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"An Empirical Model of Coronal Heating Deduced from SoHo Observations of Transition Region Dynamics"

Final Report

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The research carried out under the above award was concerned with the analysis of "explosive events" in the solar atmosphere. Explosive events are small energy releases that reveal themselves as skewed, broadened line profiles in the 10^5 K degree material of the solar transition region. Using a data set of such events from the SUMER instrument on the NASA SoHO satellite, with unprecedented temporal, spatial and spectral resolution, we have evaluated (Winebarger, Emslie, Mariska, & Warren 1999, *Ap. J.*, **526**, 471) the energetics of these events through application of the Velocity Differential Emission Measure (VDEM) analysis technique introduced by Newton, Emslie & Mariska (1995, *Ap. J.*, **447**, 915). This work has allowed us to evaluate the contribution of various terms (such as enthalpy flux, free-streaming of high-energy electrons, etc.) to the energy budget of these events.

With the analysis technique thus placed on a firm basis, we then proceeded to analyze a large sample of explosive events observed by SUMER. The work required the development of appropriate selection criteria to distinguish "interesting" events from insignificant background fluctuations, the optimization of an integral equation inversion routine to extract velocity information from thermally broadened spectral line profiles, and an in-depth analysis of the energy budget of several events.

The main conclusion of this comprehensive study (Winebarger, Emslie, Mariska, & Warren 2002, *The Astrophysical Journal,* **565**, 1298) is that the distribution of number of explosive events $N(E)$ vs. energy per event E is a steep power-law (spectral index ~ 2.9 ± 0.1) over the range $10^{22.7}$-$10^{25.1}$ ergs. Since the index of the observed distribution is greater than 2, the energy content $\int E\, N(E)\, dE$ is dominated by the smallest events in the sample. However, the observed event distribution turns over from a steep power-law form at low event energies ($E <\sim 10^{23}$ ergs), a turnover which we have shown is most likely real and not due to instrumental threshold effects. If the steep power-law distribution had been representative of the size distribution down to lower energy ranges ($\sim 10^{22}$ ergs), such small and (currently) undetectable events would have released enough energy to heat the solar atmosphere. However, we find instead that the total energy contained in the observed event distribution corresponds to a global release of only some 4×10^4 ergs cm^{-2} s^{-1} toward both the corona and chromosphere. This implies that explosive events themselves are *not* an energetically significant input to the solar atmosphere; in particular, their energy content is inadequate by at least an order of magnitude to heat the quiescent corona. Unless the distribution of small-energy events becomes steeper for low (not currently resolvable) event energies, then this result poses significant problems for suggestions that the energy contained in numerous very small, "microflare" events is responsible for heating the corona and driving the solar wind.