Application to ITER and W7-X of a novel free-plasma-boundary scheme for the SIESTA and FLIPEC MHD equilibrium codes*

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There are situations in fusion devices that demand the use of free-plasma-boundary MHD equilibrium solvers. Although codes with this capability have been available to the fusion community for decades, most of them share two basic assumptions: the existence of well-defined nested magnetic surfaces and the absence of plasma flows. We present here a novel and efficient implementation of free-plasma-boundary capabilities using SVD techniques [J.M. Reynolds-Barredo et al, *J.Comput.Phys.* **406**, 109214 (2020)] for ideal MHD equilibrium codes that: i) can treat toroidal and poloidal plasma flows or ii) allow for the development of magnetic islands and/or stochastic regions in the solution. For the former case we have created FLIPEC to solve the 2D Grad-Shafranov-Bernoulli system of equations for arbitrary toroidal and poloidal flow profiles. For the latter, we use SIESTA [S.P.Hirshman et al, *Phys.Plasmas* **18**, 06250 (2011)], a code that can calculate ideal MHD equilibria in general 3D toroidal geometries without assuming closed magnetic surfaces. We showcase the capabilities of the new scheme by using FLIPEC to quantify the changes induced by plasma flows on important features of the ITER baseline magnetic configuration such as the position of the magnetic axis or X-point [G.F. Torija-Daza et al, *Nucl.Fusion* **62**, 126044 (2022)]. SIESTA is then used to investigate whether ECCD-compensation scenarios proposed in the W7-X stellarator for bootstrap-current control distort the 5/5 magnetic island chain that usually isolates the confined plasma from the first wall [H. Peraza-Rodriguez et al. *Plasma Phys.Contr.Fusion* **60**, 025023 (2018)].

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