Project Details

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Selection Year: 2012
Program Element: Focused Science Topic

Topic: Flare Dynamics in the Lower Solar Atmosphere

Project Title:
Computational and Observational Investigations into the Atmospheric Response to Flare Accelerated Particles

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Summary:
Flares dramatically enhance emission in numerous atomic lines and continua. If properly interpreted, this emission can reveal vital information about the Sun's atmospheric state during flares. However, due to the complexity of the radiative transfer in the Sun's atmosphere, extracting this information can be quite difficult. Here we propose to perform radiative hydrodynamic simulations of the response of the solar atmosphere to flare heating. The simulations model radiative transfer coupled with hydrodynamics and make predictions of how emission will increase during flares. We will correlate our predictions with data from the RHESSI and SDO space craft. We will use spectral fitting of RHESSI hard X-ray observations to deduce details of electron beams impacting on the chromosphere. A model of the electron beam deduced from RHESSI observations will be injected as a heating term into our code to simulate the radiative hydrodynamic response to flare heating. With this heating as input, the model will solve in detail the dynamics of the flaring atmosphere and can be used to predict emission, densities, velocities, temperatures, and emission measures as a function of time during the flare simulation. These will be compared with observations.

It is important to note that spectral fitting to RHESSI data provides information about the electron beam and the state of the plasma where the beam impacts i.e., primarily the chromosphere. The non-uniform ionization in the chromosphere produces a break in the X-ray energy spectrum. Several flares have been observed that have breaks in the X-ray spectrum that are consistent with partial ionization. We will investigate to what extent this break is caused by partial ionization in the chromosphere. To do this we will compare emission measure and ionization fractions obtained from the models with those obtained directly from spectral fitting. Since the model has as its input an electron beam obtained from the spectral fit, the comparison of the output of the model with the spectral fit essentially closes the "loop" between the two and provides checks on both the models and spectral fits.

Accelerated ions are known to be a source of flare heating in the lower solar atmosphere. We are enhancing our model to include the effects of ion beam heating. We will use this to investigate the origins of white light emission, sunquakes and the broad 511 keV emission line.

The positron-electron annihilation line at 511 keV has been observed in several flares to be unexpectedly broad. The line may be broadened by thermal mechanisms, but that would require a significant amount of material to be heated to ~0.5 MK. In addition, the material stays hot even after the impulsive has ended, suggesting an energy source separate from the impulsive flare heating. One possibility is low-energy ions (

Publication References:

Summary: no summary

Reference: Allred, Joel C.; Kowalski, Adam F.; Carlsson, Mats; (2015), A Unified Computational Model for Solar and Stellar Flares, The Astrophysical Journal, Volume 809, Issue 1, article id. 104, 14 pp, doi: 10.1088/0004-637X/809/1/104

Summary: no summary

Reference: Kowalski, Adam F.; Hawley, S. L.; Carlsson, M.; Allred, J. C.; Uitenbroek, H.; Osten, R. A.; Holman, G.; (2015), New Insights into White-Light Flare Emission from Radiative-Hydrodynamic Modeling of a Chromospheric Condensation, Solar Physics, Volume 290, Issue 12, pp.3487-3523, doi: 10.1007/s11207-015-0708-x