PH3521701 现代原子物理 **2019-03-29**

Lecture summary

- Polarized atoms as a precision sensor for magnetometry and gyroscope
- Zeeman shift
  - First-order Zeeman shift
  - *g* factors: g_L, g_s, g_J, g_F
  - Ground-level of the hydrogen
- Level avoided-crossing
  - Landau-Zener transition
- Stark shift
  - Scalar polarizability and tensor polarizability

Homework

1. **Zeeman shift in hydrogen maser.** There is a uniform magnetic field of 5 mGauss present in the active region of a hydrogen maser. What fractional frequency shift would result from a drift of magnetic field by 5 μGauss (micro-Gauss) in the following two cases: (a) the maser operates on the transition between |F=1, M_F=1> and |F=0, M_F =0>; (b) the maser operates on the transition between |F=1, M_F =0> and |F=0, M_F =0>.
2. Textbook Exercise (6.8) Zeeman effect on hyperfine-structure at all field strengths
3. **Positronium atom**. A positronium atom is a hydrogen-like atom formed by a positron and an electron. What is the wavelength of the photons emitted by a transition from the n = 2 level to the n = 1 level (ground-level)? Determine the structure of the n = 1 level due to magnetic dipole-dipole coupling. Draw a diagram showing how the energies of the four n = 1 states evolve with magnetic field (see Fig. 6.10 for a corresponding diagram for a hydrogen atom).

4. **Stark shift** can be expressed as (E field direction is the quantization axis):

$$\Delta = -\frac{1}{2}\alpha_0 E^2 - -\frac{1}{2}\alpha_2 E^2 \cdot \frac{3{M_F}^2 - F(F+1)}{F(2F-1)}$$

   a. Derive the expression for the Stark shift of the stretched states (*F, M_F = +F or -F*);
   b. Derive the expression for the Stark shifts averaged over all M_F states.
   c. Estimate the order of magnitude of the polarizabilities of the ground level of the hydrogen atom.

Reading Assignments:

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