Optical Pumping of Rb^{85} and Rb^{87}

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Abstract

Optical Pumping is a spectroscopical method that was developed in the 1950's and has been a very accurate method to determine spectroscopical properties of certain materials. In this experiment the following were determined: the individual g-factors, nuclear spins, cross sectional area and ratio of the periods. For Rb^{85} the g-factor and nuclear spin were found to be: 0.3260 ± 0.0005 and 2.571 respectively. For Rb^{87} they were found to be: 0.482 ± 0.001 and 1.576 respectively. The cross-sectional area and ratio of the periods were found to be: $1.8\times10^{-16} \pm 0.3\times10^{-16}$ and 1.44 ± 0.05 respectively.

I Introduction

Optical Pumping is a spectroscopical method developed in 1950 by Alfred Kastler, whom received the Nobel Prize in physics in 1966 for his discovery. This method is one in which photons are utilized to create population differences of electronic excited and ground states. So the meaning and general concept is in the name itself.

Under startdard conditions the population difference required to carry out experiments is not possible because from statistical mechanics at thermal equilibrium we have an equal number of electrons that rise and fall from excitation levels. Due to this, they tend to cancel each others effects and no net population differences can be detected. This is also the basis of lasers where, a population difference needs to be created so that photons can be spontaneously emmitted by the lasing medium.

For this experiment the equipment that is being used is provided by TeachSpin and consists of an Radio Frequency (RF) discharge lamp, Interference Filter, Polarizers, Quarter Wave plate, absorption cell, optical detector, three sets of magnetic coils in a Helmholtz configuration and a RF magnetic coil. The sample is a Rubidium glass bulb that contains neon gas with a pressure of approximately 0.04 atm pressure. The presence of the neon gas is important as its spherical symmetry will reduce the interactions between the Rubidium atoms and the outside environment. They will act as a buffer gas.

Optical Pumping is a process in which has had much applicability in solid state and liquid state physics. However, we will only be dealing with a gas since at the solid and liquid phases the interactions between the neighboring atoms increases thus broadening the energy levels [**?**].

II Theory

(i) Structure of alkali atoms

In the experiment described in this paper we will be studying the absorption and emission from Rubidium isotopes (85 and 87) which are alkali atoms. As such the electronic structure of Rubidium is as such,

$$1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 04s^2 4p^6 5s$$

Where we can show the shorthand version as,

$$[Kr]5s$$

Where, the subscripts show the number of electrons contained in each of the electronic shells. Since the only valence electron is in the 5s shell we can consider the atom to be like that of a Hydrogen atom and only concentrate on the one electron on the fifth shell. This electron much like with other electrons can be described by means of the total angular momentum of the electron **J** where it is made of components **S** and **L**. Which, represent the spin angular momentum and orbital angular momentum respectively.

References

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