15. Atoms which are initially in an unpolarized ground state with J=3/2 are subject to optical pumping with light which is near-resonant with a transition to an excited state with J'=1/2. Assuming that all atoms excited to the J'=1/2 state decay to a 'trap' state other than the ground state and that other relaxation processes can be neglected, find the 4×4 density matrix describing the Zeeman sublevels of the J=3/2 after the optical pumping is complete. Let the quantization axis be the **z**-axis of a coordinate system. Consider the following two cases of light polarization:

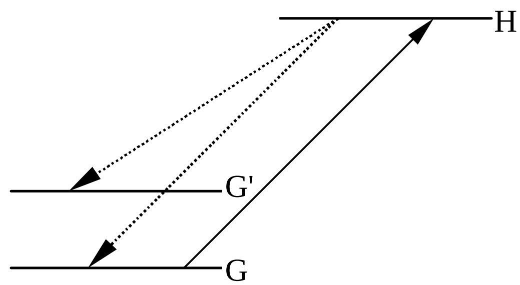
    a) right circular polarization and

    b) linear polarization along **x**.

16. An ensemble of atoms is excited from the ground state G to a state H with laser light, which is near resonant to the G→H transition with residual detuning δ. The state H spontaneously decays back to the ground state and to a metastable state G' (see figure). Describe the spectrum of the fluorescence in the two limiting cases:

    a) The laser light is monochromatic.

    b) The laser light has bandwidth $\Delta\nu_L >> \gamma/2\pi$; $\Delta\nu_L >> \delta$, where $\gamma/2\pi$ is the natural width of the state H in frequency units. Neglect all sources of broadening rather than the radiative decay of the state H.



    c) Suppose two-level atoms (levels H,G) are moving onto a monochromatic light beam. What is the frequency of the fluorescent photons observed in the orthogonal direction?

17. Suppose you have a beam of linearly polarized light of intensity *I*. You need to rotate the polarization plane by $\pi/2$ (e.g. change the polarization from vertical to horizontal). It so happens that the only optical components you have at your disposal are high-quality dichroic polarizers (elements that transmit one linear polarization and totally absorb the orthogonal polarization). The good news is that you have a whole box of

them. How do you rotate the polarization? What is the maximal achievable intensity of the output light with the desired polarization?

18. Consider the linear Macaluso-Corbino effect (Faraday rotation near a resonance absorption line) for a $J=0 \rightarrow J=1$ transition. Assume that the only line-broadening mechanism is the natural with γ_0 of the upper state. What is the spectral dependence of the rotation? How does the peak rotation scale with γ_0? (Compare this to how the peak absorption scales with γ_0.) What is the magnetic field dependence of the rotation on resonance? What is the maximum rotation angle per one absorption length?