Laboratory observations of magnetic reconnection resulting from multiscale instability cascade

A. L. Moser[1,2] and P. M. Bellan[1]

[1]Caltech
[2]LANL

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Abstract

Magnetic reconnection underlies critical dynamics in many astrophysical plasma systems. Because observed reconnection rates are often significantly higher than those predicted by classical resistivity, most modern theories instead attribute the necessary diffusion to a combination of processes that take place on scales 'microscopic' compared to the scale of ideal MHD. This leaves unanswered the question of how a system can couple the ideal MHD scale to the microscale necessary for reconnection. A laboratory plasma experiment at Caltech demonstrates one possible mechanism: an instability of an instability. The experiment produces a collimated, magnetically driven plasma jet ~ 25 cm long, with density $n \sim 10^{21-22}$ and temperature $T \sim 2$ eV. The current-carrying jet undergoes an ideal MHD kink instability which then drives a secondary Rayleigh-Taylor instability. High-speed imaging shows that if the Rayleigh-Taylor instability succeeds in eroding the plasma diameter to a sufficiently 'microscopic' scale (ion skin depth), the plasma undergoes magnetic reconnection.