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The Effect of the Chromospheric Temperature on Coronal Heating

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The solar corona is the outermost layer of the atmosphere consisting of the high-temperature plasma. To systematically understand the coronal heating, it is important to study the energy transfer from the photosphere through the chromosphere to the corona. Although recent observational and theoretical studies show a highly dynamic and complicated nature of the chromosphere[1,2], there has been little focus on the relation between the thermal structure of the chromosphere and the coronal heating.

In this study, using MHD simulations of coronal loops that are heated by the dissipation of Alfvénic waves[3,4], we investigate the role of the chromospheric temperature in determining the coronal properties. Instead of solving the radiative transfer equation, we employ a simple radiative loss function to artificially tune the chromospheric temperature.

We find that the chromospheric temperature is a key factor to determine whether the hot corona is formed particularly for short loops. When the temperature in the underlying chromosphere is high, the chromosphere is extended due to the large density scale height. Then the upper layer cannot be heated up to high temperature against conductive cooling owing to the insufficient loop length for the corona. We also find that the coronal field strength highly affects the coronal formation because the strong magnetic field enhances the heating. From our numerical simulations, we derive the condition for the coronal formation with respect to the half loop length $l_{\rm loop}$: $l_{\rm loop} = a\,T_{\rm min} + l_{\rm th}$, where $T_{\rm min}$ is the minimum temperature in the atmosphere and parameters a and l_{th} have the negative dependencies on the coronal field strength (Figure 1). It is concluded that the coronal heating is inseparably linked to the thermal structure of the chromosphere.

References
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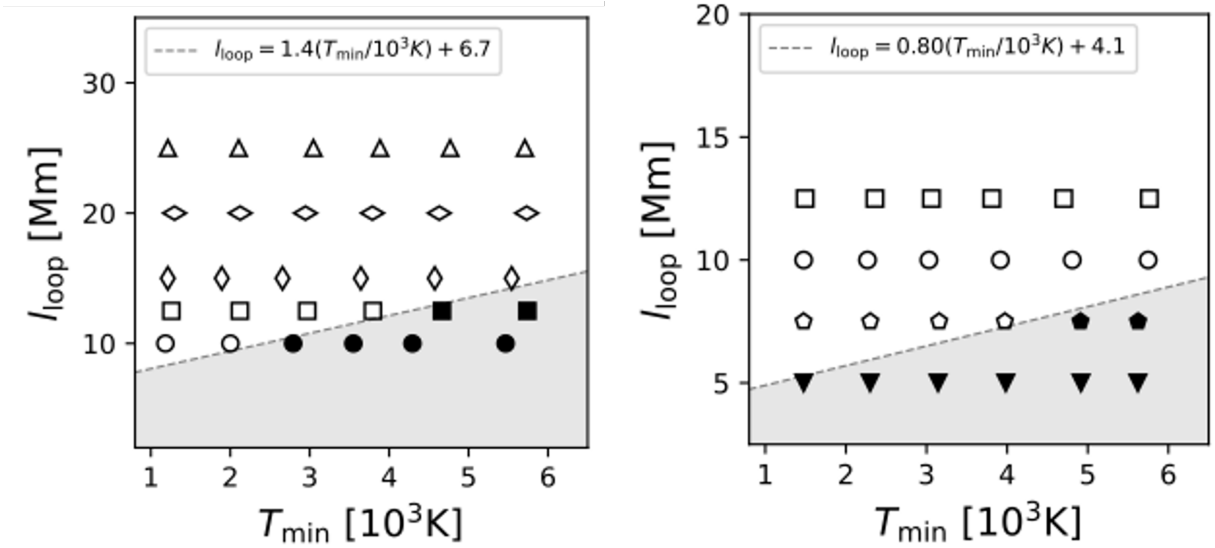

Figure 1. Half loop length with minimum temperature for the coronal field strength of 10.5 G (left) and 105 G (right). Open symbols correspond to the cases in which the corona is formed. Filled symbols are the cases in which the corona is not formed. The hot corona is not realized in the shaded region where the condition for the coronal formation is not satisfied.