Understanding Heating Frequency of Active Region Loops through Forward Modeling and Machine Learning

SPD Metcalf Travel Award Report—2018 SDO Science Workshop in Ghent, Belgium

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Bio

I am currently a PhD student in the Department of Physics and Astronomy at Rice University in Houston, TX USA. As a member of the solar physics research group, I study the dynamics of coronal loops using field-aligned hydrodynamic models. In particular, I am interested in how observations from instruments like SDO/AIA can be used to constrain properties of the underlying energy deposition in active region core loops. During the course of my PhD, I have built a software pipeline for forward modeling 3D, time-dependent, multi-wavelength synthetic emission using field-aligned loop codes and magnetic field extrapolations. Furthermore, I have used this tool to understand how the heating frequency is related to observables like the emission measure slope and the timelag. These results were presented during my talk at the 2018 SDO Science Workshop in Ghent, Belgium and will be published in a series of upcoming papers as well as my dissertation. I will be defending my PhD in the spring of 2019 and am currently submitting applications for postdoctoral fellowships at a number of institutions. I am extremely grateful to the Scientific Organizing Committee for allowing me to give this talk and to the SPD and the Metcalf Award Committee for funding my travel to Ghent.

Talk Abstract

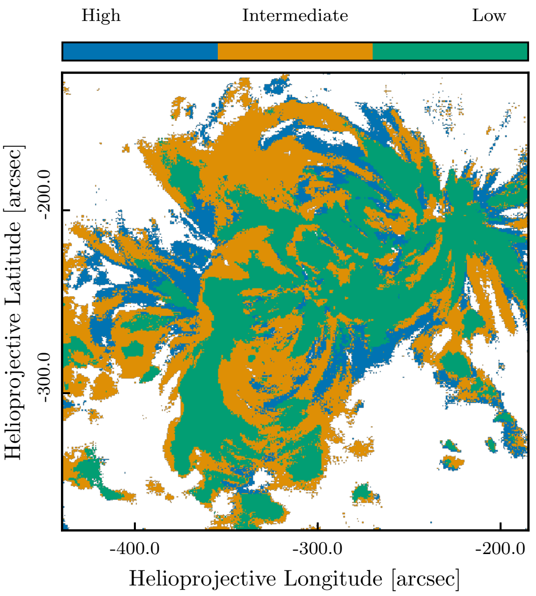

Figure 1: Heating frequency classification of observed timelags and cross-correlations from NOAA 1158

Understanding how loops in active regions are heated is a critical step in solving the coronal heating problem. In particular, constraining the frequency at which individual strands are reenergized can shed light on what mechanism releases energy from the highly-stressed magnetic field into the coronal plasma. To address this problem, we forward model time-dependent AIA intensity maps for active region NOAA 1158 using a combination of loop hydrodynamics, potential field extraplations derived from HMI magnetograms, and detailed atomic physics. We model the AIA intensity for a range of heating frequencies and constrain the total energy input based on both observed active region flux and the magnetic field strengths derived from the field extrapolation. We then compute cross-correlations for all possible channel pairs for every pixel in our synthesized active region. For a given channel pair, the delay which maximizes the cross-correlation (i.e. the timelag) provides a proxy for the cooling time between the two channels in a given pixel. We apply this same technique to twelve hours of AIA observations of NOAA 1158. To make meaningful comparisons between our synthetic and observed data, we train a random forest classifier on the synthesized timelags and apply it to our observed timelags in order to classify the heating frequency in each pixel of the active region. This approach allows us to easily and efficiently incorporate every channel pair in deciding which heating model is most consistent with our observed timelags in the context of our model. We also compute emission measure distributions from our modeled and observed intensities, as any successful heating model should be able to reproduce multiple observational signatures. This novel combination of detailed forward modeling and machine learning allows us to survey active region heating properties at an unprecedented scale.

Other Involvement

In addition to my contribution to the formal scientific program of the meeting, I also helped to co-chair the SunPy mini-workshop. Even after a full day of conference talks, around twenty-five participants, from graduate students to senior scientists, showed up to learn how Python and the SunPy package can improve their research workflows. Outside of the meeting, I also had productive conversations with several colleagues that will lead to new and interesting research collaborations.