§86. Detection of Electron Bernstein Wave in QUEST

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One of the main purposes of the QUEST is to establish steady state non-inductive current drive at high beta value. Well established current drive (CD) method using lower hybrid wave or normal electron cyclotron wave in the normal tokamak are not applicable in the density region of target for the QUEST due to the roll over of the CD efficiency and the presence of density cut-off where the normal electromagnetic wave can not propagate anymore. Only the possible method is to use electron Bernstein wave (EBW) that can in principle propagate without density limit. However, EBW can not be directly excited from normal electro magnetic wave that is coupled from normal antenna located outside of the plasma. The plasma density

Behavior of EBW expected from raytracing code and the possible scattering configuration are studied. In 1 are shown the ray tracing result in the case of 8.2 GHz injection at the condition that the central heating and current drive is expected by mode converted EBW where $N_{\|}$ is set to 0.56 as a optimal injection condition. Injected O-mode propagated up to plasma cutoff layer is reflected back and converted to X-mode. This converted X-mode propagate back near upper hybrid layer where electromagnetic X mode is converted further to electrostatic EBW. The evolution of the wavenumber component in radial and toroidal direction are shown in Fig. 2. Here, x-axis is defined in FIg. 1. It is clear that once the wave is converted into EBW radial wavenumber drastically increases as it propagates in the radial direction. In Fig. 2 are also shown the lines where scattering angle of 60°, 90°, 180° are expected for the probe beam of 170 GHz as an example. This indicates that EBW is observable by the collective scattering method just after its conversion from X-mode, but not more in the core region where main absorption occurs. It is necessary to consider much higher frequency probe beam to detect EBW at the core region.

Density fluctuation $\tilde{n}$ associated with the EBW of the power flux P_{H} can be estimated from the dispersion relation of EBW and continuity condition as

$$[\tilde{n}(\boldsymbol{k},\omega)]^2 = \left(\frac{k\epsilon_0}{e\mu_0}\frac{k_D^2}{k^2}\right)^2 \Bigg[1-\Lambda_0(\beta) - \sum_{n=-\infty}^{\infty}\frac{\omega}{\omega-n\Omega}\left[1-W\left(\frac{\omega-n\Omega}{|k_{\|}|(T/m)^{1/2}}\right)\right]\Lambda_n(\beta)\Bigg]^2 \times \frac{2P_{\mathrm{H}}}{\omega\epsilon_0} \quad (1)$$

Here, k_D is Debye wavenumer, $W(Z) \equiv \int_{-\infty}^{\infty}\frac{x}{x-Z}dx$, $\Lambda_n = I_n(\beta)\exp[-\beta]$ and $\beta = \frac{k_\perp T}{m\Omega_e}$ are taken from Ref.[1)].

Once the density fluctuation $\tilde{n}(\boldsymbol{k},\omega)$ exists uniformly in the scattering volume V scattering efficiency of the probe beam can be expressed as

$$P_s/P_i = 4\pi r_0^2[\tilde{n}(\boldsymbol{k},\omega)]^2V^2 \quad (2)$$

Optimization of the probe frequency, from the view point of source source availability, detector sensitivity, accessibility of the scattering geometry under given ports are underway.

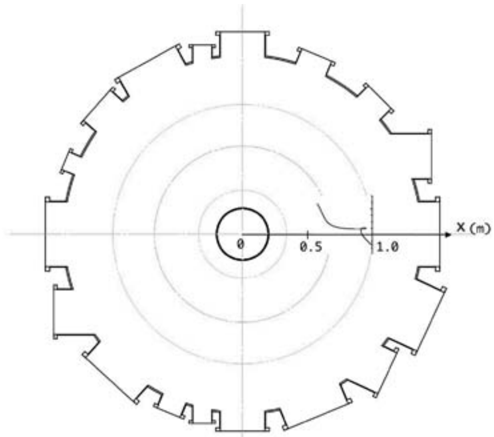

Fig. 1: An example of ray-tracing calculation. Trace indicates the all trajectories of O-mode injected with $N_{\|}$=0.56, converted to X mode and EBW.

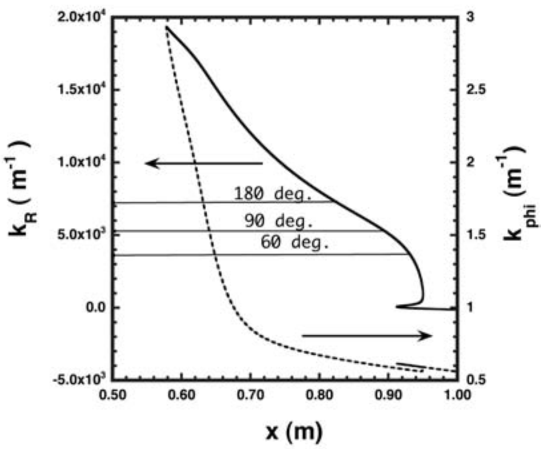

Fig. 2: Evolution of wavenumber component in radial k_R and toroidal k_ϕ) direction as a function of x which is defined in Fig.1Corresponding k_R values which 170 GHz probe beam scatted by 60°, 90°, 180° are shown with thin lines

1) S. Ichimaru, "Basic Principles of Plasma Physics" *Addison-Wesley Publishing Co. Inc. 1980.*