TECHNICAL DIGEST

MPLP-2021

The IX International Symposium

“MODERN PROBLEMS OF LASER PHYSICS”

Novosibirsk, Russia, 22 – 28 August, 2021

mplp2021.laser.nsc.ru

Organized by:

Institute of Laser Physics, SB RAS, Novosibirsk, Russia

Novosibirsk State University, Novosibirsk, Russia

Institute of Spectroscopy, RAS, Troitsk, Moscow, Russia

Federal State Unitary Enterprise "VNIIFTRI", Mendeleevo, Moscow region, Russia

Optical pumping of alkali metal atoms in buffered gas cell for different decay rates of the nuclear spin

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One of the main characteristics responsible for the sensitivity of optical quantum magnetometers [1–5] is the polarization of atoms, which can be achieved by optical pumping of alkali atoms. The higher the polarization of the atoms can be created, the greater sensitivity of the magnetometer can be achieved. The degree of polarization is influenced by the following processes: this is the interaction of alkali atoms with a buffer gas, as well as collisions of alkali atoms with each other.

When alkali atoms collide with atoms of the buffer gas, the electron spin is destroyed, and the nuclear spin can be preserved [5, 6]. This fact significantly affects the achievement of the maximum polarization of atoms. In the problem of pumping of atomic spin by circularly polarized light, the models of complete mixing of populations in an excited state are usually used.

In our work, we develop a stationary mathematical model describing the excitation of alkali atoms by monochromatic laser radiation in a gas cell with buffer gas in order to find the gas polarization upon excitation by circularly polarized radiation. The effect of collisions on the main total moment of atoms is studied taking into account the breaking of the bond between the outer electron shell and the nucleus at the moment of collision. The results are presented both with conservation of the nuclear spin and with complete its randomization. The full hyperfine and Zeeman structures of the ground and excited states are taken into account.

This work was supported by Russian foundation for Basic Research (project 19-29-10004), State assignment for Basic Research (FSEG-2020-0024).

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