Plasma heating triggered by large-scale turbulence in the wakes of CMEs

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Magnetohydrodynamic (MHD) turbulence is ubiquitous in the process of solar eruptions, and it is crucial for the fast release of energy and wave structures related to coronal mass ejections (CMEs). There are some specific turbulent regions found in our simulations: inside the current sheet (CS), above the flare loops and at the base of the CME, where the energy cascades from large to small scales. The cascading reconnection mediated by plasmoids and the scaling law in the post-CME CS are studied in detail in [1]. And the turbulence might be also related to the formation of the hot diffuse region above the flare loops, named as Supra-Arcade Fan, which is particularly an important contributor to the source of quasiperiodic pulsations (QPPs) [2].

The CME plasma has been observed to be strongly heated during solar eruptions, but the heating mechanism is not understood. The upflow from the CS, small-scale reconnection and slow shocks are competing candidate mechanisms responsible for heating the ejected plasma. Considering the Lin & Forbes catastrophic model, we present the analysis of the termination region of the reconnection site under a CME, using 2.5D MHD simulations including thermal conduction. Figure 1 shows the global evolution and synthetic images in Observatory/Atmospheric Imaging Assembly (SDO/AIA) wavelengths at the early time of an eruption. The numerical results show that the interaction between the tearing CS and the turbulence including the termination shocks (TSs) at the bottom of the CME can make significant contribution to heating the CME [3]. And the heating rate at the base of the CME is found to be greater than the kinetic energy transfer rate. Also, the turbulence can be somewhat amplified by the TSs. The compression ratio of the TS under the CME can exceed 4 due to thermal conduction, but such a strong TS is hardly detectable in all Solar Dynamics Observatory/Atmospheric Imaging Assembly (SDO/AIA) bands. Lastly, turbulence is an indispensable source for the periodic generation of coronal wave trains around the CME. This work was supported by the National Natural Science Foundation of China (NSFC) grant 12073073 and the Applied Basic Research of Yunnan Province 202101AT070018.

References

[1] J. Ye et al., MNRAS, 482, 588 (2019)
[2] J. Ye et al., ApJ, 897, 64 (2020)
[3] J. Ye et al., ApJ, 909, 45 (2021)

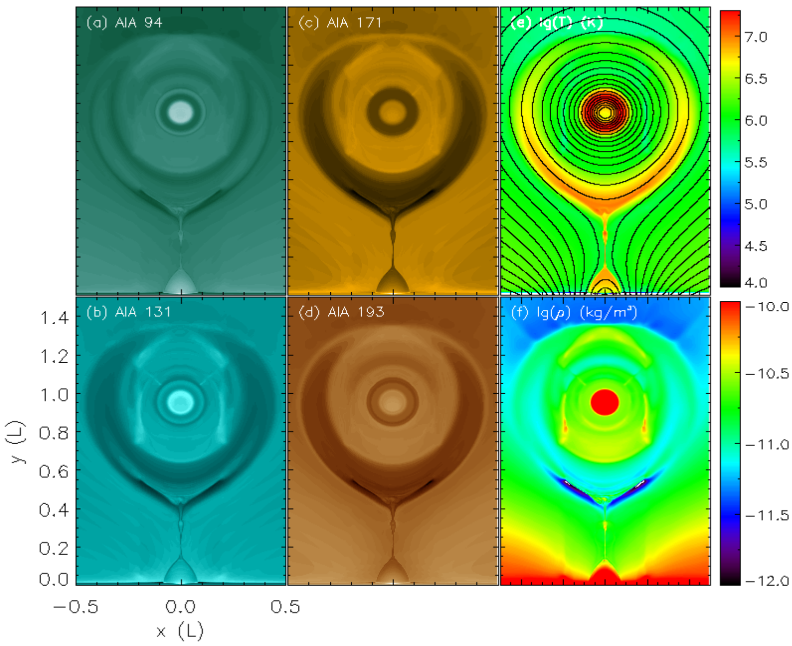

Figure 1. Global evolution in the x-y plane at a sampled time. (a) AIA 94. (b) AIA 131. (c) AIA 171. (d) AIA 193. (e) Temperature. (f) Density.