Magneto-optical switch based on high-contrast electromagnetically induced absorption resonance

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The phenomenon of coherent population trapping (CPT), since its discovery in 1976 [1, 2], has found many interesting applications in atom physics. Electromagnetically induced transparency (EIT) is the spectroscopic manifestation of CPT. The width of the EIT resonance can be much less than the natural linewidth, therefore such resonances are often called subnatural-width ones. The narrow transparency window in the absorption signal, resulting from EIT, is also accompanied by steep refractive-index dispersion of the medium. These brilliant properties make EIT attractive for applying in laser physics and spectroscopy, optical communications and quantum metrology (miniature atomic clocks and magnetometers).

Electromagnetically induced absorption (EIA) is the subnatural-width resonance with an opposite sign [3]. First that resonance was observed under a bichromatic laser field, composed of two co-directional mutually coherent waves. Then the effect was also studied with a single-frequency laser wave accompanied by a scanned dc magnetic field applied along the wave vector (magneto-optical or, so-called, Hanle configuration) [4]. Since its discovery, the scope of EIA applications happened to be rather small in comparison with the EIT resonances due to some difficulties. Indeed, many methods suggested for observing EIA could not provide narrow (< 1 kHz) and simultaneously high-contrast (> 20-30 %) subnatural-width resonances.

In papers [5, 6] we have proposed the "unconventional" scheme for observing EIA signals in Hanle configuration. It implies using two counterpropagating light waves with the same frequency and orthogonal linear polarizations ("probe" and "pump" beams). Here we further develop that method for using as a simple magneto-optical switch for laser radiation. The key requirements of the modified method consist in *1)* using an open (non-cyclic) dipole transition, *2)* a vapour cell filled with alkali work atoms and buffer gas or a cell with anti-relaxation coating of the walls, *3)* high concentration of work atoms (e.g. F=1→F'=1 transition in D_1 line of ^{87}Rb with vapour density $\sim 5\times 10^{11}$ cm^{-3}). These conditions can provide the best contrast (close to 100 %) and narrow width (< 1 kHz) of the resonance. The switch works as follows. Absorption of the probe beam is monitored as a function of the dc magnetic field B, applied along the wave vectors. As the conditions are satisfied, the probe-beam transmittance almost equals zero (<0.5 %) in the vicinity of B=0. Otherwise, when $B\neq 0$, the probe transmittance is very close to 100 %. At that, the magnetic field B can be as low as just several mG for effective control of the probe transmittance. This implies a device that can be low-power and compact, high-sensitive and easy to control.

The new scheme for observing magneto-optical EIA signals can be applied also in laser physics, optical communications and magnetometry. This work was partially supported by RFBR (15-02-08377, 15-32-20330, 14-02-00712, 14-02-00939, 14-02-00680, 13-02-00283), Ministry of Education and Science of Russian Federation (gov. order no. 2014/139, project no. 825), Presidium of the Siberian Branch of Russian Academy of Sciences and by Russian Presidential Grants (MK-4680.2014.2 and NSh-4096.2014.2). M. Yu. Basalaev was also supported by the "Dynasty" Foundation.

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