The surprising attractiveness of mode locking in tokamaks
R. Nies1,2, A.H. Reiman1,2, N.J. Fisch1,2

1 Department of Astrophysical Sciences, Princeton University, Princeton, NJ, 08543
2 Princeton Plasma Physics Laboratory, Princeton, NJ, 08540

Neoclassical tearing modes in tokamaks typically rotate while small and then lock at a fixed location when larger. Research on present-day devices has focused almost exclusively on stabilisation of rotating modes, as it has been considered imperative to avoid locked modes in order to prevent loss of confinement and disruptions. However, in larger devices, such as those contemplated for tokamak reactors, the locking occurs at a smaller island size, and the island can be safely stabilised after locking. Compared to rotating islands, the stabilisation of these small locked modes can be performed at lower wave power, does not place as strict requirements on the power deposition width and its radial alignment with respect to the island O-point, and is not thwarted by large seeding events. On large devices, it thus becomes surprisingly advantageous to allow the mode to grow and lock naturally before stabilising it.

Calculations indicate that ITER will already be in a regime where that alternative stabilisation strategy becomes preferable. ITER’s rotating island stabilisation strategy is seriously challenged by the accelerated locking caused by its blanket modules [1], as well as the large broadening of the electron cyclotron wave due to edge density fluctuations [2]. Locked mode stabilisation has been demonstrated experimentally [3], and its implementation in ITER would be possible with no changes to its design. In particular, the fixed toroidal launching angle, which was optimised for a rotating island stabilisation strategy [4], is shown to be optimal for locked mode stabilisation. Locked mode stabilisation could thus prove crucial to ITER’s success, allowing to simultaneously reduce the peak power required for neoclassical tearing mode stabilisation, increase the fusion gain \( Q \), and reduce the disruptivity.

The authors thank R.J. La Haye and F.A.G. Volpe for helpful discussions. This work was supported by U.S. DOE DE-AC02-09CH11466 and DE-SC0016072.

References