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Magnetic reconnection in the strongly magnetized regions of the low solar chromosphere within the reactive multi-fluid plasma-neutral model

Lei Ni[1], Vyacheslav S. Lukin[2]

[1] Yunnan Observatories

[2] National Science Foundation

email : leini@ynao.ac.cn

Magnetic reconnection (MR) is the most likely mechanism responsible for the high temperature events that are frequently observed around the solar temperature minimum region (TMR). We have studied MR in such an environment by employing MHD-based simulations of a partially ionized plasma within a reactive 2.5D multi-fluid model[1,2]. In strongly magnetized regions with low plasma β, the initially weakly ionized plasmas become strongly ionized during the MR process and the ionized and neutral fluid flows are well-coupled throughout the reconnection region, the effect of recombination on magnetic reconnection rate can be ignored. The reconnection characteristics are then close to those in fully ionized plasmas, the reconnection process resembles the Sweet-Parker model before magnetic islands appear, and the plasmoid instability is the main physical mechanism to result in fast magnetic reconnection in a high Lundquist number MR process. Decoupling of the ion and neutral inflows appears obviously in a high β case, and the recombination effect strongly increases the reconnection rate. The rate of ionization of the neutral component of the plasma is always faster than recombination within the current sheet region even when the initial plasma β is as high as β=1.46. The non-equilibrium ionization-recombination dynamics play a critical role in determining the structure of the reconnection region, lead to much lower temperature increases as compared to simulations that assume plasma to be in ionization-recombination equilibrium. However, the plasma temperature increases with time inside the current sheet, we can still find that the maximum value is above 20000K when the reconnection magnetic field strength is greater than 500 G. Therefore, the Si IV emission lines can still possibly be produced during such a MR process around the solar TMR.

References:

[1] **Lei Ni**, Vyacheslav S. Lukin, Nicholas A. Murphy, Jun Lin, Magnetic reconnection in the low solar chromosphere with a more realistic radiative cooling model, Physics of Plasmas, Volume 25, Issue 4, 042903(2018).

[2] **Lei Ni**, Vyacheslav S. Lukin, Nicholas A. Murphy, Jun Lin,Magnetic Reconnectionin Strongly Magnetized Regions of the Low Solar Chromosphere, The Astrophysical Journal, Volume 852, Issue 2, 11 pp. (2018).

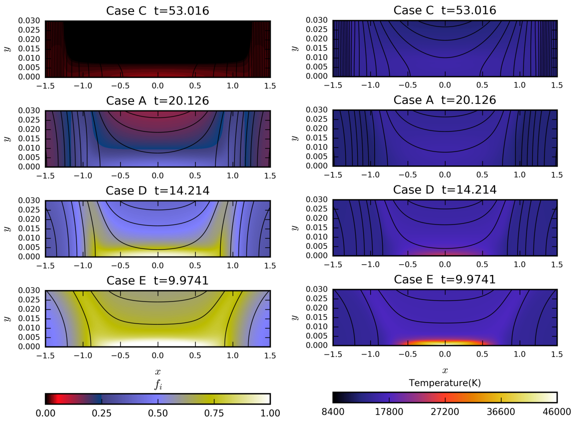

Fig. 1 The distributions of ionization degree f_i and plasma temperature at the end of the simulations in four different cases with different strengths of magnetic fields. The initial magnetic fields are B_0=100 G in Case C, B_0=500 G in Case A, B_0=1000 G in Case D, and B_0=1500 G in Case E.

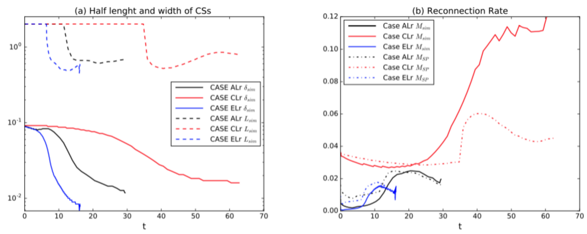

Fig. 2 (a) shows the half length L_{sim} and width δ_{sim} of the current sheet in Case ALr, CLr, and ELr. (b) shows the time dependent reconnection rates in Case Alr, CLr, and ELr, the solid lines represent the calculated reconnection rates from simulations and the dashed-dotted lines represent $1/S_{sim}^{0.5}$, S_{sim} is the calculated Lundquist number. B_0=100 G in Case CLr, B_0=500 G in Case ALr, B_0=1500 G in Case ELr.