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Ideal MHD Stability of the Quasi-Poloidal Stellarator

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Abstract

This work examines the MHD stability prosperities of the Quasi-Poloidal Stellarator[1] (QPS). The proposed QPS device is a stellarator with very low plasma aspect ratio ($R/a \sim 2.7$, roughly 1/2 to 1/4 that of existing stellarators). The dominant feature of the magnetic spectrum of QPS is quasi-poloidal symmetry: $\partial|B|/\partial\psi\theta \approx 0$ in flux coordinates. As part of its mission, QPS will explore the physics of MHD stability 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 $\langle\beta\rangle$ = 2%). The design of QPS optimized for infinite-n ballooning stability at $\langle\beta\rangle$ = 2%. The testing and optimization for ballooning stability was performed using the COBRA code.[2] The latest reference configuration has exceeded this goal with an infinite-n ballooning stability limit of $\langle\beta\rangle$ > 2% for a simple pressure profile, $p = p_0(1 - s)^2$ (where s is the normalized toroidal flux) and $\langle\beta\rangle$ > 2.3% for optimized pressure profiles. More recently, QPS plasmas have been tested for finite-n ballooning mode stability (up to n = 19) using the Terpsichore MHD stability code.[3] As expected, the β limits for finite-n ballooning modes are higher than for infinite-n: $\langle\beta\rangle$ > 2.5% for the simple pressure profile and even higher for optimized pressure profiles. Results on the impact of plasma shape variation with β on finite-n ballooning stability will be presented. The Terpsichore code has also been used to examine kink and vertical mode stability. While QPS has been designed including bootstrap current in the equilibrium, the magnitude of the bootstrap current is 1/3-1/5 that in an equivalent axisymmetric device. The reduced bootstrap current results in improved stability to kink and vertical modes. The reference QPS design is stable to vertical modes for $\langle\beta\rangle$ > 5% and is stable to kink modes for $\langle\beta\rangle$ > 4%.

[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]R. Sanchez, et al., J. Comp. Physics **161**, 576 (2000).
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