Rydberg EIT Resonances in Atomic Vapor for Sensor Applications

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Rydberg states of atoms are of interest due to their high electric susceptibility and potential applications for electric field sensors. A common optical detection of Rydberg atoms uses a two photon Electromagnetically induced transparency (EIT) transmission peak as frequency marker, and is achieved by two counter-propagating optical fields at 780 and 480 nm. Its sensitivity for atomic vapor is limited by the residual Doppler broadening. We theoretically investigate a possibility to boost the sensor response by reducing the resonance width using a temporal and especially spatial Ramsey interrogation. Two temporally or spatially separated EIT channels create a Ramsey sequence where atomic Rydberg coherence is prepared in the first region, evolves with no applied optical fields in a ”dark region” between the two channels, and then is probed in the second channel. We show that the linewidth of such a Raman-Ramsey fringe can be theoretically reduces to 50 kHz with room temperature Rydberg atoms. This theoretical work suggests an approach to have a narrow EIT feature with reduced power broadening which could be potentially beneficial for increased sensitivity in EIT-based Rydberg electrometers. We also discuss possible applications of such E-field sensitive technique in plasma and nuclear physics.