Topological characterization of flow structures in plasma turbulence

L. García[1], B.A. Carreras[2], I. Llerena[3], I. Calvo[4], J.A. Mier[1], R. Sánchez[1]

[1] *Departamento de Física, Universidad Carlos III de Madrid, 28911 Leganés, Madrid, Spain*

[2] *BACV Solutions Inc., Oak Ridge, TN 37830, USA*

[3] *Department d'Àlgebra i Geometria, Universitat de Barcelona, Barcelona, Spain*

[4] *Laboratorio Nacional de Fusión, Asociación EURATOM-CIEMAT, 28040 Madrid, Spain*

Visualization of turbulent flows is a powerful tool to help understand the turbulence dynamics and induced transport. However, in the case of turbulent plasmas in toroidal geometry, flow structures may be quite complicated and a quantitative characterization of flow structures is needed. By using computational homology tools [1], we have developed an approach that allows discriminating between topological properties of plasma turbulence flows that are relevant to the transport dynamics and the ones that are not [2].

One way to study the connection between topological properties of the flow and transport properties is by using the continuous time random walk (CTRW) approach. The CTRW approach allows us to construct transport models based on statistical properties of the microscopic motion of the particles. Basically one assumes that the particle trajectories are composed by waiting times at a given position and particle flights between two different consecutive positions.

In Ref. [2] we showed that the number of large-scale cycles and the number of large-scale connected components of the flow structure are useful in providing a connection between properties of the turbulence and properties of the induced transport in the resistive pressure-gradient-driven model. The distribution of the large-scale components gives the distribution of flights at a fixed time. The averaged trapping time correlates with the characteristic life time of the large scale cycles.

The connection between the trapping times distribution and the time evolution of the large-scale cycles will be discussed. Also, we will present results of the application of these methods to other plasma turbulence models.

References

[1] T. Kaczynski, et al, *Computational Homology*, Springer, Appl. Math. 157, 2004.

[2] L. Garcia, et al, Phys. Rev. E **80**, 046410 (2009).