



Optical Pumping

Optical pumping allows to probe atomic phenomena such as resonant light absorption, nuclear spin energy levels, Zeemann splitting and Rabi oscillations. The fundamental idea of optical pumping is to use polarized light to create an energy population distribution that is different from the Boltzmann distribution at a given temperature. In the experimental setup gaseous Rubidium is pumped, which has a hydrogen-like electronic configuration but consists of two isotopes with different nuclear spins leading to manifold lines in the spectra.

I. Required knowledge

Energy levels of Rubidium, Fine Structure, Hyperfine Structure, Breit-Rabi equation, circularly polarized light, resonant light absorption, optical pumping, Rabi-oscillations

II. Literature

- (1) Teachspin manual
- (2) James Camparo Physics Today, November 2001 p. 33
- (3) H. Haken, H.C. Wolf The physics of atoms and quanta, Springer 2004
- (4) R. Benumof Am. J. Phys. 33, 151 (1996)

III. Experimental tasks

I. Optimize the zero-field absorption (line-width, depth) with the help of the lin. polarizer, quarter-wave-plate, vertical coil current and the orientation of the set-up.

II. Measure the Zeeman levels for the two Rubidium isotopes at low magnetic fields for different rf-frequencies in the range between 50 kHz and 150 kHz.

III. Measure the Zeeman-splitting of both isotopes at high magnetic fields with two different methods:

1. With a magnetic field sweep
2. With a frequency sweep

IV. Repeat the measurements of task III for different rf-amplitudes.

V. Measure the optical pumping time and Rabi-oscillations by gating the rf-power on and off at low magnetic fields. Repeat the measurements for different rf-amplitudes.

IV. Experimental analysis

I. Plot the obtained frequencies from II. vs. the sweep coil current. What is the ratio of the slopes for the two isotopes?

II. Use the literature values of g_F to calibrate the sweep field.

III. Plot the splitting of resolved resonances from task III at high fields against the average Zeeman frequency. Determine the ground-state hyperfine splitting for the two isotopes from this plot. For high precision measurements, what is the better choice: sweeping the field or the frequency?

IV. Explain what happens at higher rf-amplitudes.

V. Determine the pumping time from the gating experiments. How do the Rabi-oscillations depend on the rf-amplitude?

V. Setup

