Problem Set #3 *Comparing classical electromagnetic waves with photon probability waves.*

Problem 1 refers to: A **standing** electric field wave (one with lots of photons) in a quantum wire stretching between *x* = 0 and *x* = *L* is described by $\mathcal{E}(x,t) = \mathcal{E}_{max} \sin(3\pi x/L)\cos(3\pi ct/L)$. Let *L* = 900 nm.

1.(a) What is the wavelength of the wave? What is the ordinary frequency? In which part of the electromagnetic spectrum (i.e., x-ray, UV, IR, light, etc.) is this wave? Explain.

(b) How many nodes does the electric field wave have for $0 \le x \le L$? Where are they located?

(c) The *electric field* energy density is $u_E = \frac{1}{2}\varepsilon_0 \mathcal{E}^2$. Calculate $\partial u_E/\partial t$. Is the electric field energy density constant in time at different points in the wire?

Problem 2 refers to: A single photon in a quantum wire stretching between *x* = 0 and *x* = *L* is described by the wavefunction $\Psi(x,t) = \Psi_{max} \sin(3\pi x/L)\exp(-ic3\pi t/L)$. Let *L*= 900 nm.

2.(a) How does the photon (kinetic) energy vary in space and time? What is the average photon kinetic energy measured many times starting with the same initial state? In what region of the electromagnetic spectrum is this photon? Explain.

(b) What is the average photon momentum (careful!) measured many times starting with the same initial state? Explain.

(c) At what frequency does the photon probability density change in time (i.e., in Hz)? Explain.