Nonlinear Thomson Scattering Measured over the Full Emission Sphere

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We measure light scattered from low-density free electrons in an intense laser focus using single-photon counting techniques. A polarizer in the collection system resolves fundamental, 2nd, and 3rd harmonic photons into orthogonal component corresponding to azimuthal and longitudinal lines on the emission sphere. Azimuthal rotation around the sphere is accomplished via rotation of the laser polarization. Longitudinal rotation is accomplished by moving the collection lens setup about an axis that contains the interaction region. Electrons are donated from helium in an otherwise evacuated chamber, backfilled to a fraction of a Torr. The 800 nm, 40 fs, 50 mJ, 10 Hz laser pulses ionize the helium early during the rising edge of each pulse. The intensity in the laser focus exceeds 2×10^{18} W/cm^2, which causes electrons to move relativistically. Individual electrons execute the well-known figure-8 trajectory in the linearly polarized intense laser field. Electrons also drift forward, owing to momentum imparted from the rising edge of the pulse. This induces a modest redshift when photons are viewed from the side. Fig. 1 shows measured 2nd harmonic photons at 60° and 120° on the emission sphere (*i.e.* ±30° from the equator). The nonlinear Thomson scattering is measured for separate orthogonal detector polarizations, along azimuthal and longitudinal lines on the emission sphere. The end-to-end dimension of the figure-8 electron trajectory gives rise to scattered photons with azimuthal polarization, while the side-to-side dimension gives rise to scattered photons with longitudinal polarization. A strong asymmetry in the emission patterns between 'northern' and 'southern' hemispheres indicates that electrons move in the same direction on both ends the figure 8 and oppositely in the middle. Moreover, one can deduce the direction that electrons travel around the figure 8.

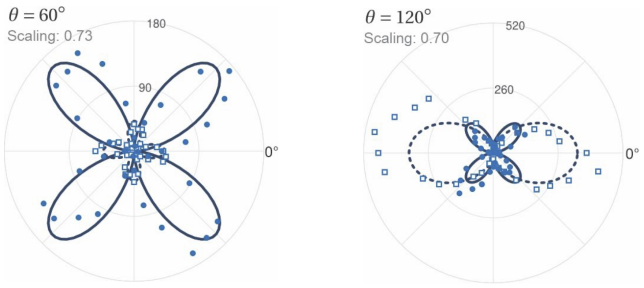

Figure 1: Measurements of azimuthal (blue) and longitudinal (green) polarization of 2nd harmonic nonlinear Thomson scattering. The data is obtained around the 'latitude' lines at 60° (left) and 120° (right) from the direction of laser propagation

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