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Magnetic reconnection and Plasma heating below the middle chromosphere

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The plasmas in the low solar atmosphere are highly stratified and the total hydrogen density decreases about 6 orders of magnitude within a thin layer of 2 Mm. The temperature in this region is generally only several thousand K and the plasmas are partially ionized. Plenty of small scale magnetic reconnection events in this region have been observed. The formation mechanisms and fine structures in the reconnection region of these events are still not clear because of the insufficient resolution and sensitivity of the solar telescopes. In this talk, we will introduce our numerical results about magnetic reconnection with strong magnetic fields below the middle chromosphere based on both the single-fluid and reactive muti-fluid models.

Our numerical results show that ambipolar diffusion and radiative cooling both result in the much faster current sheet thinning and lead fast reconnection to appear earlier in the case with zero guide filed[1, 2]. When the reconnection magnetic field is strong and the plasma β is low (~0.06), the ionized and neutral fluid flows are well-coupled throughout the reconnection region[3, 4]. The rate of ionization of the neutral component of the plasma is always faster than recombination within the current sheet region, the initial weakly ionized plasmas become strongly ionized inside the current sheet[3, 4]. The plasmoid instability terminates in a scale with length around 100 m and width around 2 m (See Fig. 1), which is still much larger than both the ion inertial length and ion neutral collision mean free path within the current sheet region[4]. Both the recombination and Hall effects on the reconnection rate are small[3,4], plasmoid instability is the main mechanism to lead fast magnetic reconnection (See Fig.2)[4]. However, 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[3]. When the plasma β above the temperature minimum region is about and smaller than 0.06, the temperature above 20, 000K can still be formed[3,4].

Our recent high resolution simulations[5] of magnetic reconnection between emerging magnetic field and the background field in the gravitationally stratified solar atmosphere will also been presented in this talk.

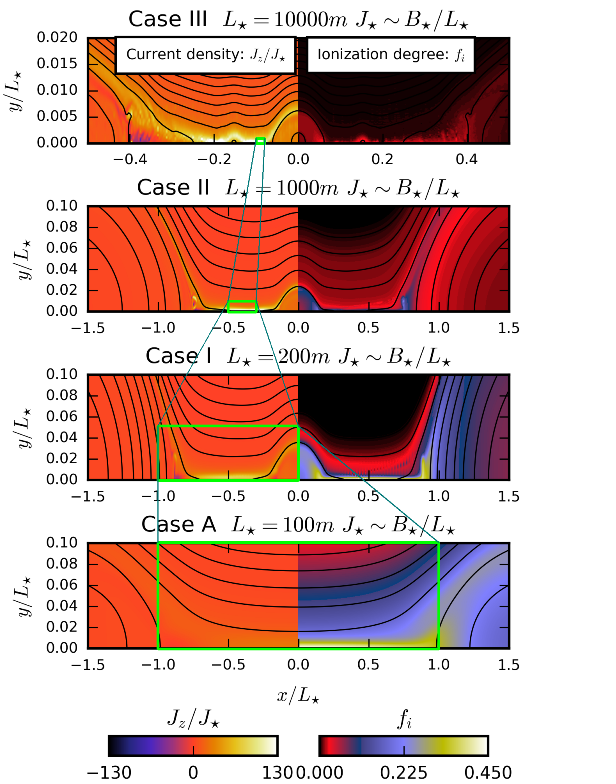

Fig.1 Magnetic reconnection in the multi-fluid simulations with different length scales (corresponding to different Lundquist number). When the Lundquist number is higher, more plasmoids appear and the current sheet is more turbulent.

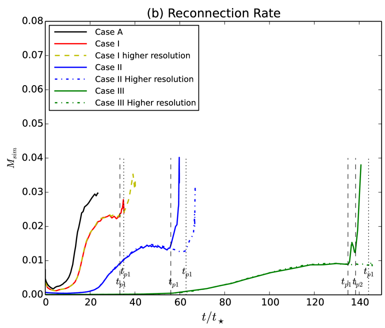

Fig. 2 The reconnection rates evolve with time in different cases as shown in Fig.1. The initial magnetic fields are B_0=500 G in all cases. t_{p1} is corresponding the time when the first magnetic island appears.

References:

[1] Ni, Lei, *et al.* 2015, ApJ, 799, 79.

[2] Ni, Lei, *et al.* 2016, ApJ, 832, 195.

[3] Ni, Lei, *et al.* 2018, ApJ, 852, 95.

[4] Ni, Lei & Lukin Vyacheslav S. 2018, ApJ, 868, 144.

[5] Ni, Lei, *et al.* 2020. Submitted.