Helical magnetic self-organization of plasmas in toroidal pinches with transport barriers formation

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Abstract.

Nonlinear MHD modeling of toroidal pinch configurations for hot plasma magnetic confinement describes several features of the helical self-organization process, which is observed in both reversed-field pinches and tokamaks. It can also give a hint on why transport barriers are formed, by far one of the more interesting observations in experiments. The work tackles these two topics, helical self-organization and transport barriers formation - adding further information and examples to the results already presented in [Veranda, et al, Nucl.Fus. 60 016007 (2020)]. Regarding the topic of helical self-organization, a synthesis of the results obtained by a 3D nonlinear viscoresistive magnetohydrodynamics model will be presented: it successfully envisionedatechniqueto“channel”reversed-fieldpinchesintoachosenmacroscopichelicalshapeandpredicted that the features of such helical self-organization, studied in the RFX-mod experiment in Padova, depend on two parameters only - plasma transport coefficients and edge radial magnetic field - which can be exploited to calm the natural tendency of reversed-field pinches to a “sawtoothing” dynamics, i.e. by decreasing viscoresistive dissipation and using helical edge fields not resonating with the plasma safety factor. Regarding the MHD description of the process of formation of transport barriers by macroscopic magnetic chaos healing, we will describe the computation of Lagrangian structures, hidden in the weakly stochastic behaviour of magnetic field lines, acting as barriers to the transport. The radial position of such structures is observed to correspond to higher gradients of magnetic field lines connection length to the edge: this provides a further indication of their possible role in the formation of electron temperature barriers.