FUSION TECHNOLOGY DESCRIPTION

EUROfusion
TECHNOLOGY TRANSFER PROGRAMME

Resonance controlled transport in phase space

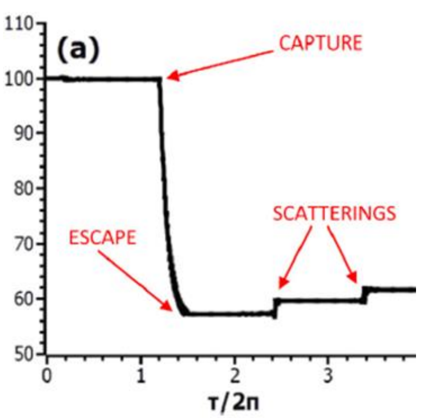
The problem of controlling transport in Hamiltonian systems is of primordial importance for charged particles in fusion plasmas. The French laboratory CPT worked on a new approach (Computer code) to control transport in phase space. The close relation of transport properties and structure of the phase space allowed to address directly the possibility of controlling transport in these systems, using captures into resonances and escapes from the resonances. Promising non-fusion applications in space propulsion, chemicals, multifluidics, passively advected quantities and two-dimensional incompressible flows are considered.

Description of the technology

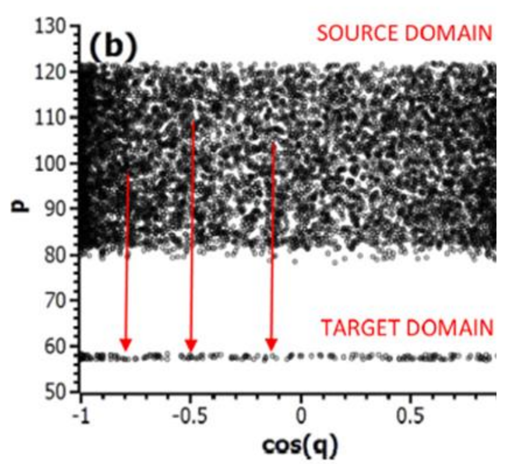
The problem of controlling transport in Hamiltonian systems is of primordial importance for charged particles in fusion plasmas. The French laboratory CPT worked on a new approach (Computer code) to control transport in phase space. Transport properties are governed by low-dimensional Hamiltonian chaos and can display many different types of behaviour ranging from regular Gaussian transport to anomalous ones such as super diffusive transport. These features are associated to the mixed phase space, comprising islands of regular motion and stochastic seas, and stickiness around islands that can give rise to long time correlation and anomalous transport features

Considering the adiabatic situation and small, smooth and slow perturbations which generate finite currents and directed transport, a system where the resonant captures remove phase points from the initial distribution of an ensemble and transport them at a large distance in the phase space, is created. These transported phase points make a secondary population that stays distinct from the original one on large enough time scales. This system can be designed to effectively cool down the particles, i.e. to make the secondary distribution significantly narrower in momenta than the original one.

After this rapid cooling, phase point starts scattering and at each scattering event vector p (motion quantity) increases slightly. However, the probability of this process is not high, because only a small portion of points become trapped and cooled in one period. So, for the control there is a choice between how much a beam has to be cooled and how many particles have to be captured. If more particles have to been cooled, it is necessary to increase the amplitude of the resonance, or wait for more periods, which ends up with the scattering and a larger dispersion.



Internal view of the multi-tube membrane reactor built by ENEA for CEA laboratories (2017).



Distribution of phase point in (cos q, p) plane after one period

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Innovation and advantages of the offer

The close relation of transport properties and structure of the phase space allows to address directly the possibility of controlling transport in these systems, using captures into resonances and escapes from the resonances. The main benefits of this technology is that it does not tailor a specific perturbation. Controlling transport: do not have many different types of behaviour ranging from regular Gaussian transport to anomalous ones such as super diffusive transport.

Non-fusion Applications

Promising non-fusion applications in space propulsion, cooling of atoms, chemicals, multifluidics, accelerators, passively advected quantities and two-dimensional incompressible flows are considered.

EUROfusion Heritage

The laboratory is a founding member of the National Research Federation for Fusion by Magnetic Confinement (FRFCM ITER), created in 2005. In addition, the CPT is a «Laboratoire de Recherche Conventionné» (LRC) with the CEA in Cadarache since 2006, and maintains a collaboration with members of the «Institut de Recherche sur la Fusion Magnétique» (IRFM) within the framework of a scientific program financed by the EURATOM organization since 2003. For example, the laboratory has carried out research activities in the framework of EUROFUSION Consortium via project WP14/ER/CEA09 (Joint experimental - theoretical effort to investigate large scale self-organisation of turbulence and flows in the framework of the L-H transition). The problem of controlling transport in Hamiltonian systems is of primordial importance for charged particles in fusion plasmas. This technique could also be used to tailor calibrated beams to the machine.

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