13th INTERNATIONAL STELLARATOR WORKSHOP

Global Ballooning Modes in Low-Shear Stellarators

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The calculation of the finite-mode-number spectrum of linear modes in stellarators is a challenging problem due to the coupling of both toroidal and poloidal Fourier harmonics. In a spectral approach, this leads to very large matrices. An alternative approach to this problem for low-frequency, short-wavelength waves and instabilities is to use the WKB-ballooning formalism [1] to construct local approximate solutions, using ray tracing and a "semiclassical quantization" formula to give the global eigenfrequencies/growth rates.

If the rays lie on topological tori, the quantization formulae are in terms of loop integrals around the topologically distinct circuits of the torus [Einstein–Brillouin–Keller (EBK) quantization]. In the opposite limit of strongly chaotic rays, the eigenvalue spectrum is effectively random, and must be described statistically ("quantum chaos").

For axisymmetric tokamaks, and for weakly localized (e.g. interchange) modes in stellarators, the field line label, α, is an ignorable coordinate and EBK quantization is possible, providing good estimates of the spectrum [2]. However for modes in stellarators for which the local ideal ballooning growth rate depends strongly on α, EBK quantization breaks down due to the phase-space rays escaping to infinity in perpendicular wavelength [1]. This runaway effect is prevented by including finite-Larmor-radius (FLR) effects or by an ideal-MHD regularization procedure simulating spectral truncation, but then the ray orbits are found to be chaotic [4].

The local ballooning growth rate has been found to depend strongly on α in H-1NF Heliac [3] and NCSX studies [5], while the ballooning angle parameter, θ_k, dependence is weaker due to low global magnetic shear. This paper presents studies of the resulting ray dynamics and discusses the implications for the ballooning mode spectrum in H-1NF and NCSX.

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Conference topic: (3) MHD Equilibrium and Stability

Poster is preferred: No

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