Quantum Mechanics 2, Autumn 2011 CMI

Problem set 7

Due by beginning of class on Monday October 10, 2011

Density matrix, parity & time reversal

1. Is the superposition of a pair of quantum mechanical pure states a mixed state? Why or why not?

2. Is a linear combination of density matrices an allowed density matrix in general? Why?

3. An SG apparatus with inhomogeneous magnetic field in the z direction is fed an unpolarized beam of atoms with $l = 1$. Find the density matrix (for angular momentum degrees of freedom) for an atom in a beam that is obtained by combining the deflected output beams from the SG apparatus. Express the density matrix in the basis where L_z is diagonal. Does it describe a pure or a mixed state?

4. Calculate the average value of the angular momentum observable $\vec{L}$ for atoms in the above combined beam.

5. Suppose a particle obeying Newton's laws moves in one dimension subject to a frictional force $F = -\gamma \dot{x}$ with $\gamma > 0$. Write down the equation of motion for $x(t)$. Find the equation satisfied by $y(t) = x(-t)$. Qualitatively, what sort of motion does the resulting equation for y describe? Is Newton's equation for the above frictional force time-reversal invariant?

6. Show that the parity operator in one dimension is both hermitian and unitary.

7. Is the time reversal operator hermitian? Why?