ABSTRACT

Physical parameters measured from an observation of a coronal loop from Gupta et al. (2015) using Hinode/EIS and SDO/AIA were used as input for the hydrodynamic, impulsively heating NRLSOFM 1-d loop model. The model was run at eight different energy inputs and used the measured quantities of temperature (0.73 MK), density (10^{10} cm^{-3}), magnetic field strength (10^5 G), and pressure (10^8 erg cm^{-3}). The model results then were compared with the observed values to see how well the model predictions matched what was observed.

RESULTS

Gupta et al. (2015) suggest at the time of observation, the loop was nearly isothermal along its length and width with an average temperature of 0.73 MK. This temperature is indicated in Figure 2 left panel by the horizontal dashed line and the point at which the simulations reach this point is highlighted by an arrow. The right panel of Figure 2 shows a close up of this region and shows that simulations of different input energies pass through this region with different slopes - higher energy simulations have steeper slopes as they cool faster.

INTRODUCTION

A complete understanding of coronal loop heating can only be achieved when simulations and observations are used together effectively. A crucial function of observers is to accurately measure loop parameters (e.g., temperature, density, loop length, magnetic field strength, plasma flows etc.) and use this analysis to infer the processes at work within the loop. This allows modelers the opportunity to contribute to the analysis of the loop by uncovering what initial conditions and heating parameters are needed to make sense of the observations. Progress in understanding coronal loops could take place at a faster rate if this type of cooperation was more commonplace.

DISCUSSION

We measure the time it takes each simulation to cool from T2 to T1 as shown in Figure 5. This time (t<sup>4</sup>) is then plotted against the input energy of each simulation. A clear trend is seen where lower energy simulations spends an increased amount of time going from T2 to T1 (as was indicated in Figure 2, right panel). The dashed line on Figure 5 shows the minimum time of 20 minutes that the observation spent in this temperature region.

Although the 3rd and 4th simulations had a similar temperature/density combination as the observation they disagree on this timescale and would not be observable in Mg VII 278.4 Å for the same length of time as the observed loop.

Our results show that our impulsively heated 1d loop model can be used to match the temperature and density of the observed loop but that the cooling periods do not match. Therefore, we conclude that simple impulsive heating cannot explain this observation and either additional steady heating component, or modeling the loop as multiple strands could bring simulation and observation closer together.

SIMULATED LOOP

The model used in this analysis is the hydrodynamic code named the Naval Research Laboratory’s Solar Flux Tube Model (Mariska et al. 1982, NRLSOFM). This NRL code allows a number of parameters to be explored and taken in values of loop length, heating rate, heating duration, loop inclination, etc. and abundances etc.

We found the observed loop’s geometry was best fit by a dipolar structure with a length of 236 Mm and a small inclination of 3.5 degrees. The NRL model is relatively quick to run (>5 mins for a loop of this length) so we performed eight runs of the simulation with a range of different input energy inputs. These energies were chosen to give the simulated loops a temperature evolution that falls within a realistic range i.e., loops with equilibrium temperature of 2MKs T ≤ 7MK (Figure 2, left panel). Here, we define the equilibrium temperature as the temperature at which the majority of the cooling is achieved by radiation rather than conduction (see Winebarger & Warren 2004).

Using their figure of the loop as observed with Hinode/EIS (sized at 110" across), given the step size of 3" and the exposure time of 35s, we estimate this loop took 20 minutes to raster over. This is the minimum time their loop was observed in Mg VII 278.4 Å. Figure 4 shows the contribution function of Mg VII 278.4 Å plotted using the CHIANTI (v7.1) function gwidth with a constant density of 10^{10} cm^{-3}. We have defined two temperatures (T1 and T2) where the full-width at half-maximum (FWHM). These temperatures define when the plasma should be observable in this line.

Figure 3 shows that two of our simulations lie in this region.

The next step was to compute the density of each simulation at the time the temperature was at the observed value of 0.73 MK. Figure 3 shows the comparison between these density values and the input energy of the simulation. Higher energy inputs result in higher densities in the simulated loops due to an increase in the amount of material evaporated into the loop from the chromosphere. The two dashed lines in Figure 3 show the minimum observed density (apex) and the average density in the top 50% of the loop as shown in Gupta et al. (2015). Our Figure 3 shows that two of our simulations lie in this region.