

## Physics 711 Homework Problems

1. Give two examples of a wavefunction and its momentum space counterpart (two separate pairs of wavefunctions). Do not use the Gaussian as an example. State where your examples are physically applicable.
2.
  - a) A spin-1/2 particle is known to have spin up along the  $z$ -axis with 50% probability and spin down along the  $z$ -axis with 50% probability. Does this particle have definite spin? If so, in which direction does it point?
  - b) A spin-1/2 particle is known to be in the state  $|\alpha\rangle = (|+\rangle + |-\rangle)/\sqrt{2}$ . Does this particle have definite spin? If so, in which direction does it point?
  - c) A spin-1/2 particle is known to be in the state  $|\alpha\rangle = (1/2)|+\rangle + (\sqrt{3}/2)|-\rangle$ . Does this particle have definite spin? If so, in which direction does it point?
  - d) A hydrogen atom is known to be in a superposition of the ground and first excited states:  $|\psi\rangle = (|100\rangle + |200\rangle)/\sqrt{2}$ . Does this atom have definite energy? If so, what is its energy?
3. At time  $t = 0$  a hydrogen atom is known to be in a superposition of the ground and first excited states:  $|\psi(t = 0)\rangle = (|100\rangle + |200\rangle)/\sqrt{2}$ . Find the state of the system at a future time  $t$  by
  - a) Solving the time-dependent Schrödinger equation.
  - b) Evolving the phase of each energy state coefficient.
  - c) Using the time evolution operator.
4. Consider the beta decay of a tritium atom in its ground state. What nucleus is formed after the decay? If the nuclear decay is instantaneous on the atomic time scale, what is the state of the atom immediately after decay? (Expand the state in the energy basis of the new atom.)