Coherent population trapping resonance on Zeeman sublevels for quantum magnetometer.

I.M. Sokolov, A.N. Litvinov

St-Petersburg State Polytechnical University, St-Petersburg, Russia,

Email: andrey.litvinov@mail.ru

One of the most important methods of mineral exploration is aeromagnetic survey. Many minerals have high magnetic susceptibility and distort Earth's magnetic field therefore they can be detected and outlined by aeromagnetic survey. It can be used as a direct search method for detection magnetite, iron, nickel, chromite and copper ore.

The main device aboard an aircraft for aeromagnetic survey is a magnetometer. Thus, the abilities of such exploration are determined by sensitivity of the magnetometer. This work is devoted to investigation of the quantum magnetometer based on the coherent population trapping (CPT) effect [1-2] on the Zeeman sublevels of the alkali metal vapors. It is known that CPT resonance can be much narrower than natural linewidth of excited level of an atom. On the one hand this fact can be used in quantum frequency standards [3]. In this case the CPT resonance is excited on the ground hyperfine sublevels with the magnetic quantum number equal to zero, because these levels are less sensitive to the external magnetic field. On the other hand, if we excite the CPT resonance on the Zeeman sublevels with nonzero magnetic quantum number, such resonance will be very sensitive to the external magnetic field. It can be used for detection and measurement of magnetic field. For measurement of three-dimensional magnetic field vector it is necessary to use three magnetometers which are directed orthogonally.

The aim of our work is finding the optimal operating conditions, active gas and laser parameters for maximum sensitivity of the magnetometer. We are going to calculate the physical limit of sensitivity of the magnetometer, based on the CPT resonance. Also we will compare sensitivity of magnetometers, based on the coated gas cell and cell with buffer gas.

In the present work, the CPT resonance in atomic vapors ^{133}Cs is theoretically studied in cells with antirelaxation coating. The analysis is based on density matrix calculations. All Zeeman and hyperfine sublevels are taken into consideration. Atomic interaction with the walls is taken into account by means of boundary conditions for the density matrix. We consider different polarization schemes of excitation of the resonance in D1 and D2 line and perform the multifactor optimization of the CPT resonance for different conditions. Sensitivity of the quantum magnetometers based on CPT resonance in^{133}Cs is compared with earlier calculated sensitivity of the CPT in ^{87}Rb.

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