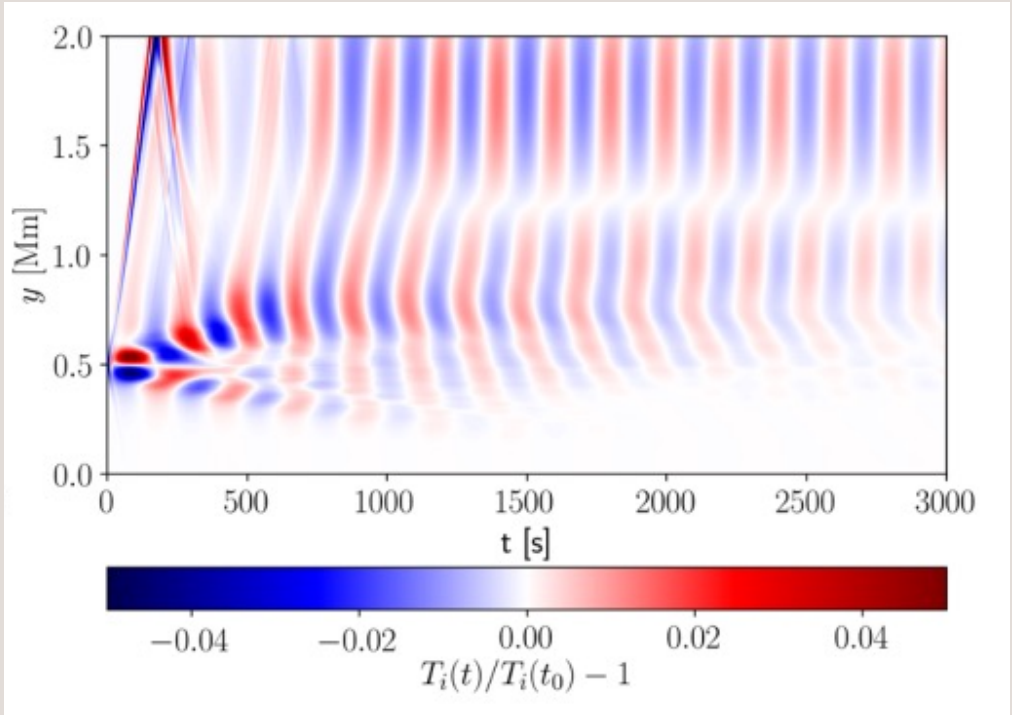
Host: Uniwersytet Marii Curie-Skłodowskiej, Poland.
Secondment Host: University of Helsinki, Finland
Supervisors: Kris Murawski, Emilia Kilpua
Industrial training: Space Applications Services, Belgium
Project: Global MHD coronal model

<u>Question</u>: How do granulation induced waves contribute to the heating of the solar chromosphere and solar wind generation?

<u>Methods</u>: Numerical two-fluid simulations of the lower solar atmosphere including ion-neutral collisions

<u>Outcome:</u> Dissipation of granulation-generated waves due to ion-neutral collisions can significantly heat the chromosphere and cause outflows.

Simulation results with coupled magneto-acoustic and Alfvén waves



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Andreas Wager (**ESR6**)

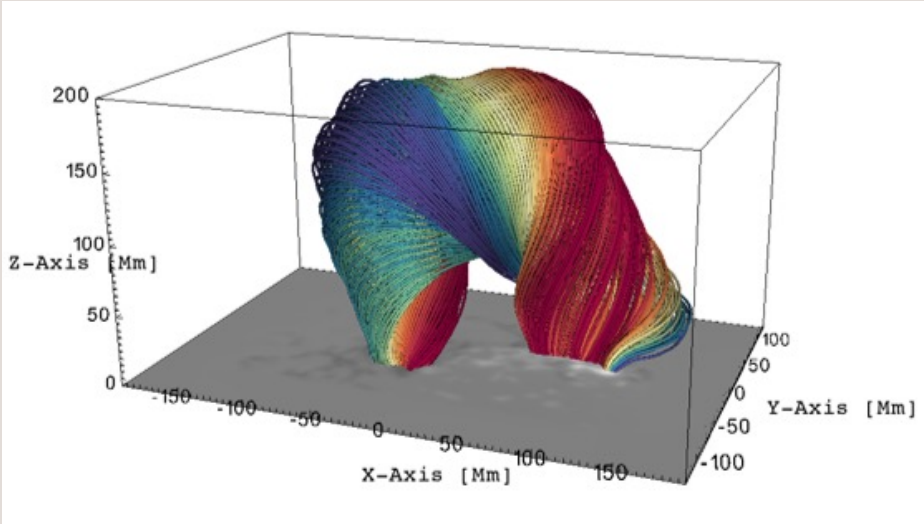
Host: University of Helsinki, Finland
Secondment Host: KU Leuven, Belgium
Supervisors: Emilia Kilpua, Daniel Price, Jens Pomoell, Stefaan Poedts
Industrial training: ASRO, Finland
Project: CME evolution in the corona

<u>Question</u>: How to identify and track flux ropes in coronal simulations, and what triggers their eruptions?

<u>Methods:</u> Compilation of a novel algorithm (with GUI) and applying it to data-driven magnetofrictional & zero-beta MHD modelling outputs.

<u>Outcome:</u> New algorithm can robustly identify / track solar flux ropes, enabling estimations of their eruptivity and early evolution

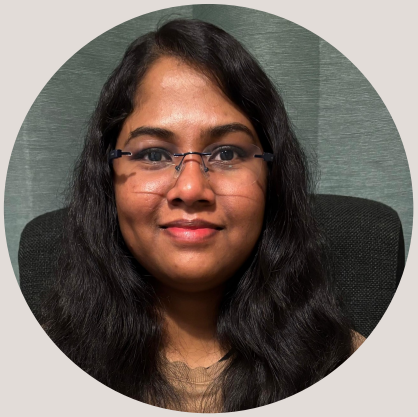
Solar flux rope indentified from the data-driven simulation output



[1] Wagner A. et al. The Automatic Identification and Tracking of Coronal Flux Ropes – Part II: New Mathematical Morphology-based Flux Rope Extraction Method and Deflection Analysis, A&A, doi:10.1051/0004-6361/202348113, 2024; [2] Wagner, A. , et al., Solar magnetic flux rope identification with GUITAR: GUI for Tracking and Analysing flux Ropes, Front. in Astron. Space Sci., 11, doi:10.3389/fspas.2024.1383072, 2024 [3] Wagner, A., et al. The Automatic Identification and Tracking of Coronal Flux Ropes. III. The Effect of Data-Driving and Relaxation Model on Flux Rope Stability, A&A, 677, doi:10.1051/0004-6361/202346260, 2024

Lidiya Annie John (**ESR7**)

Host: University of Turku, Finland
Secondment Host: KU Leuven, Belgium
Supervisors: Rami Vainio, Stefaan Poedts
Industrial training: ASRO, Finland
Project: Particle acceleration at coronal shocks

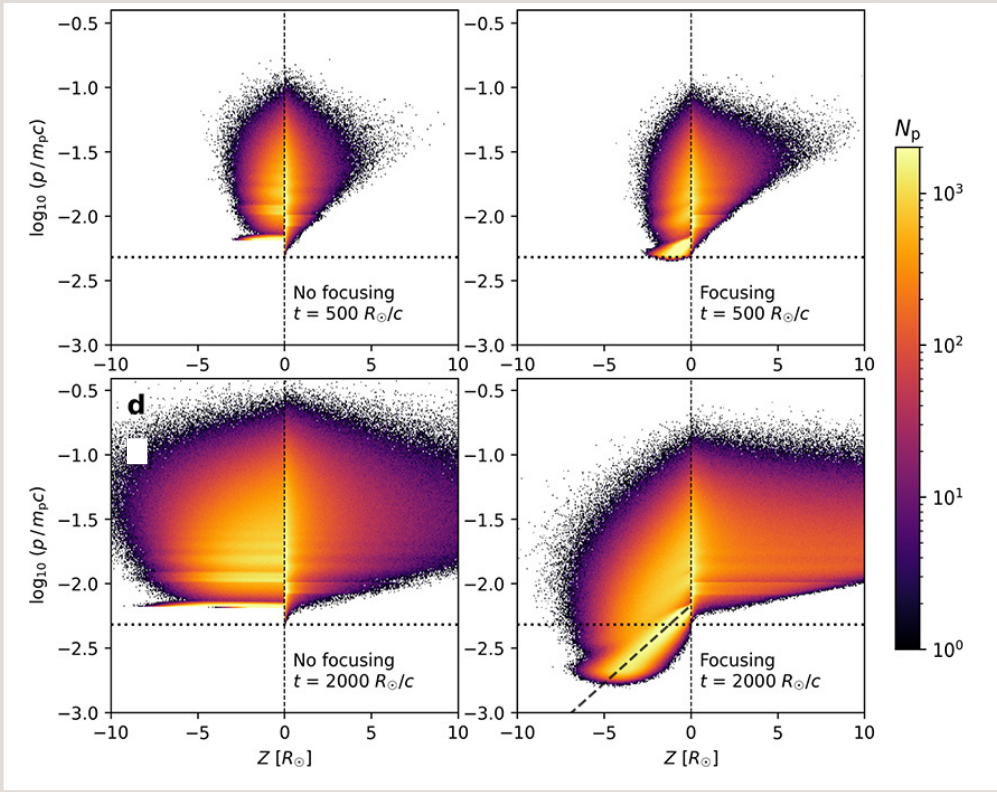


<u>Question</u>: How does the coronal environment govern the acceleration and transport of energetic particles at CME-driven shocks?

<u>Methods</u>: Test-particle Monte Carlo simulation studies with realistic coronal conditions integrated from the MHD-based COCONUT model

<u>Outcome</u>: A refined approach to SEP acceleration and transport, improving the accuracy of particle transport modeling

Evolution of Particle Distributions Without (Left) and With (Right) Magnetic Inhomogeneity-Induced Adiabatic Focusing



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Edin Husidic (**ESR8**)

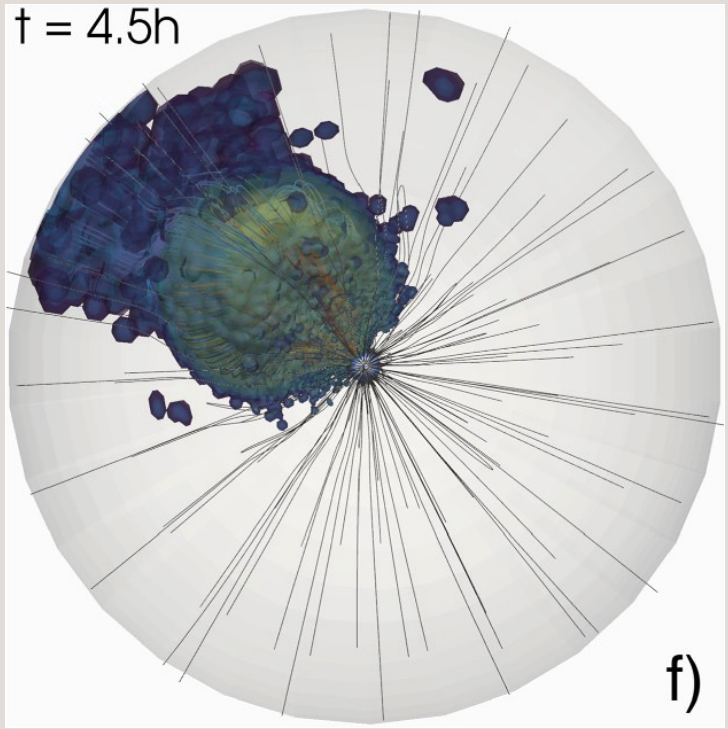
Host: KU Leuven, Belgium
Secondment Host: University of Turku, Finland
Supervisors: Stefaan Poedts, Rami Vainio
Industrial training: Space Applications Services, Belgium
Project: Particle transport in the interplanetary medium and the corona

<u>Question</u>: How do the corona and interplanetary medium affect the propagation of energetic particles coming from the Sun?

<u>Methods</u>: New combinations of a particle transport code with advanced heliospheric and coronal MHD models developed and tested

<u>Outcome</u>: Enhanced capture of shock-driven particle acceleration in the solar wind; strong perpendicular proton diffusion in CME flux ropes at very small mean free path ratios

Simulation of particle propagation in the flux rope with cross-field diffusion



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Ronish Mugatwala (**ESR9**)

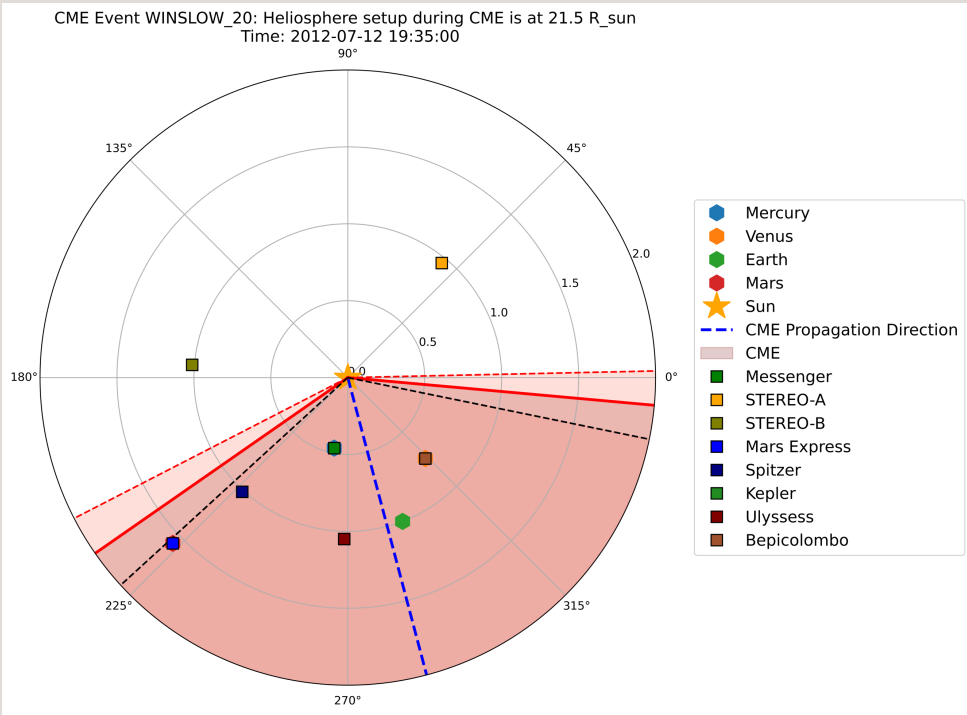
Host: Università degli Studi di Roma Tor Vergata, Italy
Secondment Host: University of Sheffield, UK.
Supervisors: Dario del Moro, Robert Erdelyi
Industrial training: NEXT, Italy
Project: Forecasting CME arrival in the whole heliosphere

<u>Question</u>: How to improve drag-based model (DBM) forecasts for predicting the arrival of coronal mass ejections (CME) at Earth or other location in the inner heliosphere?

<u>Methods</u>: Implementation of a cone CME geometry to DBM model, and model validation with a new multipoint CME database built for the project

<u>Outcome</u>: CME impact properties and arrival times can be estimated with enhanced accuracy

The importance of geometry for forecasting CME arrival



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Grégoire Francisco (**ESR10**)

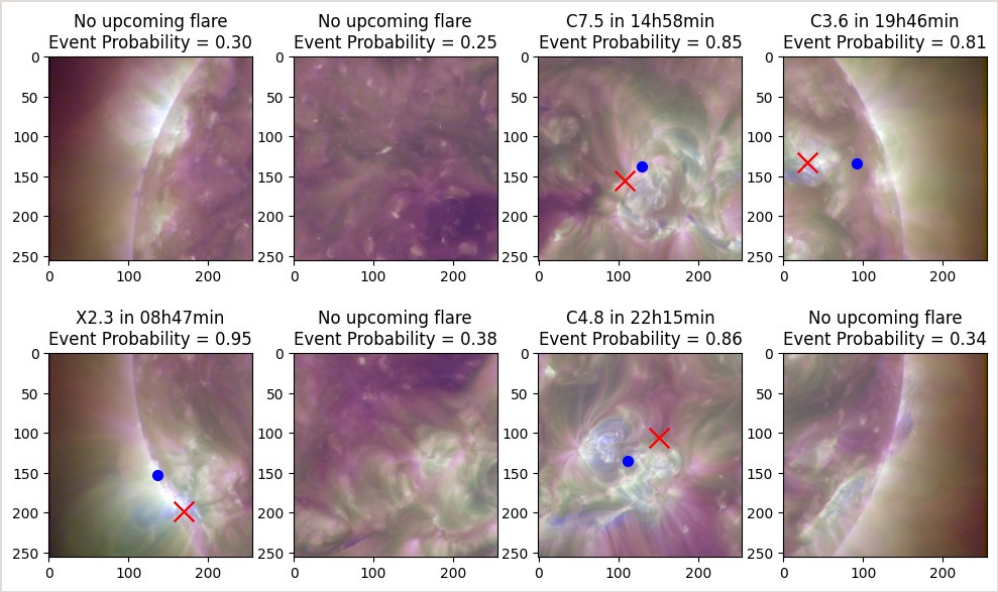
Host: Università degli Studi di Roma Tor Vergata, Italy
Secondment Host: University of Coimbra, Portugal
Supervisors: Dario del Moro, Teresa Barata
Industrial training: NEXT, Italy
Project: Forecasting solar activity with deep learning

Question: How can Artificial Intelligence techniques improve solar flare forecasting?

Methods: A novel deep learning model using coronal EUV images and line-of-sight magnetograms

Outcome: Model using EUV images outperforms model using magnetograms

Model estimations (red cross) against the truth (blue dot) for the 17 February 2020 event



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[2] Francisco, G., Berretti, M., Chierichini, S., Mugatwala, R., et al.: Limits of solar flare forecasting models and new deep learning approach, submitted to ApJ, https://doi.org/10.22541/essoar.170688972.24631782/v3

Simone Chierichini (**ESR11**)

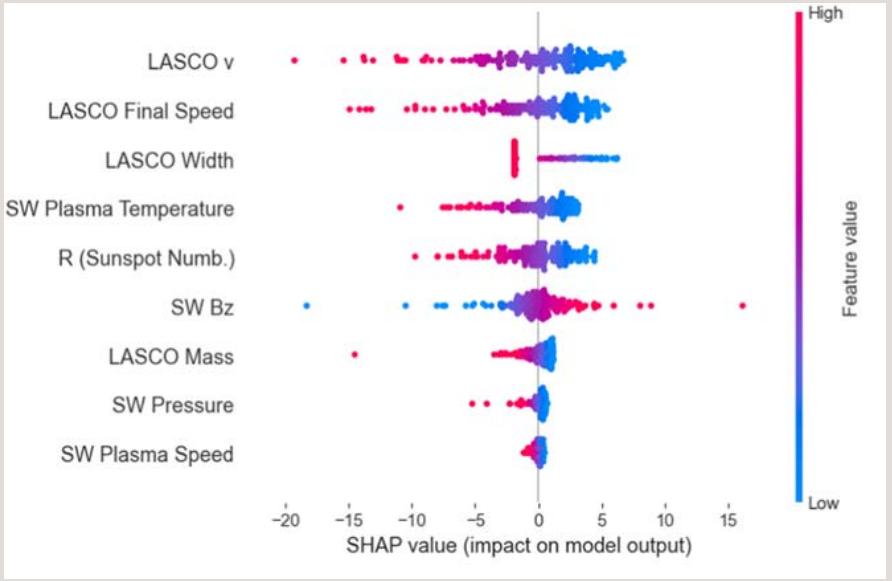
Host: University of Sheffield, UK
Secondment Host: Università degli studi di roma Tor Vergata, Italy.
Supervisors: Robert Erdelyi, Dario Del Moro
Industrial training: NEXT, Italy
Project: CME arrival modelling with Machine Learning

<u>Question</u>: How can Machine Learning (ML) techniques improve predictions of coronal mass ejection (CME) arrival?

<u>Methods</u>: New supervised learning approaches implemented to existing CME arrival prediction tools (CAT-PUMA and DBM) and estimating their limitations

<u>Outcome:</u> The use of ML techniques can improve CME arrival predictions, but robust methods are needed to evaluate their performance

SHAP (SHapley Additive exPlanations) summary plot for the training set



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Slava Bourgeois (**ESR12**)

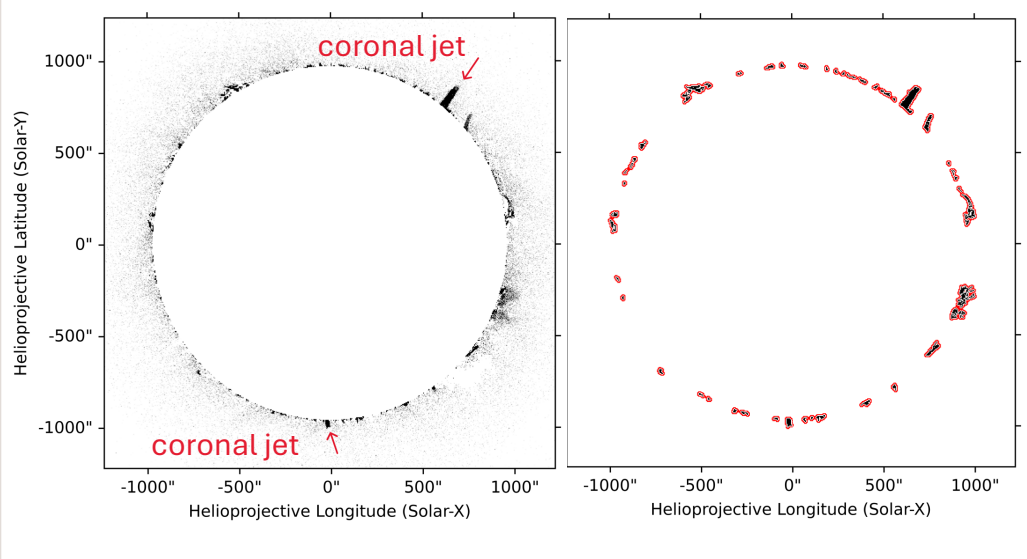
Host: University of Coimbra, Portugal
Secondment Host: University of Sheffield, UK.
Host Supervisors: Teresa Barata, Robert Erdelyi, Orlando Oliveira
Industrial training: Instituto Pedro Nunes IPN, Portugal
Project: Development of mathematical morphology algorithms to characterize the solar activity

<u>Question</u>: How to effectively identify important solar surface features from large data sets?

<u>Methods</u>: Mathematical Morphology (MM) image processing tools developed to identify sunspots and other structures, such as coronal off-limb structures

<u>Outcome:</u> New method robustly identifies sunspots and other, more complex / irregular structures → enables extensive statistical studies

Solar Dynamics Observatory AIA 304 Å images 6 June 2010 showing coronal off-limb structures (left: pre-processed, right: processed with MM techniques)



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