GLOBAL TRANSPORT OF ENERGETIC PARTICLES IN FUSION PLASMAS

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A common concern about Alfvénic instabilities in fusion devices is that these instabilities may degrade confinement of the alpha particles and other fast ions and thereby forbid a self-sustained fusion burn. Each individual Alfvénic mode tends to be relatively benign in that regard, because the wave-particle resonances associated with a single low-amplitude mode can cover only a small fraction of the particle phase space. Consequently, many modes are needed to produce global transport. This talk presents a comparative discussion of the two main transport scenarios: diffusive and convective. The first scenario involves stochastic diffusion of energetic particles over a set of overlapped resonances created by multiple eigenmodes of the bulk plasma. This scenario implies soft nonlinear saturation of the modes and applicability of their perturbative treatment. In contrast, convective transport is usually associated with non-perturbative coherent structures (holes and clumps) that form in phase space during hard nonlinear development of the instability. These non-perturbative structures can have time-dependent frequencies, which allows them to carry resonant particles over large distance in phase space. The convective transport scenario tends to produce a bursting pattern of particle redistribution or losses with significant deviations from the linear instability threshold whereas the diffusive scenario generally forces the system to remain close to the threshold and be tractable within the marginal stability concept. The talk will cover recent theoretical studies of both scenarios with a discussion of how to extrapolate them to quantitative predictions for burning plasmas.