# PHY662 - Quantum Mechanics II
# HWK #11, Due Thursday, Apr. 29, *start* of class

- Reading: pp. 506 to 521 of Shankar.

1. *Beyond the dipole.* [3 pts] Exercise 18.5.1 in Shankar: (1) Show that the $e^{i\vec{k}\cdot\vec{r}}$ factor can be kept by replacing $\vec{p}_f$ by $\vec{p}_f - \hbar\vec{k}$ in Eq. (18.5.9). (2) Verify that the final electron momentum is then biased towards $\vec{k}$, reflecting the $\hbar\vec{k}$ linear momentum imparted to the electron by the electromagnet field.

2. *Plugging in numbers.* [4 pts]

   (a) Carry out this simple practice exercise: that $\frac{e^2}{\hbar c}$ is dimensionless and calculate its value, using SI values for $\hbar$ and $c$ and converting $e^2$ to SI units by tricks we have used in other homework problems.

   (b) Exercise 18.5.2 in Shankar, part (1): Estimate the photoelectric cross section for an electron ejected from a hydrogen atom when the ejected electron has a kinetic energy of 10 Ry. Compare this cross section with the atom's geometric cross section $\approx \pi a_0^2$.

3. *Playing in oscillator world.* [3 pts; This question is based on Tuesday's lecture, the bulk of which is posted online already.] Consider a harmonic oscillator coupled to a bath of harmonic quantum oscillators, as described in Tuesday's lecture. Let $c$ be a constant with the dimensions of velocity. Explore the consequences of modifying the perturbation discussed in class, $H' = gN^{-1/2}x\sum_i x_i$, to the slightly more complicated form

$$H' = gN^{-1/2}\sum_i e^{-\omega_i x/c} x x_i \,.$$

   In the limit where the matrix elements of $\omega_i x/c$ are small, but not negligible, compared with 1, how does this modification affect the rates of different transitions?