

MHD simulations of a coronal loop with effect of Alfvén wave turbulence heating

甲斐 達也¹、*横山 央明¹、庄田 宗人²

Tatsuya Kai¹, *Takaaki Yokoyama¹, Munehito Shoda²

1. 東京大学大学院理学系研究科、2. 国立天文台

1. School of Science, University of Tokyo, 2. National Astronomical Observatory of Japan

Coronal heating is one of the most important but still unsolved problems in solar physics and heliophysics. Alfvén wave is one of the candidate mechanisms that provide magnetic energy to the corona. However, detailed mechanisms of its thermalization are unclear. Non-linear conversion to the acoustic modes and their dissipation via shock generation are found to reproduce the hot corona in studies by one-dimensional MHD simulations (e.g. Moriyasu et al. 2004; Antolin et al. 2008, 2010). However, there remains some quantitative issues to be solved when one compares their results with observations. One is the dependence on the magnetic field strength of the corona. Since the amplitude of Alfvén wave is sensitive to the distribution of Alfvén speed, a prescribed coronal magnetic field has to be observationally acceptable one. The previous works assumed the strength to be a few Gauss that is rather small that inferred from coronal seismology or potential field extrapolation. Second is the consistency with the observed emission-line widths. For example, according to the Norikura observations, Hara & Ichimoto (1999) evaluated them to be less than 20 km/s in the lines with formation temperature of a few million Kelvin. The previous studies' amplitudes of the generated shock waves are larger than this observed value which must be investigated.

In this study, we conducted a series of one-dimensional MHD simulations to solve this line-width issue by including a noble effect: Alfvén wave turbulence dissipation. Although turbulence is essentially a three-dimensional process, its heating rate was phenomenologically estimated in one-dimensional models and was implemented in the fast solar wind simulations by Shoda et al. (2018). Our present study adopted this phenomenological approximation to one-dimensional MHD equations and conducted simulations of a closed loop for applications to active-region loops in mind. We also updated the chromospheric cooling to a sophisticated model by Goodman and Judge (2012).

In the typical case with a coronal magnetic field of several tens of Gauss, the corona with 1 MK was successfully reproduced. The obtained wave amplitude was longitudinally 18.8 km/s and transversely 20.6 km/s that were consistent with the observed emission-line widths. Alfvén wave turbulence heating was found to be more dominant than heating by shocks. Parameter survey gives a dependence of transverse velocity amplitude on the strength of coronal magnetic field as a broken power law with indices of -0.3 below 100 G and -1.0 above.

キーワード：コロナ加熱、Alfvén波

Keywords: Coronal heating, Alfvén wave