NANOFLARE MODELING OF AN X-RAY BRIGHT POINT CORONAL LOOP

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ABSTRACT

We study the spatial structure and temporal evolution of an X-ray bright point loop in order to understand the role of magnetic energy dissipation. We use a time-dependent hydrodynamic model to simulate the corona and transition region in the x-ray bright point's coronal loop. For this work we model a bright point observed by TRACE and SOHO on June 17, 1998, where the magnetic field geometry is derived from an extrapolation of magnetograms. We study the effects of temporal distributions of heat deposition within the loop, as series long and short duration "nanoflares". The quantity of energy deposited and the location of the energy release is constrained by a model equilibrium magnetic field.

OBSERVATIONS

On June 17, 1998 the transient brightening of an x-ray bright point (XBP) was observed at approximately sun center by TRACE. The brightening lasted from about 09:45 to 10:45 UT, and appeared to be coincident with a flux cancellation observed in the same region by SOHO/MDI. Kankelborg and Longcope (1999) postulate that a bipole submergence model of reconnection along a current sheet applied to this particular loop will liberate $1.6 \cdot 10^{26}$ erg. While the mechanism of absorption of this energy to the plasma contained in the magnetic field is unknown, the question can be addressed indirectly through modeling nanoflares as either impulsive (short duration) events, or longer duration events.

The TRACE light curves integrated over the background-subtracted area of the bright point (about 100 pixels) are shown in Figure 1, along with the integrated $171Å/195Å$ filter ratio. A successful model of this transient brightening event must emulate a) the smoothness of the TRACE integrated light curves, b) the restriction of the filter ratio $171Å/195Å$ to values between 1.0 and 2.0, and c) the five minute time lag between the filter's maxima. We expect that the gradual rise in the TRACE data correlates with a gradual rise in heating event amplitude, frequency or duration, all of which are outside the scope of this study.

MODEL RESULTS

Extending the work of Kankelborg and Longcope (1999) to longer time heating functions, we use a modified version of their hydrodynamic code which differs mainly in the incorporation of the chromosphere. From

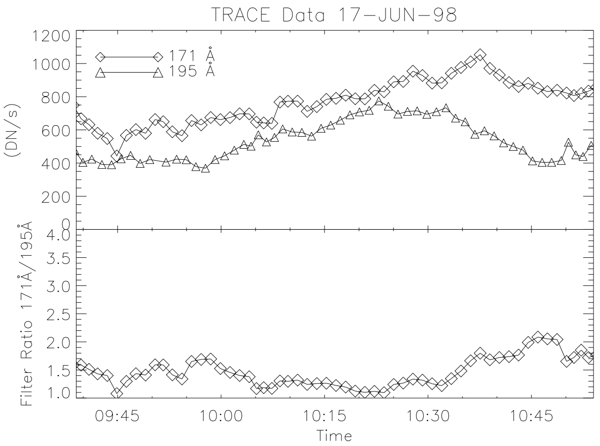

Fig. 1. TRACE integrated lightcurves and filter ratio.

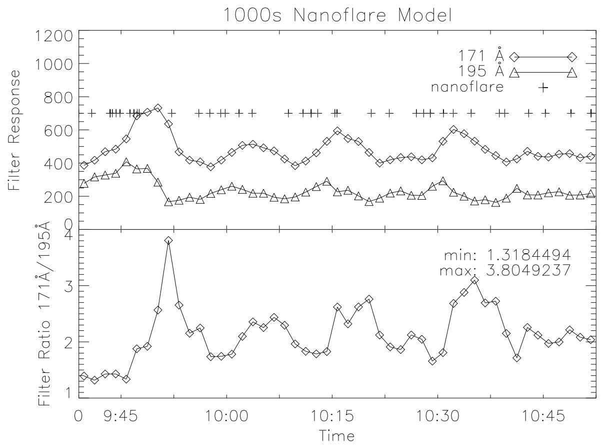

Fig. 2. Best fit model lightcurves and filter ratio.

the morphology of the TRACE observations, we derive the loop geometry including a half-length of $10^9 cm$ above the photosphere, and a crossectional area that varies from $1.8 \cdot 10^{15}\ cm^2$ at the transition region, to $1.3 \cdot 10^{16}\ cm^2$ at the loop apex. The method uses explicit finite volume advection with implicit thermal conduction. The numerical grid is static, but refined in the transition region where the temperature gradients are large. At the photosphereic boundary the model continues into a gravitationally stratified chromosphere with temperature $T = 10^4 K$. Heating of this chromosphere is not considered in the energetics of the transient brightening.

Initial equilibrium was established through a background heating of $7 \cdot 10^{-4}\ erg\ cm^{-3}\ s^{-1}$, applied uniformly in the loop, so that it settled into a steady state with a temperature maximum of $8 \cdot 10^5\ K$ and density minimum of $5.4 \cdot 10^8 cm^{-3}$ at the loop apex. From this equilibrium, spatially uniform volumetric heating functions were applied, stepping the heating up discontinuously to a constant level such that $1.6 \cdot 10^{26} erg$ were added after 145s or 1000s, respectively for the two test cases. Each model was then returned to equilibrium with the original background heating. The resulting models were rescaled by a factor of 110 in amplitude, replicated, and added in a staggered manner such that on average there was a 110s time delay between "nanoflares".

The best fit to the overall amplitude and smoothness of the data was that of the 1000s (long duration) heating events, shown in Figure 2. The smoothness of the modeled TRACE filter responses is a clear improvement over previously published work, as are the amplitude and smoothness of the model filter ratio $171\mathring{A}/195\mathring{A}$, a new analysis tool. Problems with this model include the overall amplitude of the integrated signal, insufficient time lag between peaks, and inconsistency in the filter ratio range. None of the models considered thus far optimize time spent in TRACE's peak sensitivity range. In future work we intend to include a study of regular versus random nanoflares, and the dependence of the heating function magnitude on the time lag between events.

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REFERENCES

Avrett, E.H., New Models of the Chromosphere and Transition Region, in *Mechanisms of Chromopheric and Coronal Heating*, Springer-Verlag, Berlin (1991)

Fontenla, J.M., E.H. Avrett, & R. Loeser, Energy Balance in the Solar Transition Region. I. Hydrostatic Thermal Models With Ambipolar Diffusion, *Astrophys. J.,* **355**, 700 (1990)

Kankelborg, C.C., & D.W. Longcope, Forward Modeling of the Coronal Response to Reconnection in an X-Ray Bright Point, *Solar Physics,* **190**, 59 (1999).