PROPAGATION AND DAMPING CHARACTERISTICS OF ELECTRON BERNSTEIN WAVES PERTINENT TO CURRENT DRIVE†

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In the electron cyclotron range of frequencies (ECRF) the X mode and the O mode have been successfully used in many conventional tokamaks for generating plasma current and for modifying the current profile. In the same range of frequencies electron Bernstein waves (EBW) offer an intriguing alternative for generating plasma currents. EBWs are particularly suited for high β plasmas encountered in spherical tori (ST) like NSTX. The ST plasmas are overdense to X and O modes but not to EBWs. The EBWs, excited through mode conversion of the X or O modes at the upper hybrid resonance, are strongly absorbed by electrons in the Doppler-shifted vicinity of any harmonic of the electron cyclotron resonance. In this presentation we discuss various properties of EBWs that make them desirable candidates for heating and current drive in STs.

The resonance curves describing the interaction of electrons with waves and the diffusion paths of the electrons in momentum space are affected by the parallel (to the magnetic field) index of refraction $n_{\|}$. As EBWs propagate toroidally $n_{\|}$ can span a range of values from $|n_{\|}| < 1$ to $|n_{\|}| \geq 1$. Consequently, the interaction of EBWs with electrons is more varied than for X or O modes. We find that EBWs, in comparison to X and O modes, interact with more energetic electrons. This leads to significantly better current drive efficiency.

In an ST the EBWs can be used to drive current in the outer half of the plasma or in the core [1]. In the former case, following the Ohkawa mechanism [2], the generation of plasma current is due to the induced asymmetric trapping of passing electrons by EBWs. In the latter case, following the Fisch-Boozer mechanism [3], current is generated by asymmetric change in the plasma resistivity induced by EBWs.

The approach to the cyclotron resonance is important in determining the localization of the EBW driven current. For a high field approach to the cyclotron resonance the perpendicular (to the magnetic field) wavelengths are larger than the electron Larmor radius while for the low field approach the perpendicular wavelengths are shorter than the electron Larmor radius. The spatial extent of the absorption region is broader for the high field approach than for the low field approach.

We will present these and other details of the physics of EBW propagation and damping with a view toward optimizing EBW current drive efficiency at different locations in a ST plasma. Included in the discussion will be the role of relativistic effects in the damping of EBWs [4].

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References

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