ECR plasma heating caused by absorption of surface flute modes in a bumpy magnetic field

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A steady magnetic field utilized for confining plasma is often bumpy: $\vec{B}_0 = B_{0z}\vec{e}_z + B_{0r}\vec{e}_r$; $B_{0r} = B_{00}k_m^{-1}\, sin(k_m z)d\varepsilon_m / dr$, $B_{0z} = B_{00}\left[1+\varepsilon_m(r)cos(k_m z)\right]$, $k_m = 2\pi / L$, L is spatial scale of the field non-uniformity. In fusion devices corrugation parameter ε_m is usually small: $|\varepsilon_m| << 1$. Its value is about $5\cdot 10^{-2}$ nearby plasma border in the tokamak ASDEX-U, Germany [1]. So-called mirror non-uniformity (gofer type) of confining magnetic field will dominate in Helias reactor [2]: $|\varepsilon_m| \sim 0.13$.

Here we study propagation and absorption of surface flute modes (SFM) in the model of cylindrical plasma placed in steady bumpy magnetic field. If one replaces flow coordinates in that representation of magnetic field for Helias reactor, which is applied in [2] for cylindrical ones then that representation of a mirror non-uniformity of the field $\vec{B}_0$ coincides with the $\vec{B}_0$ representation, which is applied in the paper. In this sense the offered here consideration is applicable for research of surface waves in a Helias configuration. We consider SFM in the bumpy magnetic field as a wave envelope that contains main harmonic: $\propto exp(-i\omega t + im\varphi)$, and two the nearest sidebands: $\propto exp(-i\omega t + im\varphi \pm ik_m z)$. If operating frequency of a generator is less than electron cyclotron frequency, $\omega < |\omega_e|$, then satellite harmonics experience local resonance $\varepsilon_1(r_1) = k_m^2 c^2 \omega^{-2}$ (unlike the case of SFM with $\omega > |\omega_e|$, which main harmonic experiences the local resonance $\varepsilon_1(r_0) = 0$ in a plasma periphery). Value of SFM power absorbed due to this resonance is calculated as a value ε_m^2, it can be increased if either main mode or the modes $\propto exp(-i\omega t + im\varphi \pm ik_m z)$ are eigen waves of the considered plasma waveguide structure.

ECR regime of gas discharge is known [3] as method utilized for cleaning chambers and super-conducting magnetic coils. Thus SFM absorption can be useful for sustaining such discharge, especially enhancing wave power transfer and control the localization of additional plasma heating.

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References

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