Moore, Knauer, and Meyerhofer Reply: In Ref. [1] we described the experimental observation of electron recoil during high intensity laser-electron scattering (Compton scattering) in the Thomson regime with photon energy much less than the electron rest mass, $\hbar\omega \ll m_e c^2$. Of course the distinction between Thomson and Compton scattering is somewhat arbitrary as the Thomson scattering process, both cross section and kinematics, is recovered as the low energy limit of the Compton scattering cross section [2]. We described the scattering both classically in a Monte Carlo simulation and quantum mechanically through the conservation of photon energy and momentum [Ref. [1], Eq. (2)]. This relationship was derived in Refs. [3–5]. It is important to note that under these experimental conditions, the average transverse (oscillatory) energy is significantly larger than that in the forward direction. We did not, however, attempt to calculate the quantum mechanical scattering rate.

In his Comment [6], Ugaz has begun the process of making a quantum mechanical calculation relevant to the experimental conditions. He postulates that the scattering is made up of a sequence of multiphoton scattering events, each involving ~11–15 photons. Thus, the number of individual scattering events (l) is in excess of 10^4.

While the kinematics is well described by this model, the scattering rate is not. The multiphoton Compton scattering cross section is calculated in Ref. [2] and has recently been measured [7] during the scattering of a 50 GeV electron beam with an intense laser which has parameters similar to that used in Ref. [1]. When the electron's oscillatory energy in the field approaches its rest mass, the multiphoton scattering cross section is less than, but approaches, the Thomson scattering cross section [2]. The average time between scattering events (inverse of the rate) is given approximately by

$$\tau_{\mathrm{scat}} \sim \frac{1}{\sigma_c \rho_\gamma c}, \tag{1}$$

where σ_c is the scattering cross section, ρ_γ is the photon number density, and c is the speed of light. Using the Thomson cross section, we estimate that the time between scattering events is approximately 300 fs. Thus, fewer than ten sequential scattering events are possible during the laser pulse. Additional physics, most likely the effect of stimulated scattering in the laser field, must be included to perform the full quantum mechanical calculation. We hope that the start on the quantum mechanical problem by Ugaz [6] will eventually lead to a more complete description.

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