The Life Cycle of Electron Phase-Space Vortices and Their Control of Magnetic Reconnection

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Résumé

Electron phase space vortices (EPSVs) are nonlinear electrostatic structures formed by trapped electron populations that frequently emerge in collisionless plasmas. We investigate the dynamics of EPSVs and their feedback on magnetic reconnection using 2.5D electromagnetic particle-in-cell simulations initialized with asymmetric dayside magnetopause conditions. We identify a recurring life cycle for EPSVs situated near the reconnection X-point, characterized by growth, secondary nucleation, and decay. We show that the nucleation of secondary vortices is not always stochastic but can be driven by a systematic mechanism, which evacuates the phase space to form bimodal distributions that are unstable to electrostatic instabilities. Furthermore, we demonstrate a bidirectional coupling where EPSVs significantly modify the reconnection dynamics. The interaction of EPSVs with the electron diffusion region, which has remained uncharacterised so far, results in a periodic modulation of the reconnection rate of approximately $25

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