

8.421: Pre-Class Questions 5.1

1. When can we say that a general system is coherent?

A: Generally speaking, we say “a system is coherent”, when there exists a definite, non-random phase relationship between two or more eigenstates in the system.

2. Give two examples of physical systems that exhibit coherence?

A: Any of two of the following : optical parametric oscillators (OPAs), atoms, quantum resonators, superradiance in BECs, photons.

3. In a closed quantum system, what distinguishes spontaneous emission from other transitions between quantum states?

A: No Distinction. In a fully closed system spontaneous emission would look just like an unitary transformation over our quantum state. There are experiments that have observed such a behavior in an effect called “Vacuum Induced Transparency” in which one can observe coupled oscillations between the modified vacuum due to an optical cavity and an atom inside of it.

4. A two-level atom in a coherent state undergoes spontaneous emission; bringing it it back to the ground state. Where does the coherence go?

A: The coherence of the atom is transferred to the photon. Now, the photon a coherent superposition of states in the photon number basis.

5. What is the origin of the phase fluctuations in the spontaneously emitted photon?

A: Measurement process of the photon (vacuum fluctuations). Performing a partial trace over the states of the atom.

6. How can we measure an atomic resonance with a spectral resolution narrower than its natural linewidth Γ ?

A: Delayed detection of scattered photons.