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Role of current sheet instabilities in the rapid onset of magnetic reconnection

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The subject of current aligned instabilities within ion-scale current sheets is a controversial topic in the published literature. For these thin layers, results based on fluid theory are not generally reliable while the kinetic theory is notoriously complicated. However, in recent years a formally exact technique for computing the nonlocal Vlasov stability of thin current layers has demonstrated great promise. This technique offers concrete predictions which can be tested using massively parallel particle-in-cell (PIC) simulations. Furthermore, the theoretical predictions can be properly scaled into physically interesting parameter regimes that are presently inaccessible to simulations. In this work, the properties of the lower-hybrid drift instability (LHDI) are examined using this approach for a current layer composed of multiple ion species. The theoretical predictions are verified using PIC simulations with physically realistic mass ratios and fully resolving all relevant scales. The resulting evolution of the LHDI leads to a rich variety of interesting physics. In particular, the LHDI produces a strong increase in the electron flow velocity in the central region of the sheet and induces a dramatic bifurcation of the current layer. In addition, the influence of the LHDI leads to significant anisotropic heating of the electron distribution in the central region. The linear theory predicts the combined effect of these modifications can increase the growth rate of collisionless tearing by almost two orders of magnitude, leading to a very rapid onset of magnetic reconnection for current layers near the critical scale.