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Investigation of Plasmas in a Penning-Malmberg Trap for Gabor lens development

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A Gabor lens, a type of plasma lens, utilizes the internal electric field of a trapped electron plasma to focus high energy positively charged particles, such as protons or ions [1]. This lens is formed within a non-neutral plasma confined by magnetic and electric fields in a Penning-Malmberg trap [2]. Compared to traditional magnetic lenses, Gabor lenses offer the potential for highly efficient and compact particle focusing. The focal length (f) of the Gabor lens depends on the strength of the radial field generated by the non-neutral plasma, which is determined by the plasma density (n_e), the kinetic energy of the positively charged particle (U), and the length of the plasma (l) via $\frac{1}{f} = \frac{e^2 n_e l}{4\epsilon_0 U}$ where e is the magnitude of the electric charge of the electron, and ϵ_0 is the permittivity of free space [3]. In this study, our aim is to attain a plasma density on the order of 10^{15} m^{-3} to achieve a desired focal length of 1 m for the Gabor lens.

The practical implementation of an electron plasma faces challenges related to confinement, density, lifetime, and stability. We analyze these characteristics within our trapped electron plasma. Additionally, we present the results of applying a well-established manipulation technique—rotating electric fields—to control the plasma radius [4], aiming for longer plasma lifetimes and higher plasma densities. The attainment of prolonged plasma storage times and elevated plasma densities holds significant promise for advancing Gabor lens technology, crucial for a multitude of applications including particle accelerators and beam focusing systems.

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