Alfvén chaos and complexity in space plasmas

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Alfvén turbulence is key for understanding the nonlinear dynamics of space, astrophysical and laboratory plasmas. In this talk, we will review some advances in theoretical and observational studies of Alfvén chaos and complexity and their links to Alfvén turbulence in space plasmas.

First, we introduce the theory of Alfvén chaos and complexity, in the absence/presence of noise. The transition from order to chaos is studied using the bifurcation diagram. Two types of Alfvén chaos are identified: type-I Pomeau-Manneville intermittency and crisis-induced intermittency. We investigate Alfvén complexity associated with the noise-induced intermittency, and the role of transient structures known as chaotic saddles in deterministic and stochastic Alfvén chaos. In addition, we analyse the spatiotemporal intermittency in drift-wave turbulence by applying Shannon entropy to quantify the degree of order-disorder, and show that spiky coherent structures in intermittent plasma turbulence are the result of amplitude-phase synchronization in nonlinear multiscale interactions.

Next, we discuss the *in-situ* observation of Alfvén intermittent turbulence and the complexity-entropy analysis of Alfvén magnetic field fluctuations at magnetic reconnection exhausts in the solar wind. Two case studies are considered: the leading edge of an interplanetary coronal mass ejection and the interface region of two interplanetary magnetic flux ropes. In particular, we elucidate the stochastic chaotic nature of Alfvén spiky intermittent structures driven by magnetic reconnection.

Finally, we discuss numerical MHD simulation and space observation of Lagrangian coherent structures in solar photospheric turbulence. We report the observational evidence of Lagrangian chaotic saddles in plasmas and show that the persistent objective vortices are formed in the gap regions of Lagrangian chaotic saddles at supergranular junctions. The relevance of Alfven chaos and complexity for solar eruptions and interplanetary switchbacks will be discussed.

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