PHYSICS OF PLASMAS **19**, 072105 (2012)

Ballooning theory of the second kind—two dimensional tokamak modes

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(Received 2 February 2012; accepted 24 May 2012; published online 10 July 2012)

The 2-D ballooning transform, devised to study local high toroidal number (n) fluctuations in axisymmetric toroidal system (like tokamaks), yields a well-defined partial differential equation for the linear eigenmodes. In this paper, such a ballooning equation of the second kind is set up for ion temperature gradient driven modes pertinent to a 2-D non-dissipative fluid plasma; the resulting partial differential equation is numerically solved, to calculate the global eigenvalues, and the 2-D mode structure is presented graphically along with analytical companions. The radial localization of the mode results from translational symmetry breaking for growing modes and is a vivid manifestation of spontaneous symmetry breaking in tokamak physics. The eigenmode, poloidally ballooned at $\vartheta = \pm\pi/2$, is radially shifted from associated rational surface. The global eigenvalue is found to be very close to the value obtained in 1-D parameterized ($\lambda = \mp\pi/2$) case. The 2-D eigenmode theory is applied to estimate the toroidal seed Reynolds stress [Y. Z. Zhang, Nucl. Fusion Plasma Phys. **30**, 193 (2010)]. The solution obtained from the relatively simplified ballooning theory is compared to the solution of the basic equation in original coordinate system (evaluated via FFTs); the agreement is rather good. [http://dx.doi.org/10.1063/1.4731724]