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BIEST: A boundary integral equation solver for computing Taylor states in toroidal geometries

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We present BIEST (Boundary Integral Equation Solver for Taylor states), a fast high-order numerical solver for computing Taylor states in toroidal geometries. Our solver can be applied to computing stepped-pressure equilibria in magnetically confined plasmas by computing the force-free field (Taylor states) in each constant pressure region and iteratively updating the position of the boundaries to satisfy the force balance. Our method for computing Taylor states is based on the generalized Debye representation for the time-harmonic Maxwell's equations. This formulation results in a well conditioned second-kind boundary integral equation (BIE). Another advantage of the BIE formulation is that we only need to discretize the boundary and this requires significantly fewer unknowns compared to volume discretization based schemes. We use a spectrally accurate Fourier representation for the boundary data and use special high-order quadrature rules to compute the boundary integrals. We have tested our solver for several challenging geometries, and showed that BIEST compares favorably with SPEC (Stepped Pressure Equilibrium Code) in terms of accuracy and speed.

References

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