1D Model for Alfvén Cyclotron Instabilities in the Spherical Tokamak Fusion Power Plant

S.E.Sharapov

Euratom/UKAEA Fusion Association, Culham Science Centre, Abingdon, Oxfordshire, UK

Abstract

Identification of possible alpha particle driven instabilities in spherical tokamak (ST) plasmas is one of the important problems to be assessed for a fusion power plant based on the spherical tokamak concept [1], which would necessarily operate in high-β (e.g. $\overline{\beta} \approx 60\%$ [1]), high-density regimes with $\beta_\alpha << \beta_i$. It was previously found [2,3] that the instabilities driven by the radial gradient of fast ions, i.e. toroidal Alfvén eigenmodes, chirping modes, and fishbones, become less significant or disappear as β increases. On the other hand, Alfvén cyclotron instabilities (frequency range $\omega \leq \omega_{Bi}$) driven by the energy gradient and/or temperature anisotropy, are less sensitive to β and may become dominant at high β. The existence of weakly-damped compressional Alfvén and shear Alfvén eigenmodes in high β STs is investigated within a 'hollow cylinder' ideal MHD model [4], that essentially uses a high ellipticity limit, $E = b/a \to \infty$, but keeps the large inverse aspect ratio, $a/R \leq 1$. In such a way 2D eigenvalue problem for the waves trapped in a resonating cavity inside the plasma is reduced to a 1D Schrodinger equation with a potential well determined by the magnetic well and by the radial gradient of the plasma density. This equation is solved for typical equilibrium profiles. Weakly-damped discrete eigenmodes are selected then in accordance with the 'weak-damping' condition, $\varepsilon_1(R) \neq N_{\parallel}^2$, which means absence of the resonant mode conversion (similar to the Alfvén continuum damping at low frequency).

[1] H R Wilson, G Voss, J-W Ahn et al., *The Spherical Tokamak Fusion Power Plant*, 19th IAEA Fusion Energy Conference, Lyon, France, 14-19 October 2002, paper IAEA-CN-94/FT/1-5

[2] M P Gryaznevich, S E Sharapov, Plasma Physaics Controlled Fusion (submitted)

[3] Y I Kolesnichenko et al., Phys. Rev. Lett. 82, 3260 (1999)

[4] V D Yegorenkov, K N Stepanov, 17th EPS, Venice, v.3, p.1207 (1989)