Nonlinear Modelling of Fast Ion Driven Instabilities in Fusion Plasmas

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Energetic particles are an essential ingredient in achieving the self-sustained release of fusion energy based on magnetically confined plasma; fast fusion products heat surrounding fuel ions to a level where they fuse thus leading to self-sustainment of the fusion process. A consequence of such intrinsic energetic particle populations in fusion plasmas is the influence they exert upon the stability properties of the plasma by acting as a source of free energy to drive various instabilities of the system. This can lead to a redistribution of fast particles in the plasma from the core to more peripheral regions, which reduces heating efficiency and can lead to the quench of the plasma burn, or in the worst cases, significant loss of fast ion confinement and damage to the plasma facing components.

This lecture will first describe sources of energetic particles and their confinement in fusion plasmas and then the physics mechanisms and modelling of the various instabilities that they can drive. This will cover such areas as the Alfvénic instabilities that occur in toroidal magnetic confinement devices and the impact that they have upon plasma fusion performance. Starting from a linear stability analysis the theories and models will be extended into nonlinear regimes, capturing events such as frequency sweeping that arises in response to the redistribution of the energetic particles.