Title
ECE170A Review Paper

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Radially polarized light in longitudinal acceleration of electrons

Particle accelerators allow for many useful applications in various fields. The research and development for more efficient and powerful accelerators has been underway for quite some time. There are many different ways to achieve particle acceleration. This paper discusses the acceleration of electrons in free space using lasers. The main technology that is utilized in this work is the generation of radially polarized laser pulses. This allows for high focus and therefore more intense interactions with the electrons.

INTRODUCTION

This review will focus on the portion regarding the utilization of radially polarized light. Radially polarized light allows for high focus and more intense longitudinal fields at the focus point, therefore allowing for the design of this experiment to succeed. Generally we know that in the presence of electromagnetic radiation, electrons which are part of a bound system will be excited to higher energy levels. However, in the scope of this work, the electrons are "free" and therefore will rather be influenced to accelerate and be given kinetic energy through the interaction with the incident laser. The radial polarization nature of the incident laser. The method for producing the radially polarized light is through the combination of various waveplates.

METHODS

The setup of the laser accelerator is shown in Figure S1 below.

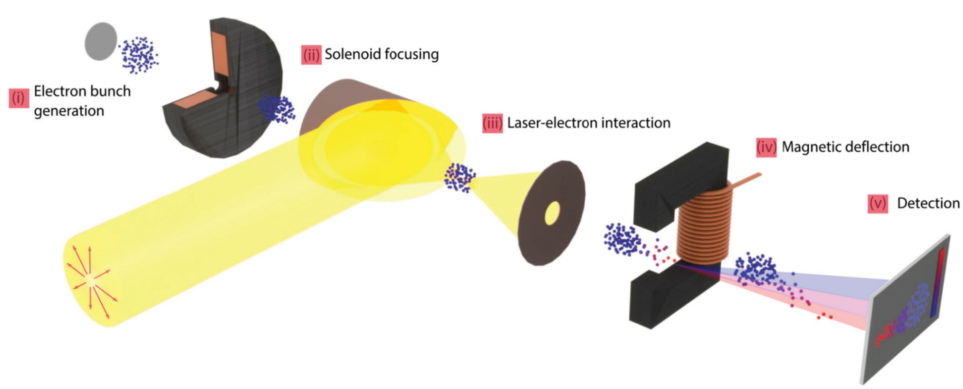
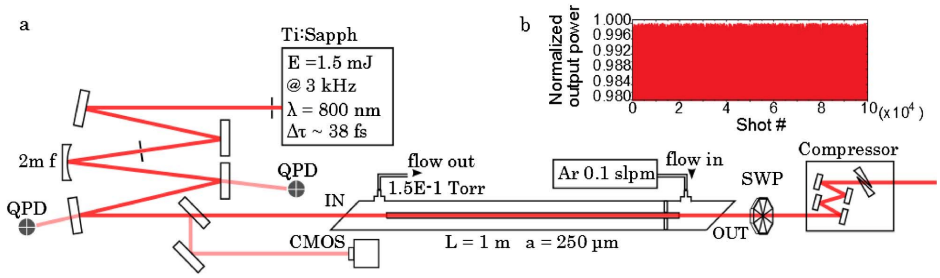


Fig. S1. Diagram of the experimental setup. The electron bunches are produced and focused down to the interaction point where the laser is also focused. The electrons are then sent into and deflected by the dipole magnet after which they are detected by a microchannel detector.

The generation of the radially polarized light is a more sophisticated process with the schematic diagram shown in Figure S2.



[1]

Fig. S2 Schematic diagram of the radially polarized laser generation used in the experiment.

Longitudinal Field Strength at focus point

By working through Maxwell's equations, an expression for the polarized components of the electric field at an reference point (x_p, y_p, z_p) can be given by:

$$E_i(P) = \frac{ikfE_0}{\pi}\exp(2ikf)\int_0^{2\pi}\int_{\theta\min}^{\pi}\frac{\alpha_i(\theta_S,\phi_S)}{1-\cos\theta_S}\exp[-ik\Phi(\theta_S,\phi_S)]d\Omega_S.$$

[2]

Although this is a fairly complicated expression for the electric field, the major result of this is the strong longitudinal field strength, which is what is utilized in the experiment of the electron acceleration done in this work. The strong longitudinal field with the tight focusing nature of the radially polarized incident laser then allows for the electron to reach high energies, as the electron energy is proportional to the field strength at the interaction point, and acceleration. [1]

REFERENCES

1. Carbajo, Sergio, et al. "Direct longitudinal laser acceleration of electrons in free space." Physical Review Accelerators and Beams 19.2 (2016): 021303.

2. Tae Moon Jeong, Sergei Bulanov, Stefan Weber, and Georg Korn, "Analysis on the longitudinal field strength formed by tightly-focused radially-polarized femtosecond petawatt laser pulse," Opt. Express 26, 33091-33107 (2018)