Use of Selective Reflection process to study “forbidden” atomic transitions of Cs D2 line

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Abstract – It is demonstrated that the use of Selective Reflection process obtained with the help of a thin cells filled with the Cs atomic vapor allows one to detect seven $F_g=3 \rightarrow Fe=5$ atomic transitions in an external magnetic field in the range of 0.5-3 kG.

Keywords— selective reflection; atomic transitions; magnetic field

I. INTRODUCTION

The reflection of light within a transparent dielectric at the interface between the dielectric and an atomic vapor shows a sharp peak when the light frequency matches the transition energy of the atom. This phenomenon is known as the Selective Reflection (SR) ([1] and see references therein). It has been demonstrated that SR is a powerful tool to realize sub-Doppler resolution of atomic transitions.

Cs atoms are widely used in laser cooling experiments, information storage, spectroscopy, magnetometry, laser frequency stabilization etc. That is why any knowledge of the behavior of Cs atomic transitions, particularly, in an external magnetic field is of high importance. It is well known that in quite moderate magnetic field $B$ the splitting of atomic energy levels to Zeeman sublevels deviates from the linear behavior, and the atomic transition probabilities undergo significant changes.

II. NANO-METRIC THIN CELL

As it was demonstrated earlier, strong narrowing in absorption spectrum can be attained with the use of Nano-metric Thin cell (NTC) with the thickness ($L = \lambda/2$, where $\lambda$ is the resonant wavelength of laser radiation, $L = 426$ nm for the case of Cs $D_2$ line). Particularly, the absorption linewidth for Cs $D_2$ line reduces to $\pm$100 MHz (FWHM), as opposed to $\pm$400 MHz in an ordinary cell. The narrowing of the line-width allows one separation of closely spaced individual transitions and study their transition probabilities in an external magnetic field [2].

III. SELECTIVE REFLECTION

In this presentation we present, for the first time, the results of experimental and theoretical studies showing a giant transition probability modification for Cs $D_2$ line $6S_1/2, F_g=3 \rightarrow 6P_3/2, Fe=5$ transition induced by a magnetic field varied in a wide range up to 3 kG. It should be remembered that, according to the electric dipole selection rules in zero $B$ field, only transitions with a change of atomic total angular momentum $\Delta F = F_g – F_e = 0, \pm 1$ are allowed, while $F_g=3 \rightarrow Fe=5$ transitions are forbidden.

In order to detect $F_g=3 \rightarrow Fe=5$ atomic transitions in an external magnetic field (0.5-3 kG) we have implemented SR with the help of 40-micrometer-thin (MT) cell filled with Cs atomic vapor. Use of thin cell is an advantageous for application of very strong magnetic field with the use of permanent magnets otherwise unusable because of strong magnetic field inhomogeneity.

Very well resolved seven components belonging to $F_g=3 \rightarrow Fe=5$ atomic transitions have been detected in the SR spectrum in the range of magnetic fields 0.5-3 kG. Note, that these spectra could be also detected with the absorption spectra of the NTC use.

IV. ADVANTAGE OF MICRO-METRIC-THIN CELL USE

The most important advantage of SR spectroscopy with micrometric-thin cell is much simpler construction of MT cell, meanwhile fabrication of the NTC [2] is up to now a tricky work (windows of the nano-cell are made either from technical sapphire or garnet crystal).

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