High-Density Electron-Ion Bunch Formation and Multi-GeV Positron Production *via* Radiative Trapping in Extreme-Intensity Laser-Plasma Interactions

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Multi-petawatt laser systems will open up a novel interaction regime mixing collective plasma and quantum electrodynamic processes, giving rise to the prolific generation of gamma-ray photons and electron-positron pairs. Here, using particle-in-cell simulations, we investigate the physics of the interaction of a 10^{24} W/cm^2 intensity, 30 fs duration, circularly polarized laser pulse with a long deuterium plasma at classically overcritical electron density (10^{22}/cm^3). We show that radiative trapping of the plasma electrons causes a high-density ($\sim 5\times10^{23}$/cm^3), a quasineutral electron-ion bunch to form inside the laser pulse. This phenomenon is accompanied by up to $\sim 40\%$ energy conversion efficiency of the laser into gamma rays. Moreover, we find that both the radiation-modified Laplace force and the longitudinal electric field exerted on the positrons created by the multiphoton Breit–Wheeler process can accelerate them to GeV-range energies. We develop a theoretical model, the predictions of which provide a good match to the simulation results. Finally, we address the influence of the ion mass, showing that the laser absorption and positron acceleration is enhanced with deuterons compared to protons.