Optimum Gaussian beam for O-X conversion in EBW heated plasmas

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The behaviour of Gaussian beams in critical layers, like cut-offs, resonances or mode conversion layers is still a challenging topic. The study of conversion efficiency in electron Bernstein waves plasma heating using the X-B or the O-X-B process [1] is particularly interesting. In this latter scenario, which has been chosen for TJ-II overdense plasma heating, and once the optimum launching direction has been determined with conventional single ray tracing [2], the main problem is to find the beam design parameters, i.e. the waist, w_0, and the focus position with respect to the launching antenna, z_0, that provide the maximum O-X conversion efficiency at the critical layer (astigmatic beams are not considered).

To solve this problem, two different approaches, using ray tracing techniques, were presented in [2] and there, an optimum beam was obtained. The result has been used in the final design stage of the TJ-II EBW plasma heating system. In short, for a given beam, defined by $\{w_0, z_0\}$, the first approach considers rays distributed perpendicularly over the beam wave front surface which is closest to the LCFS. Whenever this approach clearly fails, that is, small waists for beams focused near to the O-X conversion layer (with wider **k**-spectrum), a second approach, that considers the amplitude of the beam plane wave spectrum at its waist, is used. In principle, this second approach seems more correct but some uncertainties remain since no phase information of the different plane wave components is taken into account.

The aim of this contribution is to clarify the behaviour of the beam at the O-X conversion layer using 2-D full wave calculations, and therefore try to validate the 3-D results obtained in [2] with the second approach. Full wave calculations are performed using a 2-D reduction of the general 3-D TJ-II plasma structure. In principle, at least using the ray tracing point of view, the best choice of parameters is the one obtained from the compromise arising between the plasma curvature, the beam waist and the restrictions related with the room available for the lauching antenna. Plasma curvature spoils the coupling (note than in a plane slab plasma the best beam should be the lowest focused beam) but, also, a small beam waist is deleterious for good coupling because the corresponding beam divergence is large, even though a strongly focused beam "sees" locally a flat plasma.

References

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