Set #6

17. *Radial Current Density.*

Problem 4.6. At instant $t = 0$ the electron behavior is described by the following wavefunction:

$$\Psi(r, 0) = Ae^{-r^2/\alpha^2 + ikr}. \tag{4.32}$$

Find the normalization constant, A, the most probable value r_{pr}, and the radial part of the probability current, j.

18.

The reflection and transmission coefficient of a dielectric slab of thickness "d" are:

$$r = \frac{(n^2-1)\,(e^{2ikdn}-1)}{(n+1)^2-(n-1)^2 e^{2ikdn}} \qquad t = \frac{4n\,e^{ikdn}}{(n+1)^2-(n-1)^2 e^{2ikdn}}$$

A non absorbing photonic crystal with n=2 (real) is made up of a periodic distribution of dielectric slabs whose thickness is $d = 0.1\,a$ alternated by vacuum regions. The structure periodicity is a.

a. Find the equation that describes the photonic band gap in terms of ωa/c.
b. Plot (Python, Mathematica, Matlab etc.) such an equation as a function of ωa/c.
c. Would an incident light beam with frequency such that ωa/c=3 e ωa/c=4 propagate or not?

19. Electrons may tunnel from a metal through the application of a suitable (constant) external electric field ε. After the application of the electric field ε the potential at the metal surface taken at x=a reads as (see class notes)

$$V(x) = E_F + \Phi - e\mathscr{E}(x-a)$$

Assuming that the tunneling electrons originates from a single-electronic state, estimate the field strength ε (volt/cm) needed to draw (*tunneling*) current densities of the order of mA/cm² from a potassium sample surface.