Investigating the Dynamics of Canonical Flux Tubes

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Canonical flux tubes are flux tubes of the circulation of a species' canonical momentum. They provide a convenient generalization of magnetic flux tubes to regimes beyond magnetohydrodynamics (MHD). We hypothesize that hierarchies of instabilities which couple disparate scales could transfer magnetic pitch into helical flows and vice versa while conserving the total canonical helicity. This work first explores the possibility of a sausage instability existing on top of a kink as mechanism for coupling scales, then presents the evolution of canonical helicity in a gyrating kinked flux rope. An analytical and numerical stability space is derived by applying Newcomb's variational approach to idealized magnetic flux tubes with core and skin currents. The stability conditions indicate that as a flux tube lengthens and collimates, it may first become kink unstable, then a sausage may develop on top of the kink. A new analysis of 3D magnetic field and ion flow data on gyrating kinked magnetic flux ropes from the Reconnection Scaling Experiment tracks the evolution of canonical flux tubes and their helicity. These results and methodology are being developed as part of the Mochi experiment specifically designed to observe the dynamics of canonical flux tubes.

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