

Lecture summary

- Cs microwave clock
- Bloch vector, revisited
- Rabi method, revisited
 - Rotating frame choices
 - Linewidth
- Ramsey method
- Relaxation of the Bloch vector
 - T_1 and T_2
 - Decoherence, spin echo
- Optical Bloch equations
 - Saturation intensity
 - Power broadening
 - Light scattering cross section
- AC Stark shift

Homework

1. Study Norman Ramsey's Nobel lecture, in which he stated (on page 544 of the paper) that the resonance peaks obtained with the separated oscillatory-field method are narrower than the peaks obtained with the single oscillatory-field method. Compare the frequency sensitivities of Rabi's and Ramsey's methods. Given a coherent interrogation time T , calculate the FWHM (full width half maximum) of resonance peaks that can be achieved in ideal conditions using Rabi's and Ramsey's methods, respectively. In particular, show the narrowing factor of 0.6.
2. **Atomic cesium fountain clock**, page 134, Fig. 7.3. In a fountain clock, cold cesium atoms are launched up into a free fall trajectory. They pass through the microwave cavity with a vertical width of h_c , reach the apex at a height of h_f above the cavity ($h_f \gg h_c$), and fall back through the cavity before the atomic transition probability is measured. Based on the signal shown in Fig. 7.3, calculate the following:
 - a. The height of the fountain, h_f ;
 - b. The vertical width of the microwave cavity, h_c ;
 - c. The temperature of the cesium atoms.

* Temperature T is defined as $\frac{1}{2} k_B T = \frac{1}{2} M \langle (\delta V)^2 \rangle$, here $\delta V = V - \langle V \rangle$ is the velocity spread around the mean velocity of the atom group.
3. **Adiabatic fast passage.** A spin flip can be achieved by adiabatically sweeping either the holding magnetic field B_0 or the frequency of the oscillating transverse field B_1 across the resonance. Visualize the process using the vector model in the rotating frame. What is the adiabatic condition?

- A π -pulse can also flip spins. However, in situations when atoms of a wide velocity distribution spend very different amount of time in the radiation field, it is difficult to induce a π -spin flip on all the atoms.

4. Textbook Exercise (7.12) DC Stark effect

Reading Assignments:

- Norman Ramsey's Nobel lecture: Ramsey, [Rev. Mod. Phys. 62, 541 \(1990\)](#)

Mid-term exam 期中考试

时间：4月30日，周二，14:00 – 15:35

地点：2211 教室（不是我们平常上课用的小教室）

请带以下材料，不要带其它材料：

- 笔、直尺、计算器等一般文具
- 教科书：Atomic Physics by C.J. Foot
- 课堂上发的材料：CG coefficients, Grotrian diagrams, Selection rules 等
- 个人笔记、个人作业