Numerical simulation of the dynamics of an elongated flux core spheromak

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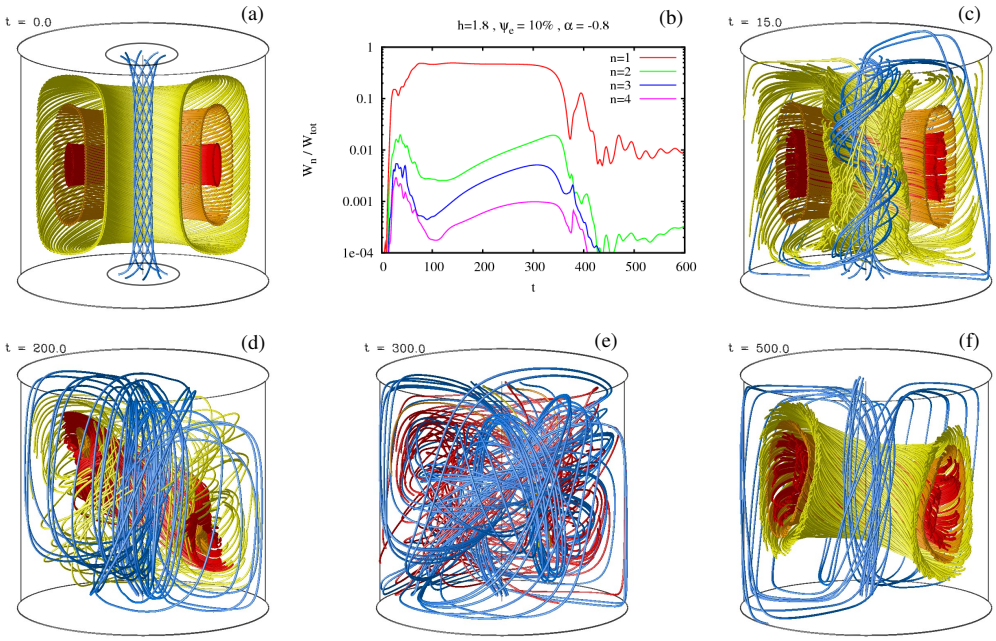
The formation and sustainment by d.c. helicity injection of flux core spheromak configurations has been demonstrated in several devices. This process relies on the relaxation and poloidal flux amplification produced by the n=1 kink instability of the central column. An experiment has been proposed to employ this helicity injection mechanism for the formation and sustainment of a very low aspect ratio tokamak like configuration [1]. If successful, it would result in the formation of a spherical tokamak (ST) surrounding a central Z-pinch. While most spheromak experiments work at small elongations ($\kappa \sim 1$) to avoid tilt instability, STs are naturally elongated ($\kappa \geq 2$). In this work we study the effect of elongation, and the excitation of both kink and tilt modes during relaxation using 3D resistive MHD numerical simulations. Some preliminary results on these issues have already been presented [2]. Here we will extend the analysis to higher elongations (up to $\kappa = 2.3$) and we will study the impact on the dynamics of different boundary conditions imposed at the electrodes. In the figure we show the magnetic field lines for several times on the evolution of the kink-unstable and tilt-unstable case with open flux shown in (a). The evolution of the magnetic energy of each mode relative to the total magnetic energy is shown in (b). The initial condition (a) rapidly develops an n=1 kink instability in the central column (c), producing significant mode activity ($t \sim 30$). Modes with n>1 decay after the kink, until $t = 100$, but the n=1 mode is fed by the tilt instability. At $t = 200$ (d) we have a tilted configuration with little n>1 activity. Notwithstanding, activity with n>1 grows exponentially until $t \sim 350$ (see (b)) leading to a disordered configuration (e). After that, from $t = 350$ to $t = 450$, a self-organization event takes place, which finishes the tilt and leads to an almost axisymetric configuration with large close flux regions (f).



[1] F. Alladio *et al*. *Nucl. Fusion* **46**, S613 (2006).

[2] P. García-Martínez, R. Farengo, 4th IAEA Tech. Meeting on Spherical Tori, 2008, Frascati, Italy. `http://www.frascati.enea.it/ProtoSphera/workshop2008/stw08-talks/farengorelaxation`