Resonant axisymmetric modes in tokamak plasmas

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A theoretical model describing the impact of divertor X-points on axisymmetric modes (toroidal mode number n=0) in tokamak plasmas is presented. It is shown that current sheets can develop along the magnetic divertor separatrix because of vertical plasma displacements [1, 2], which may have a profound impact on disruptions and MHD edge stability.

When a nearby resistive wall is present, the vertical mode can still grow on the relatively slow resistive wall time scale. Active feedback control is then required for complete stabilization. However, it is shown that the resistive growth rate can be significantly faster, scaling with fractional powers of wall resistivity, if the wall position satisfies the criterion for ideal-MHD marginal stability, thus posing more stringent conditions for active feedback stabilization [3].

It is also shown that so-called Vertical Displacements Oscillatory Modes (VDOM) can be excited in tokamak plasmas [4]. These modes have a frequency of oscillation just below the poloidal Alfvén frequency, which makes them immune to continuum damping. They are normally damped by wall resistivity but can be driven unstable by the resonant interaction with fast ions [5], leading to a new type of fast ion instability. Instability requires a fast ion distribution with a positive slope in velocity space. Conditions to produce this inverted fast ion population will be discussed. This theory may explain the observation of saturated n=0 fluctuations in recent JET experiments [6].

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