Physics 123B: Homework 5

due February 27, 4pm to Amanda Jones in Kohn Hall 1220 or by email to Prof. Balents

1. **Flux quantum:** Suppose experimentalists measure the magnetic flux of vortices in a new superconducting material. They find this flux is equal to $\pm h/4e$. What does this imply about the nature of superconductivity in this material?

2. **Fraunhofer pattern:** Here we consider the effect of a magnetic field that actually passes through a Josephson junction. Suppose a Josephson junction has thickness d (the separation between the two superconductors) in the z direction, and width L_x and L_y in the x and y directions, respectively. A magnetic field B is applied along the y direction, so we take $A_z = -Bx$. Now we can assume the phase difference $\Delta\theta$ is constant between the two superconductors, but $\gamma(x)$ will be a function of x. Then we have to generalize the Josephson equation for the current to $j(x) = j_c \sin\gamma(x)$, where j_c is the current *density* per unit length (x) across the junction, and $I = \int_0^{L_x} dx j(x)$.

   Find the maximum current, I_c, carried by the junction. Express your result in terms of the flux through junction, Φ, the flux quantum, φ_0, and L_x.

3. **Hund's rules:** What are the expected ground state S, L, and J for an ion in free space with 4 d electrons? What about with 3 f electrons?