Control of nonlinear processes in two-photon excited Rb vapours by resonant light

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Frequency up- and down-conversion in warm alkali vapours at modest intensity of the applied cw laser light has received a lot of attention in recent years due to numerous promising applications, including quantum memory and remote detection. The generation of directional laser-like blue and infrared light in alkali vapours has been extensively studied [1, 2, 3]. However, important details of interplay of parametric and nonparametric nonlinear processes, such as four-wave mixing (FWM) and amplified spontaneous emission (ASE) responsible for the new field generation, are not entirely clear. Our experiments in warm Rb vapours are aimed at finding conditions for the generation of correlated optical fields and methods for their control. Two-photon excitation of Rb atoms to the $5D_{3/2}$ level as well as the more common excitation to the $5D_{5/2}$ level provides an interesting possibility of studying the processes involved under different conditions.

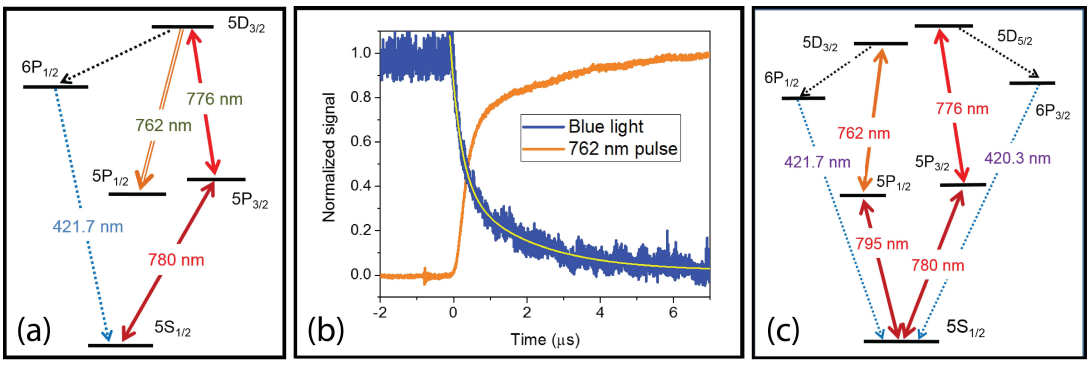

Figure 1. **(a)** Relevant energy levels of Rb atoms. **(b)** Directional blue light switching by the laser pulse at 762 nm. **(c)** Scheme of simultaneous excitation to the $5D_{3/2}$ and $5D_{5/2}$ levels.

In particular, we find that both FWM and ASE processes can be effectively controlled by additional resonant laser fields. For example, resonant laser light on the $5P_{1/2} \leftrightarrow 5D_{3/2}$ transition predominantly stimulates transitions from the more populated $5D_{3/2}$ level to the less populated $5P_{1/2}$ level reducing the population inversion on the $5D_{3/2} \rightarrow 6P_{1/2}$ transition (Fig. 1a). As a result, the generation of both directional mid-IR 5.03 μm light and blue 421.7 nm light can be completely suppressed. The measured switching time of approximately 270 ns is limited by the time constant of the applied "terminating" pulse at 762 nm, as demonstrated in Fig. 1b.

We also show that Rb vapours simultaneously excited to the $5D_{3/2}$ and $5D_{5/2}$ levels via the

$5P_{1/2}$ and $5P_{3/2}$ intermediate levels produce, as Fig. 1c demonstrates, two directional blue light fields at 421.7 and 420.3 nm, respectively, with mutually enhanced intensities. If two-photon excitation via both the $5P_{1/2}$ and $5P_{3/2}$ levels ends on the $5D_{3/2}$ level, the generated blue and mid-IR radiation are also mutually enhanced. In this case, the existence of multiple pathways for nonlinear mixing should result in strong correlation between the generated fields.

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