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P4.1047 Analytic equilibrium of elongated plasmas bounded by a magnetic separatrix and the problem of resistive axisymmetric X-point modes

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Theoretical and experimental considerations [1] suggest that axisymmetric perturbations that are resonant at the X-point(s) of a magnetic divertor separatrix may play a role for the understanding of ELMs and their active control via "vertical kicks" [2] in tokamaks.
We present the first step in the development of an analytic model for resistive axisymmetric X-point (RAXP) modes, i.e., finding an adequate, but at the same time relatively simple analytic MHD equilibrium for a plasma column with noncircular cross section bounded by a magnetic separatrix. An early example is Gajewski's equilibrium solution [3], which however has the shortcoming that infinite external currents placed at an infinite distance from the Xpoints produce the elliptical elongation of the plasma column.
Therefore, we have extended Gajewski's equilibrium to the case where external currents are located at a finite distance from the boundary of the plasma current density and the latter is distributed uniformly over a domain bounded by a nearly elliptical magnetic flux surface.
This analytic equilibrium is expected to be unstable to ideal MHD vertical displacements of the plasma column. Just like in the case of a tokamak plasma with elongated cross section, we can also expect that modulating in time the external currents can stabilize the vertical instability. In the ideal MHD case, this would mimic the passive feedback stabilization scenario of real tokamak plasmas, where time-dependent image currents are induced on the metallic wall of the toroidal vacuum chamber.
Of more interest will be to study the case of a resistive plasma extending to the magnetic separatrix. In this situation, a vertical displacement would be resonant at the magnetic Xpoints, giving rise to current sheets centred at the X-points. In the equivalent tokamak scenario, this type of perturbation is what we refer to as RAXP mode. A preliminary, conceptual analysis of RAXP modes is discussed in this article.
[1] F. Porcelli 1996 JET Report IR(96)09; J. Lingertat et al 1997 J. Nucl. Mat. 241, 402; E. R. Solano et al 2008 Nucl. Fusion 48, 065005. [2] E. de la Luna et al 2016 Nucl. Fusion 56, 026001. [3] R. Gajewski 1972 Phys. Fluids 15, 70.

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