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Frequency stabilization of diode laser on the wavelength of $5P_{3/2} \rightarrow 5D_{5/2}$ of rubidium transition

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Abstract. The method of frequency stabilization of diode laser on the wavelength of 5P3/2→5D5/2 of rubidium (776 nm) has been realized. The two-photon absorption spectroscopy of the rubidium vapors is underlie of the suggested scheme. The basic parameters such as the intensity of laser radiation and concentration of the vapors have been investigated. The frequency stability of radiation was about 1 MHz

There are several approaches to the stabilization of the laser radiation at the wavelength of 776 nm, which corresponds to the second transition 5P to 5D of rubidium atom (the first is 5S to 5P). One of the simplest approaches is based on the use of a high-finesse and a highly stable Fabry–Perot etalon in combination with a wavelength meter (lambda meter). In this scheme, the laser radiation is stabilized with respect to the transmission peak of the Fabry–Perot etalon [1], and the stabilization frequency can be chosen arbitrarily. The lambda meter is used to determine the wavelength of the laser radiation. The main problem of this scheme is the frequency drift of the Fabry–Perot etalon, which restricts the stabilization time of the laser radiation.

Another approach is based on the use of resonant absorption lines of the atom. Because the frequency of any atomic transition is stable in time, this approach does not have fundamental physical restrictions on the long-term stability of the laser. In this approach to the frequency stabilization of the laser radiation, the characteristic stabilization time is determined only by the drift of electronic components of the laser source and stabilization system.

The frequency stabilization of a laser on an atomic transition 5P to 5D can be implemented by different methods. Here, three main approaches should be singled out, which are based on the use of (1) the electromagnetically induced transparency (EIT) [2] of the first atomic transition (5S to 5P); (2) the fluorescence due to the decay of the second excited state (5D); (3) the absorption of radiation on the second transition (5P to 5D). All the three methods utilize the stepwise excitation scheme 5S to 5P to 5D. In all these cases, on the first transition (5S to 5P) the laser is stabilized by using standard methods based on the saturated absorption transition with implementation of lock-in technique [3] or stabilisation on the slope of the nonlinear absorption resonances [4].

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The experimental scheme of frequency stabilization of a diode laser on the 5P to 5D transition of the Rb atom using the absorption scheme is presented on figure 1. The scheme is based on the two-step spectroscopy of Rb atoms in a field of two counterpropagating laser beams. For its realization, we used two laser systems, a cell with vapors of Rb atoms, photodiodes, and accessory optical elements.

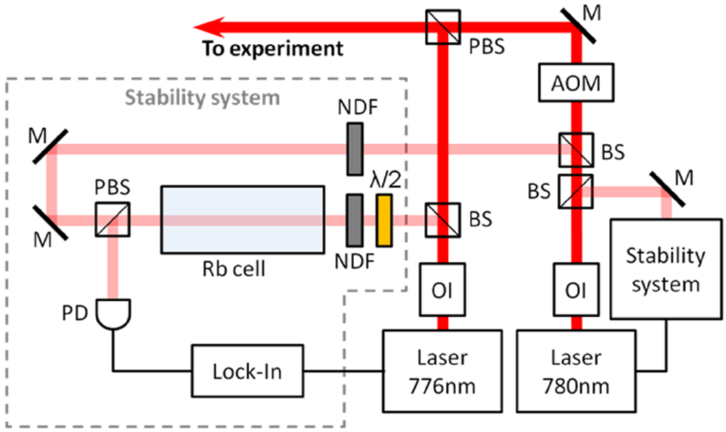

Fig. 1. Schematic of the frequency stabilization system of a diode laser operating on the transition 5P to 5D of Rb atom: (1) filter, (2) λ/2 plate, (3) beam-splitting cube, (4) mirror, (5) photodiode, (6) polarizing cube, (7) cell with Rb vapors, (OI) optical insulator, and acousto-optic modulator (AOM).

The measurements of the laser frequency stability at the wavelength of 776 nm has been realized with atomic beam of Rb in vacuume chamber. Without stabilization, the laser goes out of resonance with the atomic beam in a time of about 5 min (shift about 100 MHz). The stabilized laser retains its frequency for a few hours. The obtained stability of the laser is about 1 MHz, which is comparable with the stabilization accuracy of the laser on the first transition (780 nm).

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