QUANTUM MECHANICS II

PHYS 517

Problem Set # 4

Distributed: April 24, 2015

Due: May 4, 2015

Reduced Density Matrices

1. Reduced Density Matrices: A p electron is initially in a state with $m_l = 0$, $m_s = +\frac{1}{2}$.

a. Write down its density matrix $\rho_{i\alpha,j\beta}(t=0)$. Here $-1 \leq i,j \leq +1$ and $\alpha, \beta = \pm\frac{1}{2}$.

b. The electron state evolves in time under a spin-orbit hamiltonian $H = \lambda \mathbf{L}\cdot\mathbf{S}$. Set $\lambda = 1$ and compute the state at later time t: $\psi(t) = \sum_{i,\alpha} c_{i,\alpha}(t)|i,\alpha\rangle$.

c. Write down its density matrix $\rho_{i\alpha,j\beta}(t)$.

d. What is its entropy?

e. Compute the *reduced* spin density matrix

$$\rho^{\rm red}_{\alpha,\beta}(t) = \sum_{i=j} \rho_{i\alpha,j\beta}(t)$$

f. Plot the entropy determined by this reduced density matrix as a function of time.

g. Compute the *reduced* orbital density matrix

$$\rho^{\rm red}_{i,j}(t) = \sum_{\alpha=\beta} \rho_{i\alpha,j\beta}(t)$$

h. Plot the entropy determined by this reduced density matrix as a function of time.

i. Explain (in words) what this computation has taught you.