Spinorinės lėtos šviesos formavimas šaltose atomų dujose

Spinor slow light formation in cold atomic gas

Viačeslav Kudriašov[1], Julius Ruseckas[1], Gediminas Juzeliūnas[1],
Meng-Jung Lee[2], Chin-Yuan Lee[2], Kao-Fang Chang[2], Hung-Wen Cho[2], Ite A. Yu[2]
[1]Institute of Theoretical Physics and Astronomy, Vilnius University, Saulėtekio 3, Vilnius LT-10257, Lithuania
[2]Department of Physics and Frontier Research Center on Fundamental and Applied Sciences of Matters,
National Tsing Hua University, Hsinchu 30013, Taiwan
viaceslav.kudriasov@ff.vu.lt

Over the last decade there has been significant progress in studying electromagnetically induced transparency (EIT) phenomena, related to slow, stored and stationary light [1]. This research has been strongly stimulated by a number of applications, like low-light-level non-linear optics and quantum information processing. The slow and stationary light greatly enhance the light–matter interaction and enable nonlinear optical processes to achieve significant efficiency even at a single-photon level. The storage of light using the dynamic EIT scheme transfers quantum states between photons and atoms, serving as a photonic quantum memory. EIT-related research has made a great impact on the nonlinear optics and quantum information science.

It was recently proposed a new concept of two-component or spinor slow light (SSL) exhibiting a number of distinct features in the EIT phenomena [2]. Particularly, theoretical investigations demonstrated that the SSL in a double tripod (DT) atom–light coupling scheme can lead to the peculiar phenomena, such as formation of the quasi-particles exhibiting Dirac spectra and oscillations between SSL field components [3]. This study is the first experimental demonstration of spinor slow light [4] which may result in novel applications for quantum information manipulation, precision measurement and nonlinear optics.

The experimental study makes use of the DT transition scheme and was carried out with the laser-cooled ^{87}Rb atoms (Fig. 1). A cigar-shaped cloud of cold ^{87}Rb atoms with the dimension of 9x2x2 mm^3 was produced by a magneto-optical trap (MOT). Typically, the 10^9 atoms with a temperature of about 300 μK was trapped in the MOT. Although the system of cold atoms is not a necessary condition for the SSL formation, utilizing cold atoms helps to minimize losses such as those induced by collisional and transit decoherence processes. In this case, the experimental system is as simple as the theoretical model.

The DT level scheme consists of three atomic ground states |0>, |1> and |2> and two excited states |A> and |B> (Fig. 1a). One probe field and two coupling fields drive the transitions from |0>, |1> and |2> to |A>, respectively, to form the first tripod configuration. Another probe field and the other two coupling fields drive the transitions from the same ground states to |B> to form the second tripod configuration (Fig. 1b). This DT is a combination of two single-tripod schemes, but its physics is more abundant due to the interaction between the two components of light coupled with two atomic coherences. The DT setup was arranged in the co-propagation configuration where all fields propagate in the same direction and overlap completely (Fig. 1c).

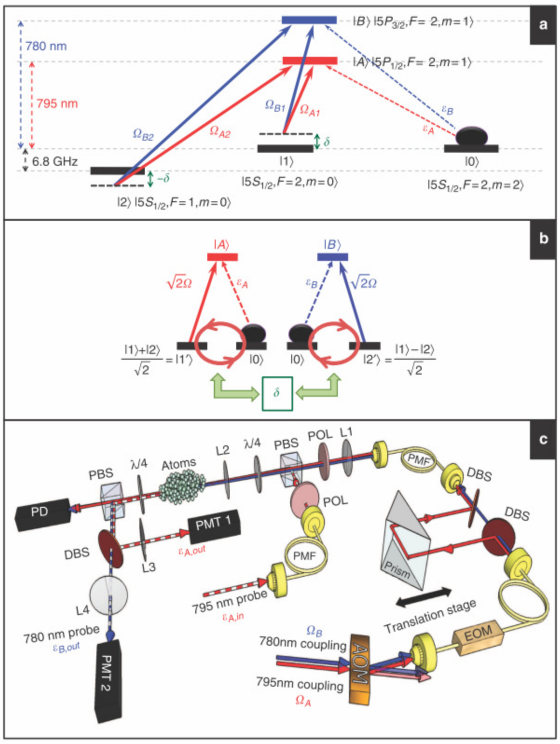

Fig. 1. The light-atom coupling diagrams (a,b) and SSL experimental setup (c).

Keywords: slow light, double tripod, atomic cloud, rubidium gas, nonlinear optics.

Literature

[1] M. Fleischhauer et al., Rev. Mod. Phys. **77**, 633–673 (2005).
[2] R.G. Unanyan et al., Phys. Rev. Lett. **105**, 173603 (2010).
[3] J. Ruseckas et al., Phys. Rev. A **83**, 063811 (2011).
[4] M.-J. Lee et al., Nature Commun. **5**, 5542 (2014).