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Abstract

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2.1 Rubidium

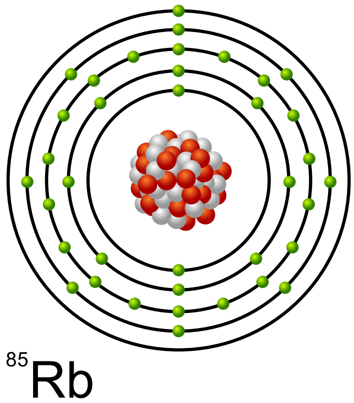

Fig. 2.1 Schematical representation of ^{85}Rb

Rubidium is a chemical element with symbol Rb and atomic number 37. It is a soft, silvery-white metallic element of the alkali metal group, with an atomic mass of 85.4678. Elemental rubidium is highly reactive, with properties similar to those of other alkali metals.

German chemists Robert Bunsen and Gustav Kirchhoff discovered rubidium in 1861 by the newly developed technique, flame spectroscopy. Because of the bright red lines in its emission spectrum, they chose a name derived from the Latin word rubidus, meaning “deep red”. [1]

Although rubidium is monoisotopic, rubidium in the Earth’s crust is composed of two isotopes: the stable ^{85}Rb and the radioactive ^{87}Rb. [2]

	Rubidium	
Isotope	85	87
Atomic mass	84.911794	86.909187
in 10^{-25}kg	1.40999	1.44316
Abundance	72.17%	27.83%
Spin I	$^5/_2$	$^3/_2$

Table 2.1 Properties of rubidium isotopes

2.2 D2 line

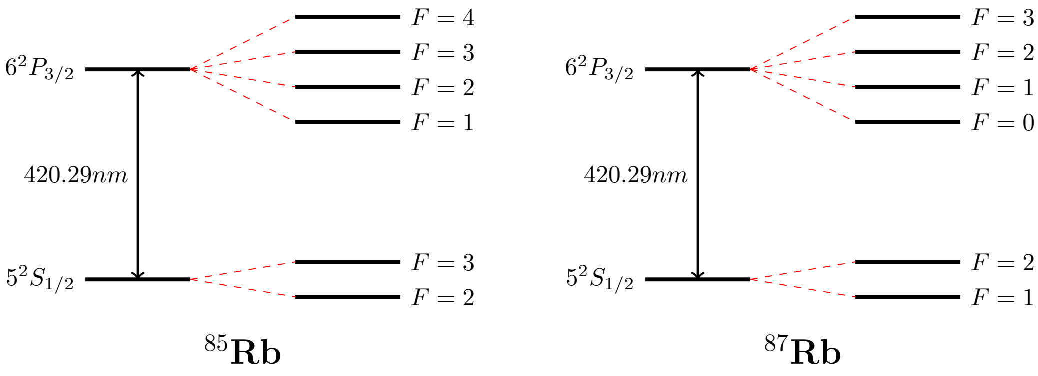

Fig. 2.2 $5^2S_{1/2} \rightarrow 6^2P_{3/2}$ transition of ^{85}Rb and ^{87}Rb with corresponding hyperfine structure

As we can see both isotopes have the same transition energy, but due to the different spin I (see table: 2.1) we get different energy levels for the groundstate [3]. This is the reason why we wittness four doppler peaks in our spectrum.

Caution: Both figures below show the correct correlation between energy and isotopes. The explanation of this is that higher energy levels need lesser transition energy to reach the same excited state.

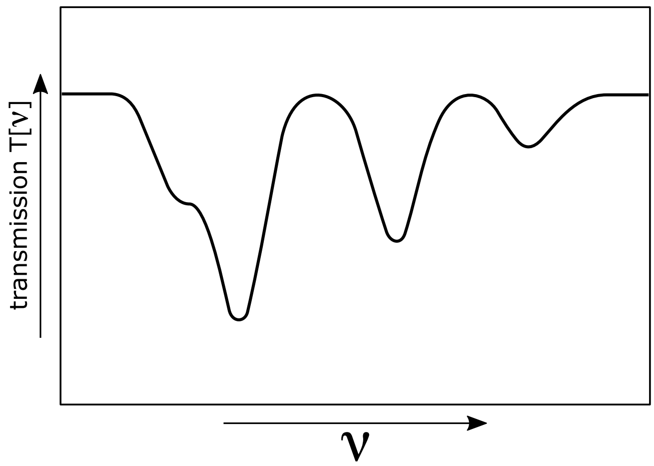

Fig. 2.3 Doppler spectrum of D2 line

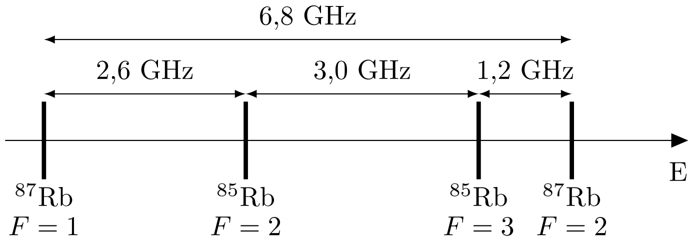

Fig. 2.4 Relative energy gaps of the groundstates between both isotopes

2.3 Two-level atom

In the upcomming sections we will derive an expression for the absorbtion or to be precise the intensity of the laser beam, but first we have to discuss the model on which basis we will do this.

The simplest model is the two-level atom with a groundstate $|g\rangle$ and one excited state $|e\rangle$. There are three possible transitions:

(1) absorbtion

(2) stimulated emission

(3) spontaneous emission

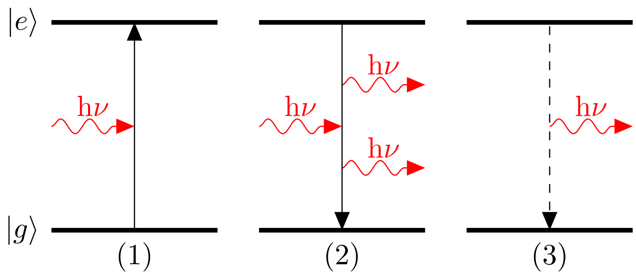

Fig. 2.5 Two-level atom model

In our case we will only consider the photon absorbtion.

2.4 Laser absorbtion

2.5 Doppler shifts

2.6 Behavior of absorbtion coefficient

2.7 Non-linear differential equation

Chapter 3

Experiment

3.1 Setup & Tools

3.2 Laser diameter measurement

3.3 Power / intensity measurement

3.4 Doppler-free measurement

Chapter 4

Evaluation

References

[1] G. Kirchhoff and R. Bunsen. Chemische Analyse durch Spectralbeobachtungen. *Annalen der Physik*, 189:337–381, 1861.

[2] G. Audi, O. Bersillon, J. Blachot, and A. H. Wapstra. The NUBASE evaluation of nuclear and decay properties. *Nuclear Physics A*, 729:3–128, December 2003.

[3] J. Reader A. Kramida, Yu. Ralchenko and NIST ASD Team (2015). NIST atomic spectra database (ver. 5.3). *National Institute of Standards and Technology*, 2015.

Appendix A

Theory

Appendix B

Experiment

Appendix C

Evaluation