Final Exam (221B), due May 10, 5pm

1. To figure out electronic configurations of multi-electron atoms, we have to take inter-electron Coulomb repulsion into account. For relatively small atoms, we can ignore spin-orbit interactions (in comparison to Coulomb replusion), and build electronic configurations using LS coupling. Namely, we add individual l to form the total L, and individual s to form the total S. We then refer to the configuration as ^{2S+1}L, such as ^1P, ^3D, etc. With the central potential alone, electronic configurations with the same orbitals are degenerate. However, inter-electron Coulomb repulsion removes degeneracy. The empirical "Hund's rule" says that configurations with larger S are lower, and among those with the same S, states with larger L are lower. Calculate the difference in energies for three different electronic configurations for the case of carbon $1s^2 2s^2 2p^2$, and show that the Hund's rule is correct. For this purpose, you can ignore the completely filled $1s$ and $2s$ orbitals, and discuss only remaining two electrons in $2p$ orbital (of course anti-symmeterized) and the Coulomb repulsion between them.

2. Consider the decay of the $2p$ state of hydrogen atom to the $1s$ state. Calculate the amplitude of the decay for $m = +1$ state using plane waves for photons, and explain the θ dependence of the amplitude for each helicity ± 1 of the final-state photon in terms of the angular momentum conservation. Show that the rate is the same as the decay rate of the $m = 0$ state.

3. How can the $2s$ state decay to the $1s$ state? You do not need to calculate the rate, but sketch how the calculation can be done, and also give an estimate of the rate.