

Project Details

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Project Title:

Investigating The Influence Of Nonthermal Electrons On Increased EUV Irradiance Observed During Solar Flares Using SDO/EVE and RHESSI

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Summary:

We propose to investigate the physical processes that drive increases in extreme ultraviolet (EUV; 6-36 nm) irradiance during solar flares. As this emission can have a significant effect on Earth's upper atmosphere (Lean et al. 2009, Qian et al. 2010), understanding its origins is a major goal of the Living With A Star program. Previous studies have shown that these increases are greatest during a flare's impulsive phase (Woods et al. 2004; 2006), suggesting that they are driven by nonthermal electrons, although hard X-ray (HXR) observations have never been utilized to confirm this. The main focus of this proposal is therefore to expand upon previous works by combining observations of solar flares from the Ramaty High Energy Solar Spectroscopic Imager (RHESSI), to characterize the nonthermal electrons through HXR imaging spectroscopy, and the EUV Variability Experiment (EVE) onboard the Solar Dynamics Observatory (SDO) to measure the associated increase in EUV irradiance.

To demonstrate how coordinated observations with these two instruments can address this issue, the preliminary analysis of two low-M-class flares is presented. EVE observations show a small increase (~3%) in the total EUV emission of one flare (an M1.2 on 5 May 2010), and a larger increase of ~11% in the other (an M2.9 on 16 October 2010). In each case, it is shown that chromospheric emission (primarily the He II line at 30.4 nm) dominates this change in EUV irradiance, and that it is temporally correlated with the power contained in nonthermal electrons as determined from RHESSI observations. The RHESSI data show that the 16 October 2010 flare had a considerably harder electron spectrum ($\delta=4$, at energies up to 100 keV), than the 5 May 2010 event which had a softer spectral index ($\delta=6$ up to only 50 keV). These preliminary findings support, and expand upon, previous studies of flare EUV irradiance that only speculated that increased irradiance is driven by accelerated particles. Joint RHESSI and EVE observations are then directly comparable to the radiative hydrodynamic simulations of Allred et al. (2005), which can model the response of the He II line to a beam of nonthermal electrons.

The EVE spectral range also contains a number of density sensitive emission lines with formation temperatures in excess of 10 MK, yielding a potentially powerful and, as yet, unused diagnostic of flare densities at high temperatures. These line ratios were tentatively applied to both of the flares described above, and clear changes in the values of the line ratios were found during the two events.

- The first task of this proposal is to complete the analyses of the 5 May 2010 and 16 October 2010 events to establish the relationship between the properties of the accelerated electrons and the increase in EUV irradiance.
- Secondly, the results of this joint analysis will be directly compared to the model predictions of Allred et al. (2005) to determine the heating mechanism and constrain the total energetics.
- The third task involves investigating the diagnostic potential of the density sensitive line ratios in the EVE spectra to determine the plasma density during the two flares.
- Finally, we will extend this analysis to the 15 other flares of varying magnitudes already jointly observed by both RHESSI and EVE, and others detected during the rise of Solar Cycle 24 to perform a statistically significant comparison of nonthermal electron energies and changes in EUV irradiance.

Publication References:

Summary: no summary

Reference: Milligan, Ryan O.; Chamberlin, Phillip C.; Hudson, Hugh S.; Woods, Thomas N.; Mathioudakis, Mihalís; Fletcher, Lyndsay; Kowalski, Adam F.; Keenan, Francis P.; (2012), Observations of Enhanced Extreme Ultraviolet Continua during an X-Class Solar Flare Using SDO/EVE, The Astrophysical Journal Letters, Volume 748, Issue 1, article id. L14, 6 pp, doi: 10.1088/2041-8205/748/1/L14

Summary: no summary

Reference: Chamberlin, P. C.; Milligan, R. O.; Woods, T. N.; (2012), Thermal Evolution and Radiative Output of Solar Flares Observed by the EUV Variability Experiment (EVE), Solar Physics, Volume 279, Issue 1, pp.23-42, doi: 10.1007/s11207-012-9975-y

Summary: no summary

Reference: Milligan, Ryan O.; Kennedy, Michael B.; Mathioudakis, Mihalís; Keenan, Francis P.; (2012), Time-dependent Density Diagnostics of Solar Flare Plasmas Using SDO/EVE, The Astrophysical Journal Letters, Volume 755, Issue 1, article id. L16, 6 pp, doi: 10.1088/2041-8205/755/1/L16

Summary: no summary

Reference: Kennedy, Michael B.; Milligan, Ryan O.; Mathioudakis, Mihalís; Keenan, Francis P.; (2013), Solar Flare Impulsive Phase Emission Observed with SDO/EVE, The Astrophysical Journal, Volume 779, Issue 1, article id. 84, 8 pp, doi: 10.1088/0004-637X/779/1/84

Summary: no summary

Reference: Milligan, Ryan O.; (2015), Extreme Ultra-Violet Spectroscopy of the Lower Solar Atmosphere During Solar Flares (Invited Review), Extreme Ultra-Violet Spectroscopy of the Lower Solar Atmosphere During Solar Flares (Invited Review), doi: 10.1007/s11207-015-0748-2

Summary: no summary

Reference: Milligan, Ryan O.; (2016), EUV irradiance observations from SDO/EVE as a diagnostic of solar flares, Solar and Stellar Flares and their Effects on Planets, Proceedings of the International Astronomical Union, IAU Symposium, Volume 320, pp. 41-50, doi: 10.1017/S1743921316002234

Summary: no summary

Reference: Milligan, Ryan O.; Chamberlin, Phillip C.; (2016), Anomalous temporal behaviour of broadband Ly γ observations

