New Method for Observing Ultra-Narrow and High-Contrast Electromagnetically-Induced-Absorption Resonances

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Low-frequency coherent atomic states underlie many interesting nonlinear optical effects. Perhaps, one of the most brilliant representatives is coherent population trapping (CPT). Since the first publications on this theme[1,2] CPT phenomenon has found numerous applications in laser physics, nonlinear optics, optical communications and quantum informatics. CPT has already benefited relevantly in the field of quantum metrology: miniature atomic clocks and magnetometers. These devices are based on the resonance of electromagnetically induced transparency (EIT), which is the spectroscopic manifestation of CPT. In 1997 the resonance of an opposite sign was discovered – electromagnetically induced absorption (EIA)[3]. Firstly EIA was studied under the two codirectional coherent light waves. Then EIA was observed in the magneto-optical (Hanle) scheme[4], which is rather simpler from experimental viewpoint. EIA effect has found much less applications than EIT one. It is difficult to observe simultaneously ultra-narrow and high-contrast EIA signals in comparison with EIT ones. Indeed, the standard methods for shrinking width of EIT resonance imply use of a buffer gas or antirelaxation coating of cell walls. However these methods happened to be useless for standard schemes of observing EIA. Recently Korean colleagues have made some breakthrough in this direction[5]. They used “bright” atomic transition F=2→F’=3 in ^{87}Rb and antirelaxation coating of cell walls. Unfortunately, besides an ordinary longitudinal magnetic field (like for the regular Hanle scheme) they also had to add a transverse magnetic field for acquiring the EIA signal.

We propose the simplest configuration for observing ultra-narrow and high-contrast EIA resonance in the Hanle scheme. The method implies use of two counterpropagating linearly polarized beams with the same frequency, which drive a “dark” atomic transition (in particular, theoretical explanations have been done for a three-level Lambda model). Any additional (transverse) magnetic field is not required. Moreover, the configuration suggested allows one to inject a buffer gas to greatly enhance properties of EIA signal approaching values like in EIT experiments. Also, the method proposed is convenient for fast and effective controlling of the resonance’s sign (EIT↔EIA) just by changing the angle between the linear polarizations.

The work was partially supported by the Russian Foundation for Basic Research (14-02-00806, 14-02-00712, 14-02-00939, 12-02-00403, 12-02-00454), by the Presidential Grants (MK-4680.2014.2 and NSh-4096.2014.2), by the Russian Academy of Sciences and the Presidium of SB RAS, and by the Russian Ministry of Education and Science.

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