# Effect of temporal delay in formation of coherent population trapping resonance in $^{87}$Rb under dynamic excitation

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The present work reports the results of studies of a new effect, which manifests itself as a temporal delay of electromagnetically induced transparency on the atomic $D_1$ line of rubidium under dynamic excitation of its Λ-system of levels by bi-chromatic pump field. It was found out that as the system excitation frequency rises, the maximum of the coherent population trapping (CPT) resonance is reached at progressively later phase of the periodic signal controlling the system excitation.

CPT resonance in this three-level system was created by scanning the frequency difference of the bi-chromatic pump field around the ground-state hyperfine-splitting frequency (6.834 GHz) of $^{87}$Rb. At relatively slow scan rates (~1 Hz) of the frequency difference, the maximum of the CPT resonance was met at the moment when the frequency difference of the bi-chromatic pumping field became equal to the value of the ground-state hyperfine-splitting frequency. At higher scan rates (>100 Hz), the CPT resonance maximum occurred at a later moment.

We studied this effect of CPT resonance formation in rubidium cells of two different types: one with buffer gas and the other with anti-relaxation wall coating. To quantify the effect, we measured the phase delay, or phase incursion of the periodical signal controlling the frequency difference of the bi-chromatic pumping field, at which the CPT resonance maximum occurred. Fig. 1 demonstrates both experimental and theoretical dependencies of the phase delay upon the scan frequency of the frequency difference of the bi-chromatic pump field. There is a clear correlation between the theoretical and experimental curves, which both reach saturation at comparatively high scan frequencies.

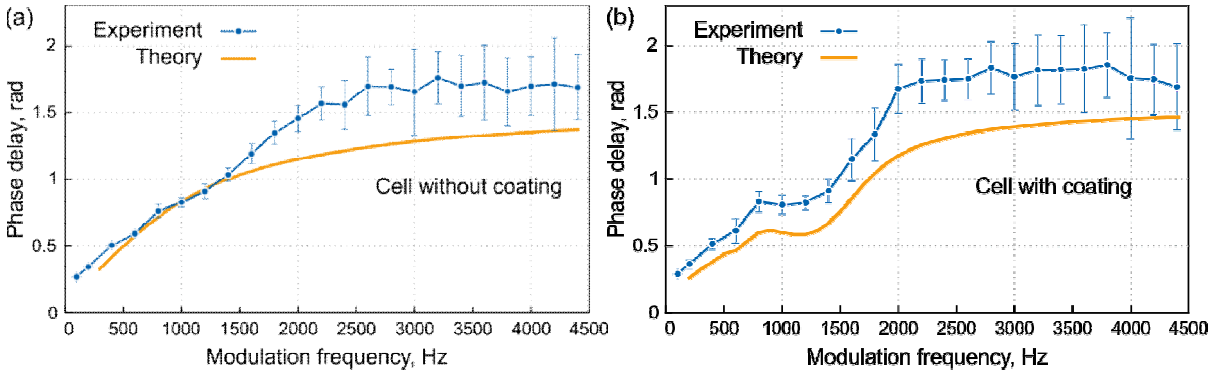


**Fig. 1** Dependence of the phase delay upon the scan frequency of the frequency difference of the bi-chromatic pumping field: a) optical cell with buffer gas, b) optical cell with anti-relaxation coating of the inside wall surface.

The present work provides details of the conducted experiments and modelling methods, discusses the influence of the discovered effect on stability of atomic clocks relying on dynamically excited CPT resonances.

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