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# Negotiating with magnetic self-organization in confined plasmas

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Abstract.

Magnetically confined plasmas of fusion interest display phenomena that find several analogies in astrophysics and other complex systems. This is the case of toroidal pinches where magnetic self-organization molds the plasma into a peculiar helical shape when the ratio of plasma current to toroidal magnetic flux exceeds the so-called Kruskal-Shafranov limit. In this case, a core kink instability ("sawtoothing" and/or "snake") tends to develop in Tokamaks [1]. Similarly, a global helical shape (so-called Quasi Single Helical, QSH, regimes) forms in Reversed Field Pinch experiments (RFP)[2,3], helically modulating the plasma up to the edge [4,5]. MHD modeling has been largely successful in capturing the basic features of such a phenomenon [6,7,8], quite evading the famous Taylor's relaxation theory for RFP [9,10]. Nearly periodic relaxation events involving current sheet reconnection can be observed [6,9], together with a magnetic chaos healing effect when the helical states are robustly achieved[11,8]. The latter effect is presently the best candidate to explain the formation of internal electron transport barriers[2] observed in RFP helical regimes. In particular, "hidden" magnetic field lines transport barriers have been recently detected in experimental-like numerical simulations, which are associated with "fine" topological structures like Cantori sets or Lagrangian Coherent Structures [12]. After summarizing these general features, we here discuss the recent successful MHD prediction of alternative helical regimes, obtained by seed edge magnetic perturbations with suitable choice of helical pitch. A first set of RFX-mod experiments substantially confirms modeling predictions [13]. The new helical regimes obtained as plasma response to edge Magnetic Perturbations are predicted to favor magnetic chaos healing in the case of non-resonant seeds. After first indications obtained in RFX-mod experiment [13], we expect to validate modeling predictions concerning transport properties in the modified device RFX-mod2 starting operation in 2020. The device, characterized by reduced plasma-wall/feed-back coils distance, will provide efficient control action in order to negotiate at best with RFP helical magnetic self- organization.

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Helical self-organization in Reversed Field Pinch. Pictorial view of plasma displacement obtained in experimental-like 3D nonlinear MHD numerical modelling.