DPP15-2015-001482

Abstract for an Invited Paper
for the DPP15 Meeting of
the American Physical Society

Laboratory identification of MHD eruption criteria in the solar corona[1]

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Ideal magnetohydrodynamic (MHD) instabilities such as the kink[2] and torus[3] instabilities are believed to play an important role in driving "storage-and-release" eruptions in the solar corona. These instabilities act on long-lived, arched magnetic flux ropes that are "line-tied" to the solar surface. In spite of numerous observational and computational studies, the conditions under which these instabilities produce an eruption remain a subject of intense debate. In this paper, we use a line-tied, arched flux rope experiment to study storage-and-release eruptions in the laboratory[4]. An *in situ* array of miniature magnetic probes is used to assess the equilibrium and stability of the laboratory flux ropes. Two major results are reported here: First, a new stability regime is identified where torus-unstable flux ropes fail to erupt. In this "failed torus" regime, the flux rope is torus-*unstable* but kink-*stable*. Under these conditions, a dynamic "toroidal field tension force" surges in magnitude, causing the flux rope to contract. This tension force, which is missing from existing eruption models, is the $\mathbf{J} \times \mathbf{B}$ force between self-generated poloidal currents in the flux rope and the toroidal (guide) component of the vacuum field. Secondly, a clear torus instability threshold is observed in the kink-*unstable* regime. This latter result, which is consistent with existing theoretical[5] and numerical[6] results, verifies the key role of the torus instability in driving solar eruptions.

[1]In collaboration with M. Yamada, H. Ji, J. Yoo, W. Fox, J. Jara-Almonte, A. Savcheva, and E. E. DeLuca. This research is supported by DoE Contract No. DE-AC02-09CH11466 and by the NSF/DoE Center for Magnetic Self-Organization (CMSO).
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