Solar flare particle heating via low-beta reconnection

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Abstract.

Observations give tight constraints on the temporal and spatial scales of particle heating in solar flares, and on the required efficiency. Electrons are accelerated into a quasi-thermal population of a few tens of keV. X- and γ-rays imply tails in electron and ion distributions reaching tens of MeV and above. Simple estimates indicate that all available electrons are accelerated at least once to moderate energies, pointing to an initial process resembling bulk heating rather than acceleration of a small or localized population. In the absence of effective collisions, wave-particle interactions are the prime candidate. Here we address the outstanding questions, *(i)* what process can heat the entire reconnecting plasma to the above energies, and *(ii),* what provides the free energy for wave-particle interactions? We propose a process in which initially the ions are heated and provide the free energy for electron heating and tail formation.

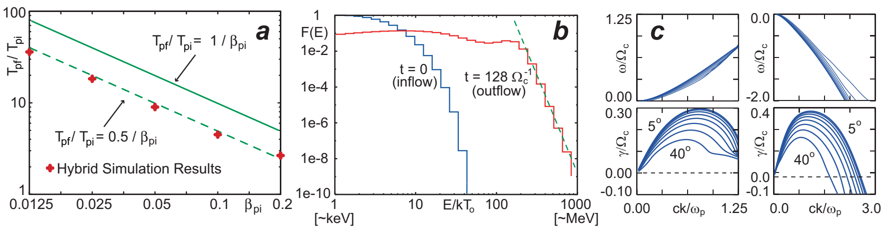

Figure 1. *(a)* Scaling with β, *(b)* ion energy, and *(c)* bi-directional F/MS waves.

Our hybrid simulations (kinetic ions, fluid electrons) for the far magnetotail (Krauss-Varban & Omidi 1995) indicate that in low-β Petschek-type reconnection, the ions are accelerated at the attached discontinuities into counter-streaming beams with close to the Alfvén speed and do not properly thermalize for vast extents of the outflow region — as recently observed in the solar wind (Gosling et al. 2005). Our new simulations show ~half of the available reconnection energy goes into heating, implying the ions to get energized by a factor of $\sim 0.5/\beta$ (Fig. 1a). The final ion energy is that observed for flare electrons (Fig. 1b) and within *ms* a seed particle pool for MeV ions is generated. Linear theory for the ion beams predicts growth of bi-directional fast/magnetosonic waves to exceed that of e.s. A/IC waves (Fig. 1c). We suggest that these waves, i.e., the free energy contained in the beams causes the efficient coupling to the electrons via transit-time damping.

Acknowledgements

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References

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