Coherent effects in a cold atomic gas

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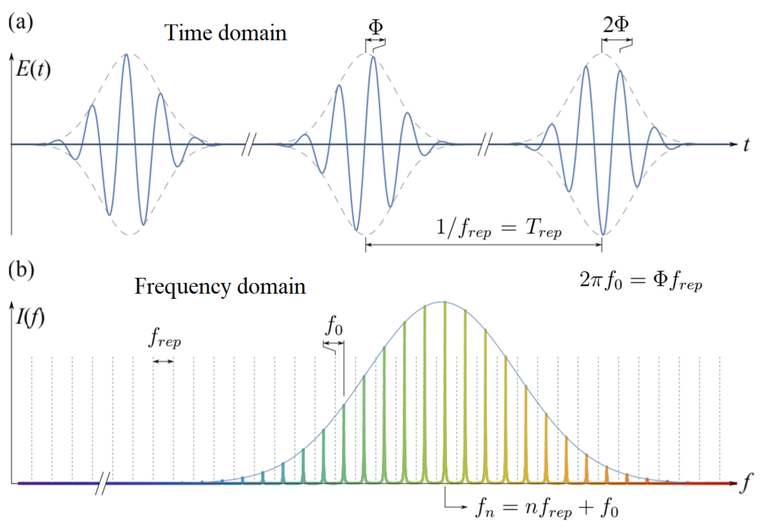
Motivation

Electromagnetically induced transparency (EIT) is a phenomenon where the optical properties of a medium are modified in a way it becomes transparent. It's closely related to similar phenomena such as slow light and light (information) storage. These effects have already been investigated using two continuous-wave (cw) lasers [1].

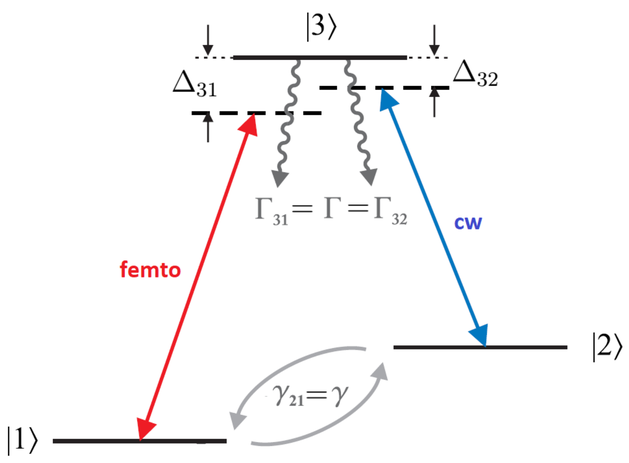
In this experiment we use one mode of a frequency comb instead of one of the cw lasers.



Using the FC could allow multi-channel, broadband EIT experiments.

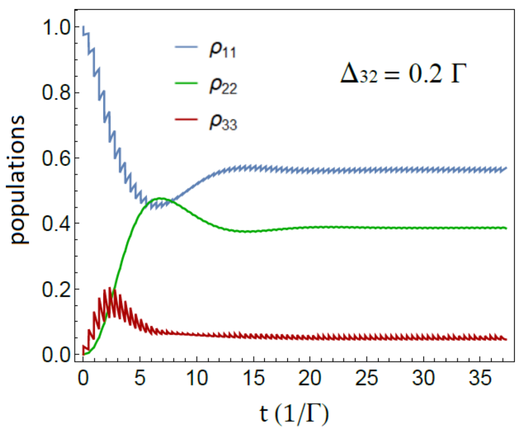
The ultimate goal is to use only an FC as a laser source, removing the need for multiple lasers for multi-channel EIT research.

Theory and numerical results

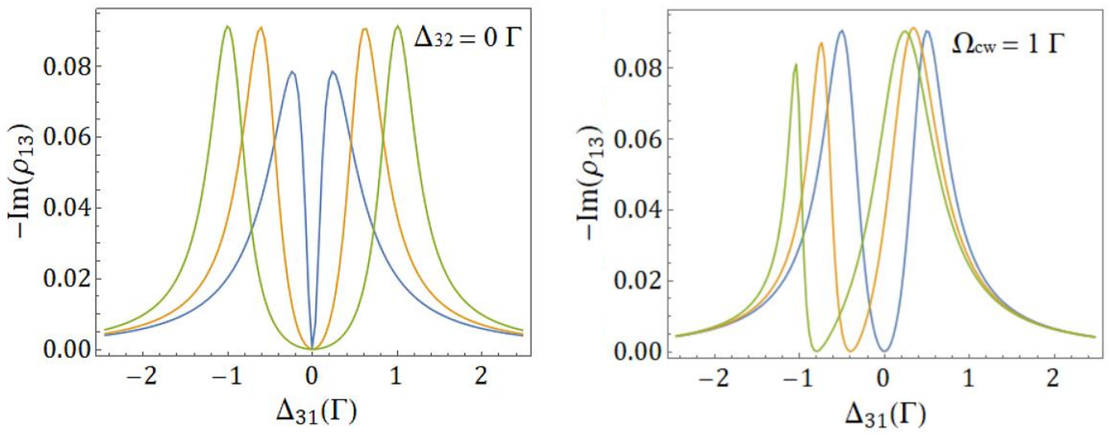


Lambda system interacting with one mode of a frequency comb and a cw laser.

System dynamics is acquired by solving the optical Bloch equations where a system is described by a density matrix.



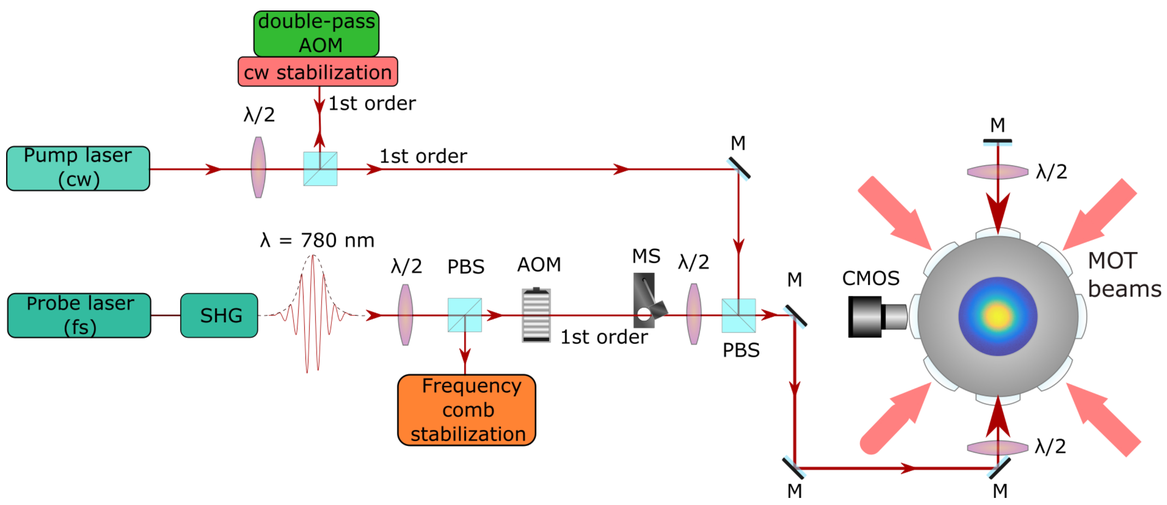
Zig-zag behavior is determined by short periods of interaction with a pulse. Between the pulses, relaxation and interaction with the cw laser are taken into account [2].



Imaginary parts of the off-diagonal terms of the density matrix correspond to the absorption coefficient.

Typical behavior of EIT – a narrow transparency window in the absorption depending on detuning and power of a laser.

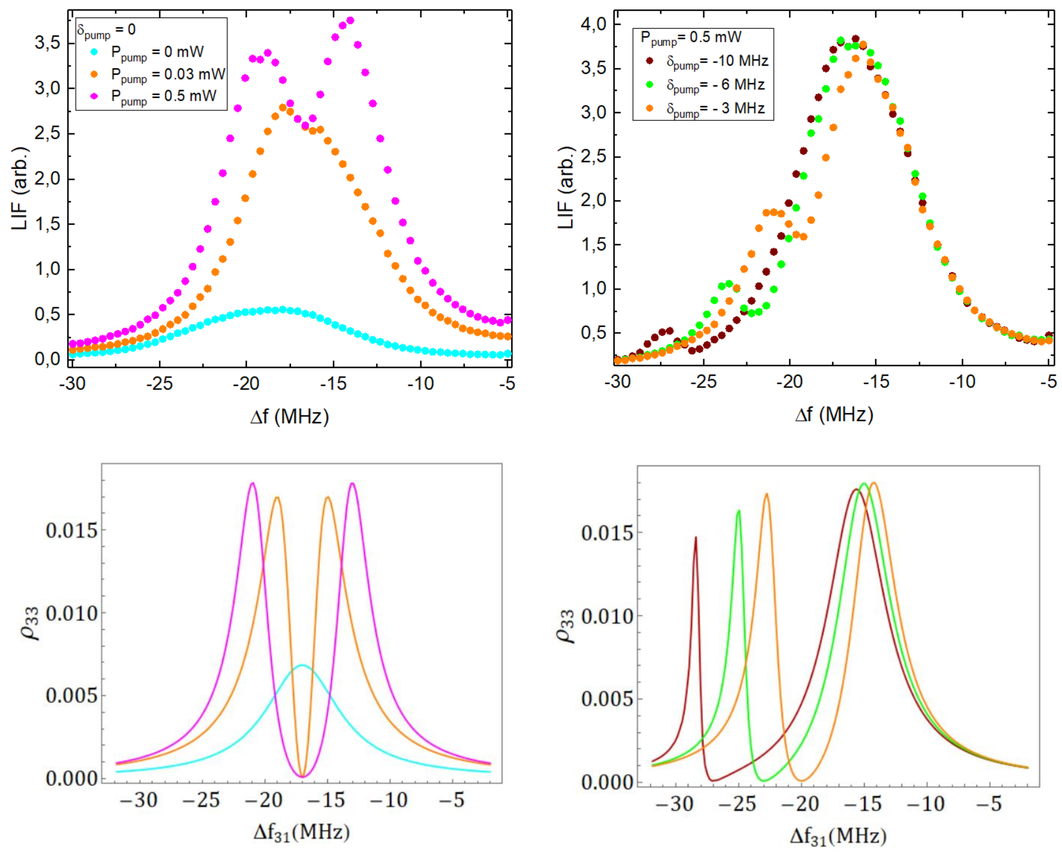
Setup



A cloud of ^{87}Rb atoms was used, cooled in a magneto-optical trap (MOT). Frequencies of the pump and probe lasers were stabilized.

Experimental results

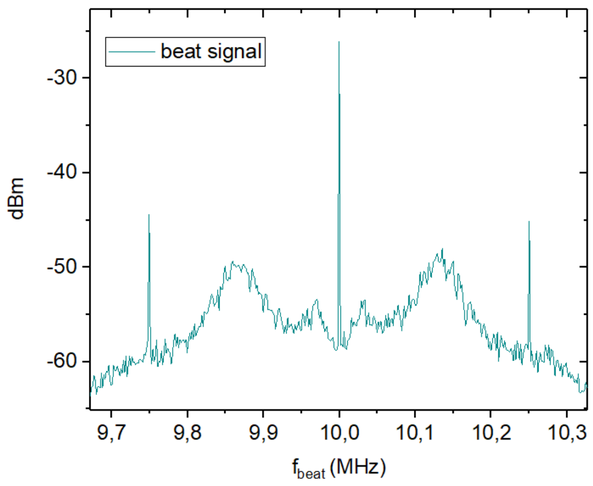
Data was acquired by measuring laser induced fluorescence (LIF) and the radiation force on the cold rubidium cloud.



Conclusion

We modelled a lambda system interacting with a frequency comb and a cw laser. Numerical results were compared with experimental data. Predicted behavior is in good agreement and coherent effects are visible. However, the measured transparency dip of EIT is less than predicted because the cw laser and the FC were not phase locked, i.e. their relative phase was not fixed.

Overlook



We will continue with the research with more detail. One mode of the frequency comb and the cw laser are now phase locked.

Finally, we aim to use only a frequency comb as a laser source for the experiment.

References: [1] M. Fleischhauer, A. Imamoglu, and J.P. Marangos, Rev. Mod. Phys. 77, 633(2005) [2] Felinto et al., Optics Communication 215, 1-3(2003)