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## High-temporal-resolution studies of resonant optical response in atomic vapor nanocells

Resonant interaction of a narrow-linewidth continuous-wave (cw) laser radiation with atomic vapor (notably, alkali metal vapor) is intensely studied in the past decades, driven by fundamental interest and important emerging applications. Most of these studies deal with a steady-state regime of interaction of atomic ensemble with resonant light required for establishment of the relevant processes. The steady-state regime implies an onset of a dynamic balance between elementary processes (e.g. absorption and emission), which leads to the invariance of the average level of an atomic signal in time under invariable excitation conditions. But a question remains: is the stationary signal time-independent in a short time scale? The dynamic contribution of elementary processes (Rabi cycle) can be revealed in measurements with high temporal resolution.

As is known since three decades, intrinsic stochastic phase fluctuations in cw laser (notably, diode laser) field, which determine the finite linewidth of the laser radiation, are converted to amplitude modulation during the resonant interaction with atomic systems. The theory of phase-to-amplitude noise conversion predicts two distinct temporal components of the atom's response: an adiabatic component and a nonadiabatic component manifesting itself as population variations oscillating at the Rabi frequency. Signature of optical Rabi oscillations in the transmission spectrum of Rb vapor exposed to cw laser radiation with fixed resonant frequency has been recently observed experimentally using an ordinary cm-long vapor cell. Irregular appearance of fast oscillations in this work was ascribed mostly to the lack of synchronization of contributions from numerous individual atoms involved in resonant interaction.

This problem can solved by using optical vapor nanocells, where the number of contributing atoms in the interaction region is orders of magnitude less, and, besides, the Doppler broadening is strongly suppressed. Experimental studies with implementation of fast detection and signal processing (e.g. FFT) techniques must be combined with comprehensive theoretical analysis and modeling of the problem. Besides phase-to-amplitude laser noise conversion in atomic media, the model should take into account specific peculiarities of interaction of the laser radiation with atoms in a nanocell, such as spatial anisotropy of the response that can limit interaction time.

From the practical point of view, the expected results can be used for characterization of both the laser field (particularly, determination of spectral linewidth and spatial distribution of intensity across the beam) and atomic vapor cells (the shape and width of the FFT spectrum profile carries information about the real optical length of the cell, the real vapor density, the presence of buffer gas or dielectric coating, etc.). The obtained results can be possibly useful also for quantum information technologies and sensing applications.

**Additional information:** Theoretical part of the study will take place at ICB-UBFC-France but the candidate will have to participate to the experiments that will take place at the Institute for Physical Research at Ashtarak, National Academy of Sciences of Armenia.
At least one round trip France-Armenia per year is therefore expected.

**Academic training requested:** Master of Physics

**Keywords:** quantum physics, atomic physics, atomic spectroscopy, laser experimentation, interaction alkali vapors with magnetic field.