Lagrangian Coherent Structures in Solar Plasmas

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Abstract:

Dynamical systems theory is concerned with the identification of the basic building blocks of the system under investigation and how they interact with each other to produce the observable dynamics. Examples of those building blocks are unstable equilibrium and periodic solutions, nonattracting chaotic sets and their manifolds, which are special surfaces in the phase space that basically control the observable dynamics, guiding solutions in preferred directions in the phase space. In this talk, we show that the dynamical systems approach can be employed to investigate solar plasmas by adopting a Lagrangian reference frame, where the phase space for each fluid element is studied and the building blocks of the turbulence can be efficiently extracted by appropriate numerical tools. We reveal how finite-time Lyapunov exponents, a traditional measure of chaos, can be used to detect attracting and repelling time-dependent manifolds that divide the plasma in regions with different behavior. These manifolds are shown to accurately mark the boundaries of granules in observational data from the photosphere. In addition, stagnation points and vortices detected as elliptical Lagrangian coherent structures complete the set of building blocks of the photospheric turbulence. Such structures are crucial for the trapping and transport of mass and energy in the solar plasma.

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References: Chian, A. C.-L.; Silva, S. S. A.; Rempel, E. L.; Rubio, L. R. B.; Gošić, M., Kusano, K., Park, S.-H., Lagrangian chaotic saddles and objective vortices in solar plasmas, PHYSICAL REVIEW E 102, 060201(R) (2020)

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Invited talk