Homework   6 December 2005

(Due, 5:00 pm Tuesday 13 December)

Optical pumping.

Consider a transition from a $J=1$ ground state to a $J'=2$ excited state.

assume:
- electric dipole transition, on resonance
- weak excitation, $I/I_0 \ll 1$ for any transition
- initially, before any excitation, all $J=1$ sublevels are equally populated
- the light is σ^+ polarized.
- excited state lifetime is $\tau = \Gamma^{-1}$
- you may ignore any off-diagonal density matrix elements

a) enumerate (list) all possible excitation and decay transitions and give their relative strengths (proportional to the transition rates) relative to the strongest being unity.

b) explain qualitatively what will happen after a long time – what is the equilibrium situation?

c) write rate equations for the populations of all relevant states.

hint: if $I/I_0 \ll 0$, all excited populations remain small and can be eliminated from the problem.

d) solve the rate equations is steady state and compare your result with b).

e) solve the rate equations as a function of time, beginning when the laser is turned on, with equal populations in the ground states. plot the results for population vs. time for each ground state in scaled units of time =

$$\left(I/I_0 \, \Gamma \right)^{-1}$$

f) approximately how many photons are scattered per atom before the system reaches steady state?