Interfacing atoms and light coupled to excited transitions in warm rubidium vapors

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Atomic transitions between excited states in alkali atoms attract more and more attention, due to their numerous applications, including photon pair generation [1], also at telecommunication wavelengths [2], as well as control of Rydberg states [3].

Among others, an important configuration of atomic levels is the diamond configuration, depicted in Fig. 1(a).

In our experiment we apply three driving laser fields, at 780 nm, 795 nm and 776 nm, and observe the signal at 762 nm as a function of driving lasers' detunings.

Experiments are feasible both in warm atomic vapors and cold ensembles. In case of warm atoms, Doppler broadening plays a significant role. In case of the co-popagating configuration of laser beams [Fig. 1(a)], the two-photon transition to $5D_{3/2}$ level is Doppler-broadened. Consequently, the spectrum of signal generation will be broadened.

Generally, the solution to this problem is the counter-propagating configuration [Fig. 1(c)]. However, in our case the phase matching condition does not allow perfect counter-propagation of driving beams. Instead, the angle between 780 nm and 776 nm is 10 degrees, as can be seen of the figure. A consequence is the additional, transverse Doppler broadening.

We have measured the four-wave mixing in both configurations and constructed the theory that enables us to predict the power of generated signal. Our theoretical approach takes into account the Doppler broadening, light polarization and hyperfine structure. Consequently, we can predict the signal power both in case of warm atoms and cold ensembles.

In the co-propagating configuration we obtain a fully analytical solution. The counter-propagating configuration requires integration over two velocity components. In this case, numerical integration is necessary.

Figure 2 presents experimental (a) and theoretical (b) results in the co-propagating configuration for a single four-wave mixing resonance. Cross sections (c) and (d) display excellent agreement of our theory and experiment.

More details can be found in a recent paper [4].

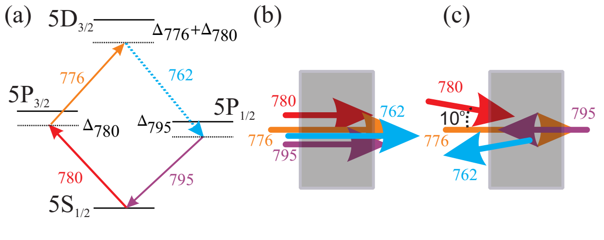

FIG. 1. Experimental configuration: (a) Levels and transitions used in the experiment, (b) co-propagating configuration, (c) counter-propagating configuration.

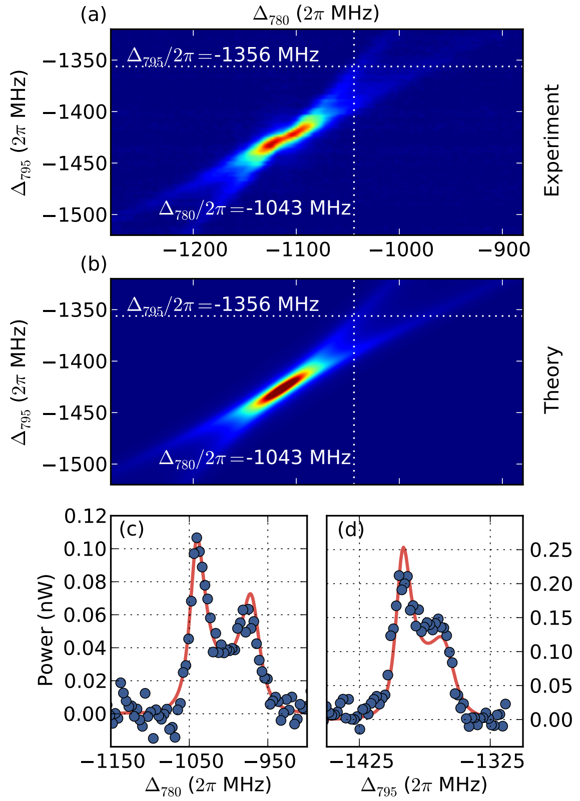

FIG. 2. Experimental (a) and theoretical (b) results for the power of generated signal at 762 nm as a function of driving laser detunings Δ_{780} and Δ_{795} in the co-propagating beam configuration. Plots (c) and (d) are the cross sections of the maps with experimental data (dots) and theoretical prediction (solid line).

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