Lagrangian Coherent Structures in magnetized plasmas: Particle transport in a time dependent magnetic configuration

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The understanding of transport phenomena in low-collisionality, magnetized plasmas is one of the most challenging tasks in the investigation of both laboratory and space plasmas due to their generally non-diffusive nature. In recent years the concept of Lagrangian Coherent Structures (LCS) has been introduced by G. Haller in the context of transport processes in complex fluid flows [1]. LCS are a generalization of the dynamical structures observed in autonomous and periodic systems to temporally aperiodic flows. Therefore, they separate the flow domain into macro-regions inside which fast mixing phenomena take place. Over the finite time span which characterizes the LCS these macro-regions do not exchange fluid elements and thus act as transport barriers. In two recent works [2, 3] we apply this conceptual framework to the study of particle transport in a magnetized plasma. Futhermore we introduce a simplified model that allows us to consider explicitly a magnetic configuration evolving in time on timescales comparable to the particle transit time through the configuration. This analysis requires that a system that is aperiodic in time is investigated. In this case the Poincaré map technique cannot be applied and LCSs remain the only viable tool. By means of a numerical procedure we investigate the LCSs in the case of a magnetic configuration with two island chains that are generated by magnetic reconnection and evolve nonlinearly in time. The comparison with previous results [4, 5], obtained by assuming a fixed magnetic field configuration, allows us to explore the dependence of transport barriers on the particle velocity.

References

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