Clusters of helicity and stochastic linking number generation in plasma

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Magnetic field lines in an ideal plasma preserve the topology, characterized by the Gauss linking number. However strong transversal gradients of current flowing approximately along the magnetic field lines favor magnetic reconnections and in the presence of a small resistivity the topology changes. Spatial distribution of the density of the linking number will also change showing concentration of current filaments and formation of magnetic islands. Current sheets in magnetically confined plasma exist in the poloidally rotating layer at the edge of a toroidal discharge (mode-H in tokamak) and the reconnections take the aspect of an extreme event (edge-localized modes, ELMs). We first describe the tearing mode that produces the breaking of the current-vorticity layer with formation of filaments. Then we examine this process in a framework in which the process of local concentration of magnetic helicity can be seen as a transition to spontaneous clusterization. The current layer between two Y points is then populated with travelling small magnetic islands.

The statistical process of helicity fluctuation and the generation of linking is examined as a field theoretical model where the topological transition (i.e. change of the topological degree given by a Gauss linking number) is mediated by random sphaleron transitions. Since this model (inspired from baryogenesis) produces finite increase of the topological content at every event of transition, we will estimate the rate of increase of the local concentration of linking number in the filaments in the ELM. Compared with the classical tearing-mode description, the generation and clusterization of linking number appears to be more detailed.

Finally we draw a parallel with the concentration of vorticity in the process of spontaneous formation of cyclonic events in the atmosphere. Here the process is reversed, with build up of large amplitude vortices from small scale helical atmospheric convections. The approximative two-dimensional geometry of the flow is the origin of the inverse cascade but the topological transitions correspond to the same clusterization of the helicity.

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[2] F. Spineanu, M. Vlad, Rom. Rep. Phys. **67**, 573 (2015).

[3] F. Spineanu, M. Vlad, Chaos Solit. & Fract. **81**, 473 (2015).