§9. Experimental Study of Electromagnetically Induced Transparency in Magnetized Plasma

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Electromagnetically induced transparency (EIT) is a well-known phenomenon in which the optical properties of a medium, such as absorption and emission, are dramatically modified as a result of superposition of quantum states of the medium when irradiated by two lights [1]. This has been demonstrated only in Bose-Einstein condensate atomic gas and solid state until now. In particular, EIT underlies the recent widely known "light stopping" experiments [2]. Recently, an idea of EIT in plasma, which is completely a classical system, was suggested [3]. The essential difference is that the plasma considered here is completely classical system, and no quantum mechanical effects are invoked to produce the EIT.
It is well known that electromagnetic right-hand polarized wave with a frequency equal to the electron cyclotron frequency of plasma is resonantly absorbed by magnetized plasma. It is shown in ref. [4] that this absorption does not occur in the presence of a second, properly frequency-tuned, electromagnetic pump wave. The plasma can be made transparent at the cyclotron frequency. The frequency of the pump wave is detuned from the probe frequency (the electron cyclotron frequency) by the plasma frequency. Transparency occurs because the currents induced at the cyclotron frequency by sideband of the pump can cancel the currents induced by the probe right-hand polarized wave. This phenomenon can be applied to compression of electromagnetic microwave, ion acceleration, control of the spatial absorption profile of electron cyclotron heating (ECH) wave in fusion plasma and so on. In this research, we aim the experimental demonstration of EIT phenomenon in magnetized plasma. At first the magnetic configuration in the experiment which is planned to realize magnetized plasma EIT was determined by calculation. Figure 1 shows the magnetic field lines (top) and spatial profile of field strength (bottom) of calculated mirror configuration for the EIT experiment. The electron cyclotron resonance layer is indicated with red color in the bottom plot (f_{ce}=3.45GHz).
The probe wave (f_{pump}=2.45GHz, 20 kW) is injected along the field lines from the left strong field side and the power transmitted through the plasma will be measured for various pump wave power cases. Measurement of density fluctuation whose frequency range is around the plasma frequency is planned using microwave interferometer/ reflectometer.

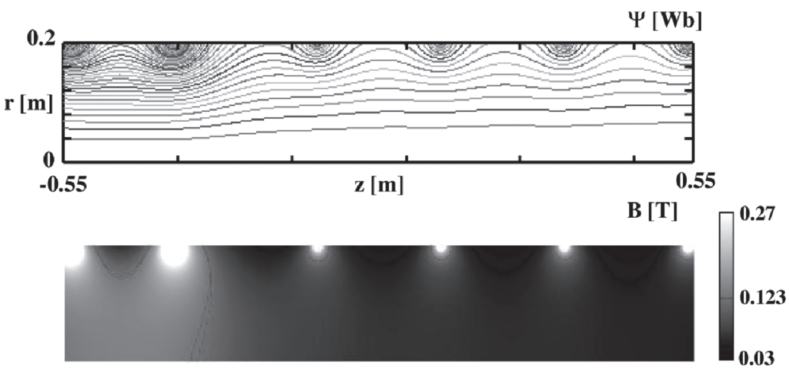

Fig. 1 Magnetic field lines (top) and spatial profile of field strength (bottom) of calculated configuration for the EIT experiment. The electron cyclotron resonance layer is indicated with red color in the bottom plot (fce=3.45GHz).

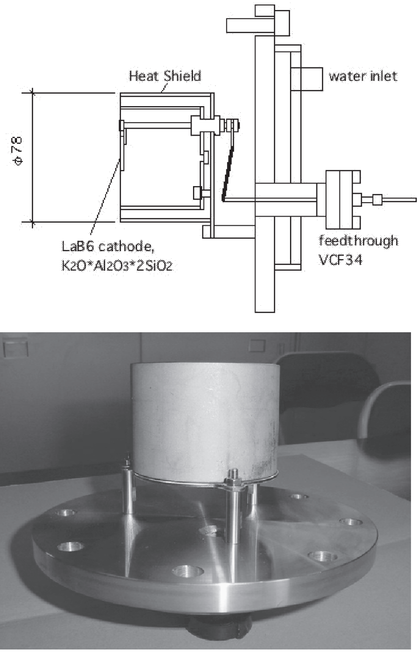

Fig. 2 Design and photo of the plasma emitter.

The plasma density is required to be in the range of 10^{14}-10^{15} m^{-3} in order to satisfy the frequency matching condition which is described as $\omega_{pump}=\omega_{ce}-\omega_p$. Therefore we constructed a plasma emitter [5] as a plasma source (Fig. 2). This employs potassium type alminosillicate and LaB_6 powder as ion emitter and electron emitter respectively. In next stage, characteristics of the plasma emitter will be investigated and it will be applied to the EIT experiment.

Reference

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