Control of Test Particle Transport in the Scrape Off Layer

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Transport of energy,momentum and current as well as particles remains a key issue in fusion devices. At the ITER level, modest changes in the confinement properties can dramatically change the achieved energy amplification factor Q. The main ITER scenarios are based on transport barriers, at the separatrix, H-mode barrier, or so-called Internal Transport Barriers. The onset of such transport barriers is most often associated to large heating powers. It thus appears that the localised control of turbulent transport requires a large and controlled heating power,which will lower significantly Q. It is thus of interest to investigate alternative means of controlling transport that would require a lower power. The present effort is based on the possibility of bridging transport in fusion devices that is based on Hamiltonian motion of particles and recent advances of control in Hamiltonian systems.

The effort is narrowed to the control of test particle transport in three specific situations: a case of turbulent ExB test particle transport with broad wavevector spectra and where reduced transport is achieved, a case with only two modes interacting (e.g. tearing modes) that is representative of the MHD triggered transport, and finally a case of magnetic field lines where the reconstruction of magnetic surfaces within a region of stochasticity is obtained. We stress that in all these situations our method provides control terms that are a small modification of the original system, namely transport control terms characterised by a lower energy than those terms leading to the chaotic transport.

Although the control term obtained in these investigations is not yet realistic with respect to any implementation in fusion devices it shows that a perturbative control of turbulent transport is possible. Moreover the operating window of such control is not too narrow so that the control term can be modified, in particular simplify while preserving a good efficiency.

As a further step in the direction of obtaining a control term of interest for fusion plasmas implementation, in this work we consider the application of our Hamiltonian control scheme to the problem of the ExB test particle transport in the case of a turbulent potential given by TOKAM code outputs. As this code models the electrostatic turbulence observed in the Scrape Off Layer of tokamaks, it is of interest to investigate what kind of results our perturbative scheme gives in controlling highly developed turbulent transport. The effect of the control term, namely a small modification of the electrostatic turbulent potential, on the dynamics of charged test particles is studied comparing the diffusion coefficient and the probability distribution function of step sizes obtained with and without control term. A reduction of diffusion as well as of large step sizes is strongly induced by the control term in the weakly turbulent regime. Increasing turbulence the control term has still some effects on the regularization of test particle dynamics but its size is not more small with respect to the turbulent potential.