

Cross-scale coupling in the magnetotail: Quick reconnection triggering

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Understanding cross-scale coupling between MHD and dissipation scales in collisionless plasmas is challenging. Magnetic reconnection is an impressive example of the cross-scale coupling. While there is observational evidence that the magnetotail current sheet thickness becomes as thin as comparable to the relevant ion inertia length, whether it thins further down to electron scale to initiate reconnection is an open question. Carrying out a large scale 3D full particle simulation, we have recently found that quick triggering of magnetic reconnection is possible even in an ion-scale current sheet. If one thinks of the two-dimensional tearing mode as the triggering agent of magnetic reconnection in a current sheet of the Harris-type, the current sheet has to thin down to the electron scale for the instability to grow quickly. When the third dimension in the current-wise direction is taken into account, we have found that reconnection can be triggered very quickly. For the quick triggering, the lower-hybrid drift waves excited at the edges of the current sheet is indispensable. This wave excitation brings about formation of a thin current layer sustained by accelerated electrons. The inductive electric field, which is generated through change of the current profile, can efficiently accelerate meandering electrons around the magnetic neutral sheet. As a result, electric current in the thin layer is mostly carried by non-adiabatic electrons. Thus, the electron acceleration is playing a crucial role in making the quick triggering available. The result shows that the cross-scale coupling process is essential to enable the quick triggering of magnetic reconnection in an ion-scale current sheet. While it is unlikely that the mechanism studied here will work in its present form, we think that it still remains as a key element. Speculations on these issues in the Earth's magnetotail will be discussed.