Ayan Ray et al., J Phys Chem Biophys 2014, 4:5
http://dx.doi.org/10.4172/2161-0398.S1.006

OMICS Group Conferences
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2nd International Conference and Exhibition on
Lasers, Optics & Photonics
September 08-10, 2014 Hilton Philadelphia Airport, USA

Control of coherence in a Ξ system and its utility in optical switching

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Implementation of the idea of coherence control in a multilevel atom-photon interaction has remained as a key topic of research and proves to be helpful in many frontline applications including optical switching. The possible methods of control of coherence may include selective transfer of population, interaction of multiple dark states etc. We demonstrated such kind of control in case of a Ξ system comprising of $5S_{1/2}(F) \rightarrow 5P_{3/2}(F/) \rightarrow 5D_{5/2}(F//)$ levels of ^{87}Rb atom. This particular level scheme is important in view of its wide application in metrology, frequency conversion, atomic line filter ($5D_{3/2}$ in this case) etc. However with recent progress in research, it has been found that Electromagnetically Induced Transparency (EIT) in a Ξ system is associated with background of double resonance optical pumping (DROP) for cyclic probe transition (e.g. F=2→F/=3). As strong EIT condition requires population confinement within the concerned Ξ level coupling, the DROP itself originates from loss of population to F=1 state. This counter-intuitive requirement sets the backdrop of our present work. We introduced a third laser (named Repump after convention used in Laser Cooling experiment) connecting F=1→F/=2 for controlling the coherence in the medium. Depending on the direction of propagation of Repump (counter or co) w.r.t probe laser, the existing Λ (probe-repump) system either exhibits (i) velocity selective Raman type population transfer or (ii) a narrow (subnatural) EIT. For the first case we have shown that the repumping process may be made more selective if it is taken to degenerate zeeman sub-level basis (σ+ polarized) compared to hyperfine level repumping (linearly polarized). This study is further supported by monitoring of blue fluorescence (~420 nm) in the $\{5S_{1/2}(F) \rightarrow 6P_{3/2}(F^{///})\} \rightarrow 5D_{5/2}(F^{//})$ decay channel. It shows the relative population history at 5D5/2(F//) under various conditions; which directly shows enhancement of two photon interaction under re-pump process. However the figure of merit for coherence control is measured via. Line width of EIT (ΓEIT) and relative line strength vs. re-pump intensity. It shows that the σ+ Repump is most efficient in strengthening EIT with a vis. a vis. preservation of the sub-natural character of ΓEIT. This setup is implemented in case of a slow-fast dual mode optically switchable DROP-EIT rich medium and it is found that indeed the repump process helps in attaining better modulation depth by efficiently retrieving the 'Radiation Trapped' atoms from F=1 state. As a matter of fact we had also shown the beneficial aspect of repumping process in case of an ALF. Considering the second (ii) kind of coherence control method, which involves interaction of nearly degenerate Dark states, is an ongoing study and we are yet to arrive at a definite conclusion over its prospective beneficial role.

Biography

Ayan Ray has completed his PhD at the age of 30 years (2005) from University of Calcutta. He spent a brief stay at Optics Group, University of Melbourne and Laser Physics Application Spection, Raja Ramanna Centre for Advanced Technology (RRCAT) to pursue Postdoctoral studies (2005-06). Later on he moved to Atomic Physics and Quantum Optics Section, Bhabha Atomic Research Centre (2006-10). Currently he is working in Radioactive Ion Beam Facility Group, Variable Energy Cyclotron Centre (2010 onwards).

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