Third Semester Report

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Ph.D. Thesis title: Developing state-of-the-art Space Weather forecast tools

Description of research in current semester

From 2022, I am the representative of the Hungarian Solar Physics Foundation (HSPF) on the Board of the European Association for Solar Telescopes (EAST).

Magnetic helicity flux

The Astrophysical Journal accepted our paper (Soós et al., 2021) on the analysis of evolution of the different magnetic helicity flux components for 14 flaring and 14 non-flaring active regions (ARs). As a continuation of this research, I am partly involved in the supervision of two new BSc students' thesis. On one hand, the task is to mathematically derive the standing magnetic helicity flux waves as pre-cursors of solar eruptions in ARs using MHD equations. On the other hand, we now further investigate what have found in Soós et al. (2021) in relation to Coronal Mass Ejections (CMEs). Namely, we search for what connection may be between flares, CMEs, and the magnetic helicity flux components.

Sheffield Solar Catalogue

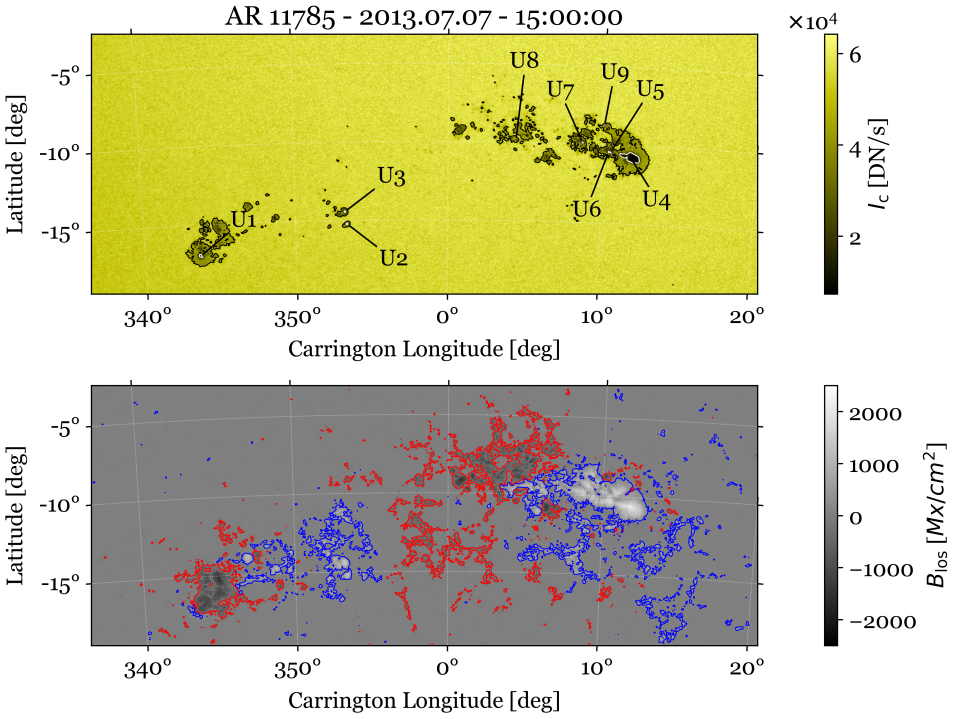

Figure 1: Example of a found Active Region in 2013, using my own sunspot search algorithm.

In parallel, I have also started developing my own sunspot search algorithm (based on intensity levels). I use continuum and magnetogram maps data from the Solar Dynamics Observatory (SDO). In short: I have i) looked for identifying the boundaries of the penumbra (46 kDN/s) and the umbra (18 kDN/s) in intensity maps, ii) calculated a range of suitable parameters of identified penumbras and umbras, iii) calculated additional parameters of the magnetograms with the intensity indices of the umbras and penumbra determined in continuum maps, and iv) identified additional parameters in magnetograms with ±150 G boundary levels. Also, most importantly, I have corrected the pixels for foreshortening and limb darkening. Furthermore, I have created a labeling system for spots. In the meantime, I have also compared IDL and Python codes to see if they would lead to a different result. But I didn't find any significant differences. An example of my algorithm results is shown in Fig. 1. All of this is to verify the results of the soon-to-be-launched Sheffield Solar Catalog (SSC). Then, I have made a small-item comparison of the results of SSC, Debrecen Sunspot Data (HMIDD), and my own algorithm. B, L, and LCM values for the spots are very similar in all cases. In contrast, the spot sizes only match between my own algorithm and the SSC. I think this is due to the fact that a lot of manual changes have been made to the HMIDD, i.e. it is not a robust automated procedure. The magnetic data will also be different in the HMIDD results. I have also managed to detect a few bugs in SSC that have now been fixed. Now, I'm working on expanding SSC with new features (e.g. principal component analysis of umbras and penumbras).

Solar Jets

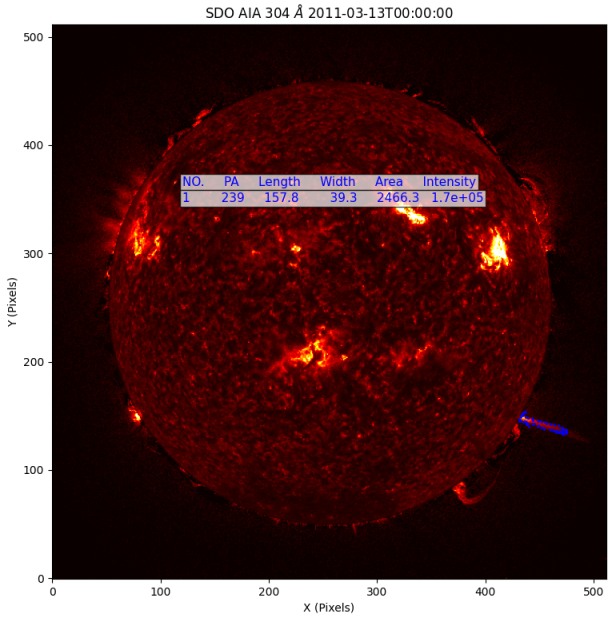

Figure 2: Example of a detected jet.

Furthermore, I have received a solar jet detection code developed by Dr Jiajia Liu (Queen's University Belfast), with that I started to expand Jiajia's solar jet database. For now, my task is to expand the currently 6-hour cadence database. That is, I have to refine Dr Liu's database to 3-hour resolution for the entire SDO timeline (2010 – 2022). Once the higher time resolution database is complete, I will perform various statistical studies. Our main science objectives with the whole SDO timeline are: i) identify the active longitude with the help of

jets, ii) mapping the fine structure of the data (e.g. detect swirls, connect with Rossby waves), and iii) look for solar cycle variability i.e. how the power law index changes as a function of time (possible evidence for two dynamo on the Sun). A nice example of a jet detected by the code which is manually confirmed is shown in Fig. 2.

Magneto-Optical Filter

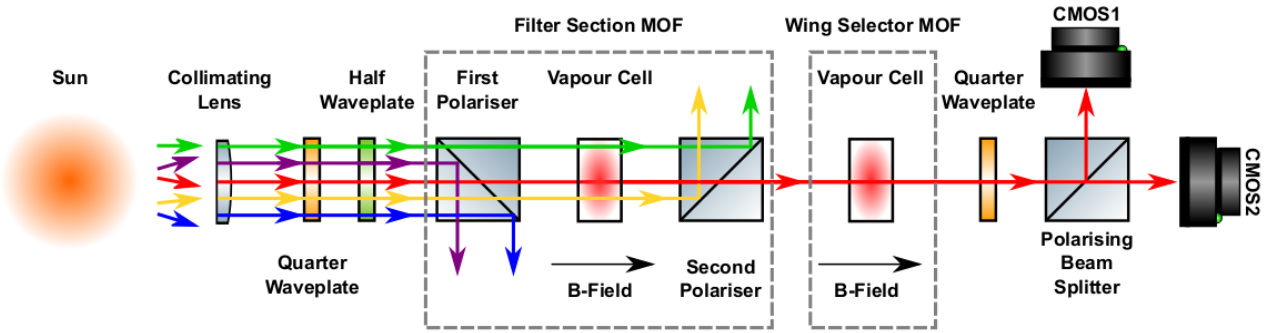

Figure 3: Schematic summary of the MOF cell.

My supervisor has been successfully applied for several huge grants, under which at least one or more cutting-edge Magneto-Optical Filter (MOF – see Fig. 3) may be built in Hungary and assemble a miniature Space Weather (mSW) Forecast Station. In addition to my theoretical research topics, I take part in the construction of these MOF cells and the assemble of the Station. These MOFs are the crucial part of the Solar Activity Monitor NETwork (SAMNet) telescopes. The first prototype was made at Durham University under the direction of Prof Dr Róbert Erdélyi. Now our goal is to i) build the same MOF cheaper and more efficiently, ii) one or more MOFs with another spectrum line, and iii) build a proof of concept miniature Space Weather Forecast Station. It will be materialized in cooperation with Za-Sa Kft. and Wigner Institute.

The renovation of the water tower of the former Gyula Monitoring Station has recently been completed. Now the work begins on our part. We have to prepare the headquarter of SAMNet the Gyula Bay Zoltán Solar Observatory (GSO), which is about to be commissioned, for operation. This includes the carrying and installation of the necessary solar physics equipment to the observatory, the assembly of furniture, and the start-up and calibration of every equipment including utilities.

In addition to all of this, perhaps the most exciting task of the semester is, we started to develop a three-dimensional chess.

Awards in current semester

- Financial support granted from the Doctoral School of Physics (772.900 HUF) for AZ-EQ6GT mount.
- Financial support granted from the Doctoral School of Physics (559.900 HUF) for ZWO ASI 1600MM Pro camera.
- National Astronomy Meeting 2021 fee waiver granted.

Publications in current semester

- Sz. Soós, M. B. Korsós, H. Morgan, and R. Erdélyi: On the differences in the periodic behaviour of magnetic helicity flux in flaring active regions with and without X-class events, The Astrophysical Journal (2021)

Studies in current semester

- Space Weather Awareness Training Network summer school: Introduction to Space Weather (November 8-12, 2021)
- Csillagaktivitás -aktív csillagok I. (FIZ/5/035)
- Space weather and space climate (FIZ/5/059)
- (Exo)Bolygólégkörök szeminárium I. (FIZ/5/043)

Conferences in current semester

- European Solar Physics Online Seminars, from 10 September 2020, Thursday on each second week.
- UK Solar Online Seminar Series, from 17 September 2020, once a month on Thursdays.
- National Astronomy Meeting 2021 (Online, July 22, 2021), with oral talk: Different periodic behaviours of magnetic helicity flux in flaring and non-flaring AR cases
- 16th European Solar Physics Meeting (Online, September 9, 2021), with oral talk: Different periodic behaviours of magnetic helicity flux in flaring and non-flaring AR cases
- XVIIth Hvar Astrophysical Colloquium (Online, September 22, 2021), with short poster presentation: On the differences in the periodic behaviour of magnetic helicity flux in flaring active regions with and without X-class events
- Solar Physics and Space Plasma Research Centre seminar (Online, October 29, 2021), with seminar presentation: On the differences in the periodic behaviour of magnetic helicity flux in flaring active regions with and without X-class events
- Planetariums and Demonstration Observatory Workshop (Pécs, November 21-22, 2021)

Professional activities in current semester

- Gyulai Csillagászati Napok (Gyula, July 24, 2021), with oral talk: Csillagok élete és halála
- Gyulai Csillagászati Napok (Gyula, July 24, 2021), Gyulai Csillagászati Napok tudományos fóruma

Teaching in current semester

- Csillagászati észlelési gyakorlatok 4 (cg1c4eg4), 2 hours a week during semester time.
- Csillagászati észlelési gyakorlatok 2 (cg1c4eg2), holding only the observational lessons with telescopes during semester time.

References

Sz. Soós, M. B. Korsós, H. Morgan, and R. Erdélyi. On the differences in the periodic behaviour of magnetic helicity flux in flaring active regions with and without X-class events. *arXiv e-prints*, art. arXiv:2112.05933, December 2021.