国立天文台天文シミュレーションプロジェクト 成果報告書

Radiative MHD simulation on heating and wave propagation in the chromosphere

Wang Yikang (東京大学)

利用カテゴリ　XC-B

Observation-based model could provide temperature profile in the chromosphere. This observation-based temperature profile is higher than the radiative equilibrium temperature profile, which suggests that heating process is necessary in the chromosphere. Dissipation of shock waves is considered as a candidate for heating the chromosphere. Previous researches on wave heating in the chromosphere are usually lack of detailed analysis of wave modes in the realistic model, which is our main target.

We did 2D MHD simulation with RAMENS (Iijima & Yokoyama 2017) code. This code solves radiative MHD equations from the convection zone to the corona that self-consistently includes convection, LTE (Local Thermodynamic Equilibrium) radiative transfer, chromospheric radiative loss, coronal radiative loss and heat conduction. The simulation shows that MHD waves are generalized by convection motion and propagate in the chromosphere, where they steepen to shocks and dissipate for heating the chromosphere.

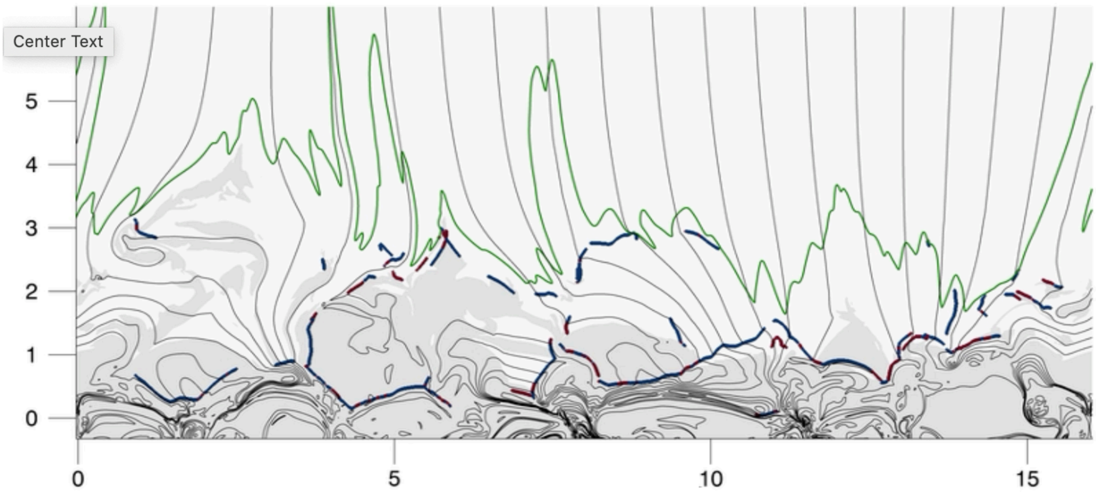

Figure 1. A snapshot of the simulation result. Green line shows the position of transition region. Grey lines are magnetic field lines. Shadow region marks the high beta area. Blue and red lines mark the position of shock front, where blue lines represent fast shocks and red lines represent slow shocks.

We also identify shocks by examining the divergence of velocity. Regions with negative velocity divergence that exceed some critical value are identified as shock front. Gas pressure and magnetic pressure in the upstream and downstream regions are compared to determine whether it is fast shock or slow shock. One snapshot of the result is shown in Figure 1.

We also estimate the amount of heating related with the shock using physical parameters in upstream and downstream regions. For detailed information on the method of estimation of heating rate one could refer to Wang & Yokoyama 2020. The result shows that radiative loss is balanced by shock heating. In addition, fast wave is dominant in heating the chromosphere in both low beta and high beta regions (see Figure 2).

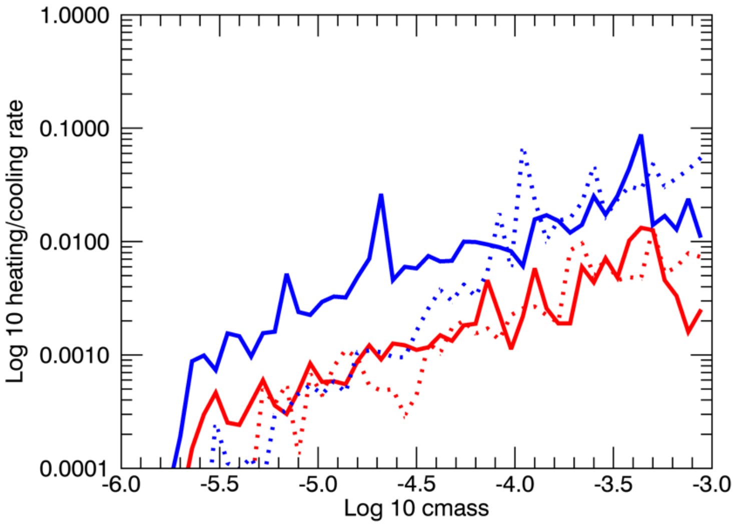

Figure 2. Time averaged spatial distribution of heating rate by fast wave (blue) and slow wave (red). Solid lines represent the result in low beta region. Dotted lines represent the result in high beta region.

It is suggested that fast waves in the low beta chromosphere are generated by mode conversion. The following work that we are now working on is quantitatively determining the effect of mode conversion in generation of low beta fast wave. In addition, as a part of future plan, results with simulation extended to 3D is also being analyzed.