1st Asia-Pacific Conference on Plasma Physics, 18-23, 09.2017, Chengdu, China

Intrinsically Three-Dimensional Magnetic Reconnection Induced by Ballooning Instability in Earth's Magnetotail

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Recently, the intrinsically three-dimensional (3D) nature of the magnetic reconnection process induced by ballooning instability in Earth's magnetotail has been revealed for the first time in our MHD simulations [1,2]. Represented by a generalized Harris sheet, the magnetotail configuration itself is two dimensional due to the symmetry in the dusk-dawn direction. Under certain conditions, such a configuration can become unstable to ballooning instabilities, which in its nonlinear stage can induce the formation of plasmoids, even though there is no pre-existing X-line in the magnetotail region considered. The spatial distribution and structure of the quasi-separatrix layers, as well as their temporal emergence and evolution, indicate that the associated magnetic reconnection can only occur in a 3D geometry, which is irreducible to that of any two-dimensional reconnection process [3]. Such a finding provides a new perspective to the long-standing controversy over the substorm onset problem, and elucidates the combined roles of reconnection and ballooning instabilities. It also connects to the universal presence of 3D reconnection processes previously discovered in various natural and laboratory plasmas.

References

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