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Fast high-order integral equation solver for stepped pressure magnetohydrodynamic equilibria

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The equations determining static magnetohydrodynamic steady-states in toroidal geometries are conjectured to generically lead to unphysical non-integrable current singularities for the most physically desirable non-axisymmetric steady-states. In the last 25 years, a new model for confined magnetized plasma steady-states, based on a piecewise constant pressure profile approximation, has been developed to study these singularities of the MHD model, and analyze and design non-axisymmetric fusion experiments [1, 2].

Numerical solvers for this stepped pressure equilibrium model solve the equations iteratively. At each iteration, Beltrami magnetic fields must be computed in each separate region with constant pressure; then, the boundaries of each of these regions are evolved in order to satisfy force balance at the location of the pressure jumps. The iterations stop when the Beltrami equations are satisfied in each region, and force balance is satisfied at each interface.

We have recently developed a fast, high-order integral equation based solver for the computation of Beltrami magnetic fields in toroidal domains [3]. In this talk, we will show how we combine this solver with a gradient-based optimization algorithm to compute converged stepped-pressure equilibria.

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