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Plasmoid Instability in Forming Current Sheets[1]

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The plasmoid instability has had a transformative effect in our understanding of magnetic reconnection in a multitude of systems. By preventing the formation of highly elongated reconnection layers, it has proven to be crucial in enabling the rapid energy conversion rates that are characteristic of many plasma phenomena. In the well-known Sweet-Parker current sheets, the growth of the plasmoid instability occurs at a rate that is proportional to the Lundquist number (S) raised to a positive exponent. For this reason, in large-S systems, Sweet-Parker current sheets cannot be attained as current layers are linearly unstable and undergo disruption before the Sweet-Parker state is attained. Here, we present a quantitative theory of the plasmoid instability in time-evolving current sheets based on a principle of least time [1]. We obtain analytical expressions for the growth rate, number of plasmoids, plasmoid width, current sheet aspect ratio and onset time for fast reconnection. They are shown to depend on the Lundquist number, the magnetic Prandtl number, the noise of the system, the characteristic rate of current sheet evolution, as well as the thinning process [1,2]. We validate the obtained analytical scaling relations by comparing them against the full numerical solutions of the principle of least time. Furthermore, we show that the plasmoid instability exhibits a quiescence period followed by a rapid growth over a short timescale [1,2,3]. [1] L. Comisso, M. Lingam, Y.-M. Huang, A. Bhattacharjee, Phys. Plasmas 23, 100702 (2016). [2] L. Comisso, M. Lingam, Y.-M. Huang, A. Bhattacharjee, ArXiv e-prints (2017), arXiv:1707.01862 [3] Y.-M. Huang, L. Comisso, A. Bhattacharjee, ArXiv e-prints (2017), arXiv:1707.01863

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