Nonlinear quantum optics for spinor slow light

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Atoms excited to high-lying Rydberg states with a principal quantum number above 50 have recently attracted a significant attention [1]. The strong interaction between the Rydberg atoms allows one to investigate non-linear quantum optics at the level of individual quanta. This is achieved by coherently coupling slowly propagating photons to strongly interacting atomic Rydberg states under the conditions of the electromagnetically induced transparency (EIT) [2]. In an usual Rydber EIT, a ladder atom-light coupling configuration is typically emplyed involving an atomic ground state, an intermediate excited state and a Rydberg state. Here we propose to use for Rydberg EIT a more complicated double tripod level scheme [3], shown in Fig. 1. In the double tripod scheme two probe laser fields are propagating inside tha atomic medium leading to a two component (spinor) slow light. In the case of non-interacting atoms the propagation of the two-component slow light has been recently demonstrated experimentally [4]. In comparison to previously used schemes for quantum nonlinear optics with Rydberg states, the double tripod scheme can combine spin-orbit coupling for the spinor slow light with an interaction between photons. This enables the generation of the second probe beam even when two-photon detuning is zero. In a ladder atom-light coupling configuration the interaction is always attractive independent from the detuning [5]. In contrast, in the proposed scheme the interaction can become repulsive if the one-photon detunings have opposite signs.

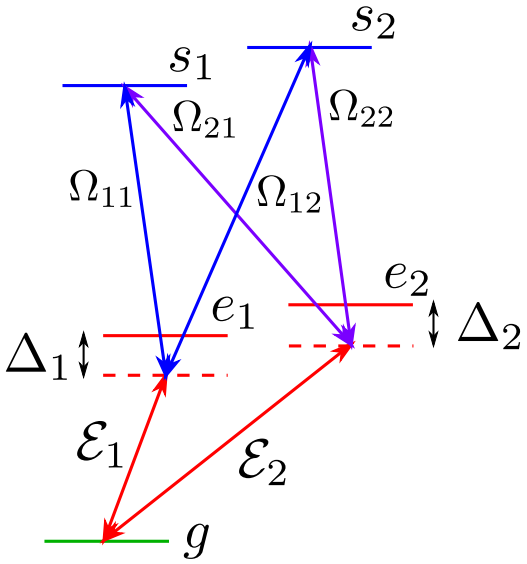

Figure 1: Double tripod atom-light coupling scheme involving the Rydberg levels s_1 and s_2

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