Polarization-Resolved Nonlinear Thomson Scattering from Laser-Driven Electrons

J. Peatross, B. Pratt, C. Schulzke, and M. Ware
Department of Physics and Astronomy, Brigham Young University, Provo, UT 84602, USA
Corresponding author: peat@byu.edu

Abstract

We outline an experiment for measuring polarization-resolved fundamental, second, and third harmonic photons scattered from low-density electrons in a Ti:sapphire laser focus, at intensities above 10^{18} W/cm^2. Different components of the well-known figure-8 electron motion may be associated with orthogonal polarization components of the scattered light.

Introduction

In their landmark analysis nearly a half-century ago, Sarachick and Schappert described trajectories of and radiation from classical electrons in an intense laser field.[1] In the average rest frame, an electron oscillates along a well-known figure-8 path, owing to both the electric and magnetic forces of the laser field. At relativistic intensities, electrons scatter both odd and even harmonics into the far field. This relativistic nonlinear Thomson scattering was first observed by the Umstadter group in a 1-atm plasma in the 1990's.[2] They measured second and third harmonics scattering in directions perpendicular to the focus. To our knowledge, the polarization of this scattered light has not previously been analyzed, either experimentally or theoretically.

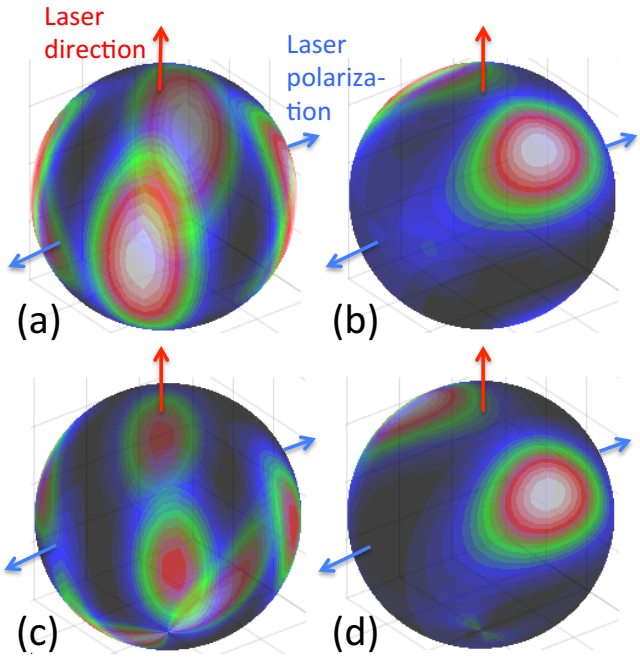

Fig. 1. (a) Azimuthal and (b) longitudinal polarization components of second-harmonic Thomson scattering emitted in all directions. Repeated in (c) and (d) for the third harmonic.

Figure 1 shows polarization components of the emission patterns for second and third harmonic light, resolved along 'latitude' and 'longitude' lines. The free electrons are stimulated by linearly polarized 800 nm laser light at 1.5×10^{18} W/cm^2. The added dimension of polarization gives insight into different aspects of the figure-8 electron motion.

Experiment

We describe ongoing experiments on low-density targets (i.e. $<10^{-4}$ Torr), where we count fundamental, second, and third-harmonic photons scattered by free electrons in an intense laser focus. Figure 2 shows the expected polarization-resolved angular distribution of the emission in a plane perpendicular to the laser beam (same parameters as Fig. 1). Plot 2(b) shows the spatial distribution of total emission (previously measured), and plots (c) and (d) show the resolved polarization components that we are attempting to measure. Acknowledgement: NSF 1708185.

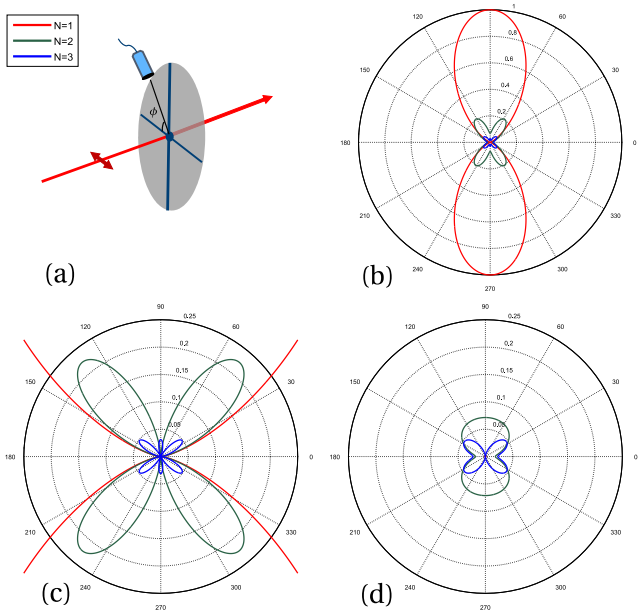

Fig. 2. (a) Schematic of nonlinear Thomson-scattering measurements. (b) Total light emission as a function of detector angle for N=1,2,3 harmonics. Zoomed in (c) azimuthal and (d) longitudinal polarization-resolved emission.

References

[1] E. S. Sarachik and G. T. Schappert, "Classical Theory of the Scattering of Intense Laser Radiation by Free Electrons," Phys. Rev. D **1**, 2738-2753 (1970).
[2] Chen, S. Y., Maksimchuk, A., and Umstadter, D. "Experimental observation of relativistic nonlinear Thomson scattering," Nature **396**, 653-655 (1998).