Proseminar zu Grundkonzepten: Aufgabe 2

H. Ritsch

7.12.2017

The Jaynes Cummings model

Consider a single optical field mode of frequency ω coupled to a single two-level atom. The coupling implements a resonant energy exchange between the atom and the field.

- **Hamiltonian dynamics:**

  1. Introduce a truncated Fock basis for the field and a 2-Level or Spin basis for the atom with the corresponding raising and lowering operators.
  2. Define the system parameters. Introduce the product basis of the combined Hilbert space and the corresponding operators in the full Hilbert space. Use these to construct the Hamiltonian in a rotating basis. Calculate the energy spectrum.
  3. Define the initial state with the atom excited and the field in the vacuum state and calculate the Schr"odinger time evolution of $\psi(t)$. Calculate mean values of photon number and atomic populations.
  4. Do the same for a state with initially one or two photons present.
  5. Plot photon number distributions and Q-function of the field at different times. For fun: create a movie of Q(t) .
     Hint: Use **ptrace** to extract the field density matrix from $\psi(t)$.
  6. Same as above for the field initially in a coherent state.

- **Master equation:**

  Let us add cavity decay now.

  1. Define the jump operator J and jump rate κ and use the build in function *timeevolution_master* to add the effect of cavity decay. Plot again mean values for atom and field as function of time.
  2. Add a driving field η to the Hamiltonian and calculate time evolution and steady states. Plot the steady state number of photons for fixed pump strength as function of the frequency difference between pump and cavity frequency for different coupling strengths g. Assume that atom and cavity are resonant.