Problem Set 3

Due February 8, 2018 PHY 215B

Problem 1. Considering

$$N\left(\frac{xz}{r^2}\right)f(r),$$

where N is a normalization constant, apply the rotation of C_{4z} for the square. Please note that the state is one of the Y_{2m}'s in rectangular coordinates. Derive the *simplest* (the *least dimension*) unitary matrix acting on this function and its partner (states which are coupled by the symmetry operators of the group of the square).

Problem 2. Show that the dipole operator $(q/c)\boldsymbol{A}_x p_x$ (where q is the charge of a particle, $\boldsymbol{A}_x$ is a constant vector potential along x, and p_x is the x–component of the momentum operator) transforms like the x–component of an $\ell = 1$ wave function of a hydrogen atom under the symmetry operators of the square. This is the justification that the components of a dipole operator can be classified as one of the irreducible representations of a group as the $\ell = 1$ states.

Problem 3. Construct the character table for the group of the square. (It has 8 operators and 5 classes.) Identify which irreducible representation of the state given in Problem 1 belongs to. Work out the selection rule or rules for the optical transition or transitions from the state given in Problem 1 and the electric field of the light given in Problem 2.

Suggested readings: Tinkham 4.5, 4.9