Due: Thursday, 02/10

5. In an atomic polarizer which is a part of an atomic beam apparatus, atoms with the ground state total angular momentum J=1 are prepared polarized along **z** i.e. in the state with m_J=1. In a separate part of the apparatus (the analyzer), one probes population of the m_J=0 state with respect to another axis **z'**. Suppose the two axes are misaligned by an angle $\boldsymbol{\beta}=\beta\cdot\hat{\mathbf{y}}$ (which means that the axes **z'** is obtained by rotating the **z**-axis around the **y**-axis through the angle β).

a) Find the analyzer signal dependence on β.

b) Suppose now that β=π/2. Find the spinor corresponding to the state prepared in the polarizer in the rotated coordinate frame. In other words, if we chose **x** as a quantization axis, how should we write the state polarized along **z**? What is the expectation value $\langle J_{Z'}\rangle$ in this state?

6. Consider an atomic state with electron angular momentum J. For a spinless nucleus, the Zeeman effect in this state in a weak magnetic field B_z is given by $\Delta E = g_J \cdot \mu \cdot B_z \cdot m_J$. Here ΔE is the Zeeman shift of the Zeeman component $m_J=\langle J_Z \rangle$, $\mu = e\hbar / 2mc = 0.93\cdot 10^{-20}$ erg/Gs=1.40 MHz/Gs is the Bohr magneton and g_j is the Lande factor. Now suppose that the atomic nucleus has angular momentum I. In the absence of external fields, we can now classify atomic states according to their total angular momentum F. States with different values of F are split due to the hyperfine interactions. If we now apply a weak magnetic field (weak enough that Zeeman splittings caused by it are much smaller than the hyperfine intervals), each of the F-states will split according to $\Delta E = g_F \cdot \mu \cdot B_z \cdot m_F$.

Neglecting the interaction of the nuclear magnetic moment with the external magnetic field and using the vector model, find expression for g_F in terms of I,J,F and g_J. Justify the neglect of the nuclear magnetism contribution.