Electron density n_e interferometer measurement introduction (extreme simplification $B = 0$)

Electromagnetic transverse wave:

$$E_x(z,t) = E_0 \cos(\omega t + kz)$$

Maxwell Equations@Vacuum:

$$\begin{aligned} \nabla \cdot \mathbf{E} &= 0 \\ \nabla \cdot \mathbf{B} &= 0 \\ \nabla \times \mathbf{E} &= -\partial_t \mathbf{B} \\ \nabla \times \mathbf{B} &= \mu_0 \epsilon_0 \partial_t \mathbf{E} \end{aligned}$$

$\Longrightarrow$

The refractive index: $N = 1$

Maxwell Equations@Plasma:

$$\begin{aligned} \nabla \cdot \mathbf{E} &= \rho / \epsilon_0 \\ \nabla \cdot \mathbf{B} &= 0 \\ \nabla \times \mathbf{E} &= -\partial_t \mathbf{B} \\ \nabla \times \mathbf{B} &= \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \partial_t \mathbf{E} \end{aligned}$$

$\Longrightarrow$ The refractive index:

$$N = \sqrt{1 - \frac{{\omega_p}^2}{\omega^2}} \approx 1 - \frac{ne^2}{2\varepsilon_0 m \omega^2}$$

The phase shift:

$$\Delta\varphi = -\frac{e^2}{2c\varepsilon_0 m\omega} \int_0^L n(l)\, dl$$

credit:[Conrad Schiff@underthehood.blogwyrm, 2016, H.-W.Bartels at al., 1993, Matěna, L., 2015]

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