Optimized up-down asymmetry to drive fast intrinsic rotation in tokamaks

J. Ball[1], S. Brunner[1], O. Sauter[1], F.I. Parra[2,3], M. Barnes[2,3], and M. Landreman[4]

[1] Swiss Plasma Center, École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

[2] Rudolf Peierls Centre for Theoretical Physics, Oxford University, Oxford, OX1 3NP, UK

[3] CCFE, Culham Science Centre, Abingdon OX14 3DB, United Kingdom

[4] Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, Maryland 20742, USA

E-mail: Justin.Ball@epfl.ch

Up-down asymmetric tokamaks, or tokamaks with poloidal cross-sections that lack mirror symmetry about the midplane, spontaneously rotate. Plasma rotation is commonly used in current experiments to stabilize MHD instabilities. However, it is unclear if future, larger devices like ITER or a reactor will have sufficiently fast rotation. From ideal MHD, we derive physical tokamak equilibria and demonstrate that breaking up-down symmetry with lower-order shaping effects (e.g. elongation and triangularity) will be easier to accomplish in an experiment. Furthermore, using analytic gyrokinetics we argue that low-order shaping will also drive faster intrinsic rotation. Next, using nonlinear gyrokinetic simulations we optimize the low-order shaping effects to maximize the rotation. These simulations indicate that up-down asymmetry can drive the rotation needed to provide MHD stabilization in an ITER-like device. Lastly, we compare our results to preliminary experiments on the TCV tokamak.

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