2C48

Second Ballooning Stability Access in the Quasi-Poloidal Stellarator

D. Westerly,[1] A. S. Ware,[1] L. A. Berry,[2] S. P. Hirshman,[2] J. F. Lyon,[2] R. Sanchez,[3] D. A. Spong,[2] D. J. Strickler[2]

[1]Department of Physics and Astronomy, University of Montana, Missoula, MT 59812-1080
[2]Oak Ridge National Laboratory, P.O. Box 2009, Oak Ridge, TN 37831-8070
[3]Universidad Carlos III de Madrid, Madrid, Spain

Abstract

Access to second ballooning stable regions in the Quasi-Poloidal Stellarator[1] (QPS) is investigated. The proposed QPS device is a very-low-aspect ratio (A = 2.7) stellarator with a $|B|$ spectrum which exhibits quasi-poloidal symmetry. The QPS experiment will test the concept of quasi-poloidal symmetry as a pathway for obtaining adequate neoclassical confinement at very-low aspect ratio and in addition will explore the physics of MHD stability and anomalous transport in a quasi-poloidal symmetric device. QPS has been designed to run with a bootstrap aligned current profile (a total current of ≤ 40 kA) at $\langle\beta\rangle \leq 2\%$. However, similarities in the magnetic spectrum of QPS and that of very high-β, quasi-poloidally-symmetric, hybrid stellarator configurations[2] have led us to investigate the existence of second ballooning stable regimes in QPS at higher β values. The computational work on high-β plasmas in quasi-poloidally symmetric stellarator hybrids investigated non-axisymmetirc plasma equilibria with tokamak rotational transform profiles that displayed regions of second stability for $5\% < \langle\beta\rangle < 20\%$. This is in contrast to recent theoretical work by Hegna and Hudson that has suggested that regions of second ballooing stability do not exist for three-dimensional magnetic equilibria.[3] In this work, a reference QPS coil set is used to generate high-β ($\langle\beta\rangle > 5\%$) free-boundary equilibria. Variation of the external coil currents, plasma pressure profile, and plasma current profile is used to optimize for ballooning stability at high-β. Equilibria with large second ballooning stable regions have been obtained at $\langle\beta\rangle \sim 6\%$. The role of the plasma current profile in accessing second stability will be discussed. Overlap (or lack thereof) between regions of weak magnetic shear and bad curvature is explored and the effect of degrading quasi-poloidal symmetry on this region of overlap is investigated. Finally, the link between qps and second stability access in three-dimensional equilibria is investigated.

[1]J. F. Lyon, et al., "Physics and Engineering Design of a Very-Low-Aspect-Ratio Quasi-Poloidal Stellarator", in preparation for Nucl. Fusion, (2003).
[2]A. S. Ware, et al., Phys. Rev. Lett. **89**, 125003 (2002).
[3]C. C. Hegna and S. R. Hudson, Phys. Plasmas **9**, 2014 (2002).