A High Power THz Radiation Source

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Large amplitude electrostatic (ES) plasma waves are excited in plasma accelerators. By applying a static magnetic field transverse to the propagation direction of the wave, a fraction of the ES wave can be converted into electromagnetic radiation. This process can be described as Cerenkov radiation in a magnetized plasma, and can be used to produce short pulses of high power (i.e. GW) radiation in the THz wavelength range.[3-4]

INTRODUCTION

Recently, large amplitude plasma wake (up to 100 Gev/m) can be excited in plasmas accelerators. By applying a modest magnetic field (B_0), the wakes' group velocity becomes nonzero. These two features enable the wakes to propagate through the plasma and couple out into vacuum as radiation at the plasma boundary. It appears that MWatt to GWatt sources of 100 GHz to 1 THz radiation could be achieved with present facilities.

The geometry of the radiation source discussed here is given in Fig.1. A short electron or laser beam propagates in the positive x direction, exciting a plasma wake as shown. The wake has wave number **k** at angle θ to the Z axis. The wake satisfies the Cerenkov condition: $V\cos\theta = \omega/k$, where V is the velocity of disturbance creating the plasma wake. The frequency of the resulting radiation is given by the intersection of the Cerenkov condition and dispersion relation of the magnetized plasma as shown in Fig. 2.

In this paper, first, we review the Cerenkov radiation from a magnetized plasma for the Cerenkov radiation. Then we describe our experiment plane and parameters.

CERENKOV RADIATION FROM A MAGNETIZED PLASMA

The frequecy of the Cerenkov radiation is given by the intersection of the Cerenkov condition and the dispersion curves. In Fig. 2, the k vector lies in the (x, y) plane ($k \perp B_0$). In this case, the dispersion relation (Lower branch of the XO mode) in the magnetized plasma, as given in Ref. 1, is

$$\frac{c^2k^2}{\omega^2} = 1 - \frac{\omega_p^2}{\omega^2}\frac{\omega^2-\omega_p^2}{\omega^2-\omega_H^2}. \qquad (1)$$

Where the upper freqency is given by $\omega_H=(\omega_p^2 + \omega_c^2)^{1/2}$, the electron cyclotron frequency by $\omega_c=eB/m_ec$ and the cutoff frequencies are given by $\omega_R=[+\omega_c + (\omega_c^2 + 4\omega_p^2)^{1/2}]/2$, $\omega_L=[-\omega_c + (\omega_c^2 + 4\omega_p^2)^{1/2}]/2$. When $\theta = 0$, the Cerenkov condition is $ck/\omega = 1$, so the intersection is at $\omega = \omega_p$. At large angles, ω increase to ω_H. In the magnetized plasma, the mode has two field component, electromagnetic E_y and elctrostatic E_x. For propagation in the

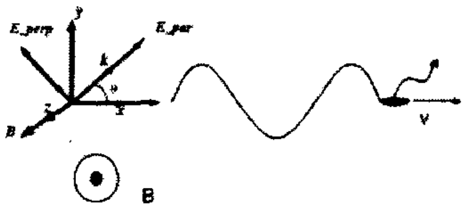

FIG. 1. Geometry for Cerekov radiation generation

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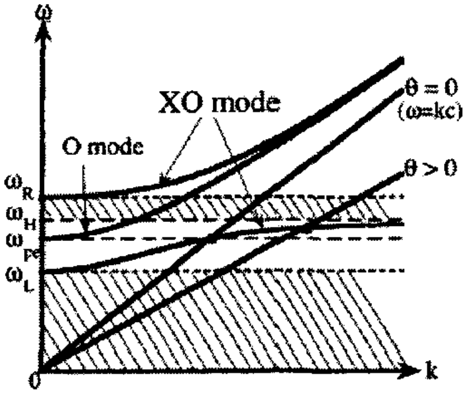

FIG. 2. Cerenkov wakes are produced at the intersection of the Cerenkov condition and the plasma dispersion curves

forward direction, the amplitude ratio of the components, E_y/E_x, is found from the dielectric tensor for a magnetized plasma, as given in Ref. 2: $E_y/E_x = \omega_c/\omega_p$.

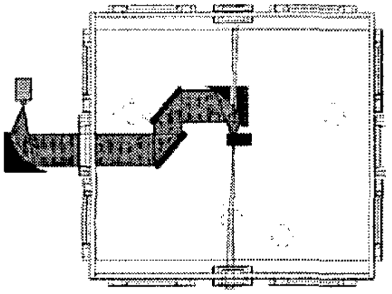

FIG. 3. Integration in the Experiment

EXPERIMENT DESIGN AND PARAMETERS

In the Neptune laboratory, a high power (?100J in ?100ps), two-frequency CO_2 laser pulse (λ_1=10.592μm and λ_2=10.296μm) is focused at the center of a chamber filling of gas (H_2 or D_2) or metallic vapor (Li, Na, Cs), as shown in Fig. 3. The spot size, w_0, approximates 200μm with an Rayleigh length, Z_R?1.2 cm. The plasma parameters are : plasma denstiy n_p?9?10^{15} cm^{-3}, plasma length L?3cm, wave amplitude $\varepsilon=\delta n_p/n_p$?0.3 ($\delta n_p$ is the plasma density perturbation). So we suppose to get a 30μJ radiation, which corresponds to B_0?6 KG. Then an off-axis parabola with a hole in the optical axis reflect the radiation to two flat copper mirrors. The CO_2 laser pass through from the hole. After reflected by the two copper mirrors, the radiation get out of the chamber and is focused by another off-axis parabola to the detector.

SUMMY

A static magnetic field is applied transversely to the laser beam path. The laser pulse emits Cerenkov radiation through coupling to the L branch of the XO mode of the magnetized plasma. The radiation is emitted essentially in the forward direction, at the plasma frequency(?1 THz). The method allow a high power THz radiation source generated in the plasma.

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