Calculation of coupling to the electron Bernstein wave with a phased waveguide array

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Abstract. Conventional electron cyclotron heating using the O- and X-modes to carry energy from the plasma edge to the cyclotron resonance layer is not possible for high density, low magnetic field devices (RFPs and STs, for example), since these modes are evanescent in all but the very edge of the plasma. As an alternative, we consider coupling to the electron Bernstein wave (EBW) with a phased waveguide array, the mouth of which is inserted to the vicinity of the upper hybrid resonance at the edge of the plasma. The calculation of the waveguide reflection coefficient is similar to the lower hybrid coupling problem solved by Brambilla, but the character of the plasma surface admittance is quite different for the EBW than for the lower hybrid wave. Two models for the surface admittance are compared. In the first, the lowest-order EBW is included in the calculation, while in the second, the cold plasma model (which does not have any mode corresponding to the EBW) with weak collisions is used. The surface admittances obtained in those two models for parameters relevant to coupling experiments performed in the Madison Symmetric Torus (MST) are compared, and found to agree closely, despite the very different physics in the models. A significant asymmetry with respect to the direction mutually perpendicular to the static magnetic field and the radial direction (the poloidal direction in tokamak geometry, the toroidal direction in the edge of the RFP) is found. This phenomenon is related to the well-known up/down asymmetry in fast wave launch in the ion cyclotron radio frequency and to the up/down asymmetries previously reported for the fast wave in the lower hybrid radio frequency. The effect is very strong in this situation due to the density gradient scale length being much shorter than the local wavelength (violation of WKB condition) in the coupling region.

PACS numbers: 52.35.Hr,52.50.Sw

Submitted to: *Plasma Phys. Control. Fusion*