

Physics 4410 - Quantum Mechanics II – Fall 2004  
Problem Set 4

Due September 22, 2004 at 11:00 AM in Duane G2B21

Reading assignment: Shankar Chapter 10, Liboff Section 11.11

If you didn't do them last semester, work Shankar 10.3.1, 10.3.3, 10.3.4 (not for credit).

1. Shankar 10.3.2
2. Shankar 10.3.5 (double points)
3. Liboff 12.20 (The operator  $\hat{\mathcal{X}}$  is equivalent to  $P_{12}$  in Shankar's notation.)
4. Show that the time evolution of the density matrix is given by  $\hat{\rho}(t) = \hat{U}(t)\hat{\rho}(0)\hat{U}^\dagger(t)$ , where the Hamiltonian is time-independent and  $\hat{U}$  is the propagator.
5. If we have a pure (coherent) ensemble at  $t = 0$ , can it evolve into an incoherent ensemble at a later time? Justify your answer. (You may find the result of the previous problem helpful.)
6. Liboff 11.73 – note that you can define a density matrix just as easily for a single particle as for an ensemble!