CD-P5 AAPPS-DPP2019

3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

# Lagrangian Coherent Structures as skeleton of transport in low collisionality and chaotic magnetic systems

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In recent years the use of dynamical techniques to investigate the transport features in magnetized plasmas assumed an important role, especially in plasmas with low collisionality. In this regime transport is highly anisotropic, collisions are no longer the main actors and, as it has been shown, e.g. in Reversed Field Pinch (RFP) and Stellarator studies[1,2], the magnetic topology plays a very important role: neglecting the finite Larmor radius and drifts, in this regime thermal particles move essentially along magnetic field lines.

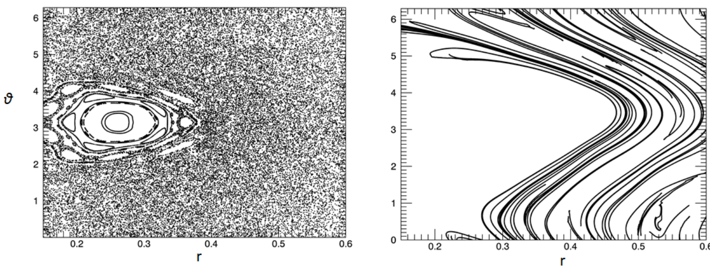
The transport properties in such systems are usually analyzed drawing the Poincaré map of the magnetic field. Unfortunately, especially when strong chaos affects the system, the Poincaré map gives only a general picture of the transport neglecting that there exist coherent patterns governing the transport process. Moreover, the Poincaré map can be applied only under some circumstances: the system has to be periodic and thus, for an evolving 3D magnetic configuration, this means to study the confinement properties at fixed time instant.

The goal of the present work is to go beyond these limits applying Lagrangian Coherent Structures (LCS) technique[3], borrowed from the study of Dynamical Systems, to magnetic field configurations in order to underline coherent patterns and thus regions of the system having different transport characteristics. In our work the LCS technique has been applied to carry on three studies.

The *first* study focuses on a simplified model that allows us to consider explicitly the case where the magnetic field evolves in time on timescales comparable to the particles transit time through the configuration[4,5]. In contrast with previous works on this topic[6], this analysis requires that a system that is aperiodic in time be investigated.

The *second* study, expanding previous works[7], extends our analysis to realistic numerical reproduction of a RFP configuration. In particular we focus in two different situations with resonant and non resonant dominant mode. In this two frame, a further distinction regards the amplitude of the dominant mode respect to the others: two time instants, with different level of field line chaos, are analyzed.

Finally in the *third* part, starting from the cases of previous study, an effective magnetic field[8,9] for *non*-thermal particles is constructed and analyzed. This allows us to show the different coherent patterns that determinates the transport of thermal and non-thermal particles and thus how different energy particles obey to different transport.




Left panel: Poincaré plot of the magnetic field when a broad spectrum of Fourier components affects the dynamics.
Right panel: Corresponding Lagrangian Coherent Structures that determinate the motion of the field lines over 6 toroidal loops.

## References:

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