TE_{10} mode and plasma interaction in rectangular waveguide

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The interaction of electromagnetic waves with plasma has been a fascinating subject due to its diverse applications in particle acceleration, frequency upshifting, resonance absorption, controlled fusion investigations related to ITER (International Thermonuclear Experimental Reactor) etc [1 – 5]. For the purpose of particle acceleration, researchers have mainly focused on lasers due to their ultrahigh intensities. In such mechanisms, it is required that the laser pulses propagate without diffraction or changing their shapes in the plasma. Moreover, it is desirable that this interaction remains for longer distances. However, the propagation characteristics of electromagnetic waves have been found to get modified during their propagation in the plasma. In this context and the application to ITER, we have therefore studied in the present article the interaction of TE_{10} mode with plasma. Our model considers two waveguides of identical size, out of which one is evacuated and another one is filled with plasma. The TE_{10} mode propagating in evacuated waveguide encounters the plasma in second waveguide. Under this situation, the propagation characteristics of the mode and the distribution of plasma density are found to change self consistently.

In order to study the microwave and plasma interaction, we consider the propagation of TE_{10} mode in a rectangular waveguide, which continues to propagate through another waveguide filled with plasma. Through the Maxwell's equations we obtain the field components of this mode in evacuated waveguide and consider the plasma effect through plasma dielectric constant ε. Then by balancing the effects of ponderomotive force with the electron pressure gradient force, we obtain differential equations in terms of the electric field component of TE_{10} mode in the plasma filled waveguide. These equations are solved using fourth-order Runge-Kutta method. We obtain the electric field structure in the waveguide and observe the corresponding density perturbations. The effects of microwave frequency, plasma density and waveguide width are studied on the amplitude of the electric field and wavelength of the microwave. This investigation is carried out for homogeneous plasma in the waveguide and also when the initial equilibrium density distribution is Gaussian. Finally a comparative study is made between these two investigations.

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