Polarization Effects in Thomson Scattering by Free Electrons in a Strong Laser Field

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Abstract

Nearly a half-century ago, Sarachick and Schappert published a landmark description of classical electron motion and associated scattered radiation 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 a far-field spatial pattern. This relativistic nonlinear Thomson scattering was observed by the Umstadter group in the late 1990's. [2] They measured the net intensity of second and third harmonic light scattered out the side of the laser focus at various angles.

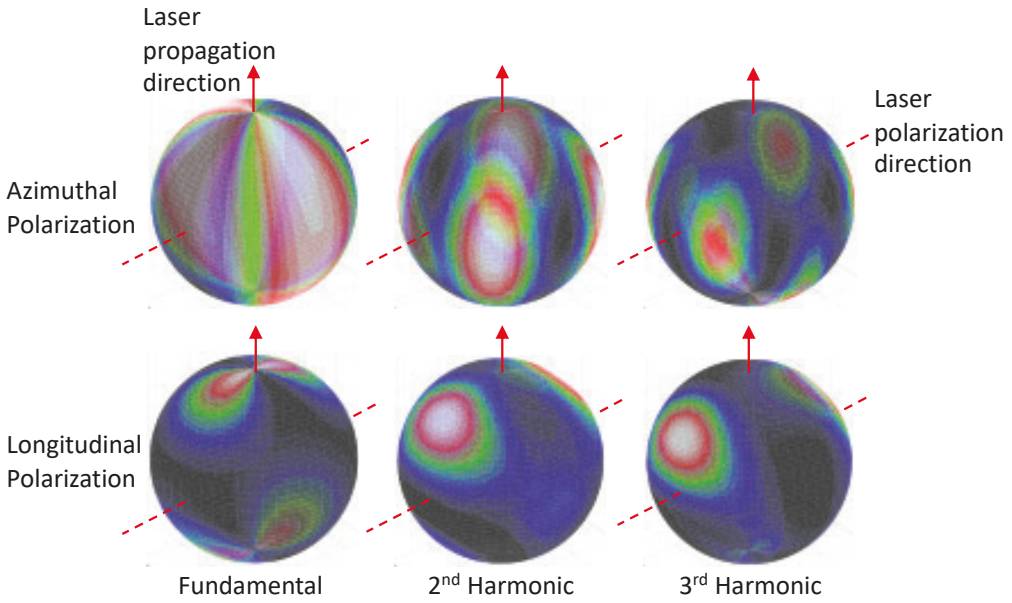

Fig. 1. Azimuthal (top) and longitudinal (bottom) polarization components of the fundamental, second harmonic, and third harmonic of Thomson scattering in the far field. Electrons are stimulated by linearly-polarized 800 nm light at 1.5×10^{18} W/cm^2.

Fig. 1 shows calculated polarization-resolved patterns of the scattered radiation -- first, second, and third harmonics. The polarization components are resolved along 'latitude' and 'longitude' lines. This additional dimension of information lends further insight into the electron motion and radiation behavior. We outline ongoing experiments 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 features of the figure-8 electron motion may be associated with the orthogonal polarization components of the scattered light. These kinds of measurements may also reveal characteristics of the laser vector field distribution in the focus. Acknowledgement: NSF 1708185.

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).