A new class of three-dimensional ideal-MHD equilibria with current sheets

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Ideal MHD predicts singular current densities in 3D equilibria with nested flux surfaces: a pressure-driven 1/x current density that arises *around* resonant rational surfaces, and a Dirac δ-function current that develops *at* those surfaces. Only recently have these currents been computed numerically [1], and we provide details of the calculation. We show that locally-infinite shear (i.e. discontinuous rotational-transform) at the resonant surfaces ensures well-defined solutions.

Singularities in the current *density* are allowed in ideal-MHD, but the current passing through any surface must be finite for any physically-acceptable equilibrium model. While the integral of the δ-current density is finite, the 1/x current diverges over certain surfaces. This led to the conclusion that pressure gradients cannot exist in the vicinity of rational surfaces and thus that the possible pressure profiles are either fractal [2] or discontinuous [3].

In this talk, we present a new class of 3D, globally-ideal, MHD equilibria with (i) continuously nested surfaces, (ii) arbitrary, continuous and smooth pressure profiles, (iii) arbitrary, 3D boundaries, (iv) without unphysical currents, and which are (v) analytic functions of the boundary [4]. Examples of such equilibria, computed with the SPEC code, are shown and verified against generalized solutions to Newcomb equation, showing excellent convergence.

The results imply that a resonant magnetic perturbation can penetrate all the way into the centre of a tokamak without being shielded at the resonant surface, even within ideal MHD.

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