QUANTUM MECHANICS III

PHYS 518

Term Project Topics

Distributed: November 19, 2008

Prepare a written document addressing the topic that you have been assigned (see below). The document must be prepared as if it were to be submitted to a professional journal. You will also prepare a talk based on this topic, to be given to the class on the date assigned. Allow 20 minutes for the talk, with 5 minutes for questions from the audience. The written version of your talk will be delivered to me in *.pdf format 48 hours before it is presented. When delivered, it will be mounted on the course's web site and be accessible to everybody.

This term project is presented in partial fulfillment of the requirements for a passing grade in this course.

Dec. 3 — Ed Damon - Quarkonium: Compare the hydrogen quantum numbers, spectrum, transitions, and widths with the positronium quantum numbers, spectrum, transitions, and widths. Describe the charmonium and the bottomonium quantum numbers, spectrum, transitions, and widths. Describe how the J/ψ was discovered and how its properties were related with those of positronium.

Dec. 3 — Joey Lambert - Josephson Supercurrent: Fill in the steps that are missing in B. D. Josephson's original paper in which he predicted both DC and AC tunneling supercurrents.

Dec. 5 — Rachel Kratzer and Sean Lynch - Interstellar Masers: Describe the equilibrium $H \leftrightarrow p^+ + e^-$ at temperature T and density n using the Saha equation. Describe how proton-electron recombination occurs, how the $(n, l, m_l)^*$ excited state quickly reaches states with saturated quantum numbers $l = n - 1$, $m_l = \pm l$ ("drip line"). Describe why the saturated states can only decay to saturated states under $E1$ transitions. Compute the (free space) lifetime of the state $|n, l = n - 1, m_l = \pm l\rangle$. Show how this leads to population inversions. Under what conditions might you expect laser action? Describe observations of interstellar maser activity. When was this measured, how, and by who?

Dec. 8 — Zhou Di - Density Functional Theory: Describe *Density Functional Theory*. State the fundamental theorems of this field. Explain what they mean. Show how they enable computation of the properties of the hydrogen molecule. Present two additional applications to larger molecules.

Dec. 8 — Brad Hubartt - Quantum Biochemistry: Choose any one of the DFT suites of codes and describe how the inputs are used to construct the skeleton of a molecule, and what information the code provides as output. List the codes that are available and compare their strengths and weaknesses.

Dec. 8 — Derek Mitchell - Plasmons: Explain what *Plasmonic Nanostructures* are (H. Wang et al., Acc. Chem. Res. (2007), **40**, 53-62). Why they are replacing photonic devices at the present time?

Dec. 8 — Dan Flynn - Mössbauer Effect in Biomolecules: Derive the quantum mechanics of the Mossbauer effect and describe two applications to biologically active molecules.