Atomic spectroscopy: From tunable atom-surface interaction to probing large optical depth medium

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The talk will be dedicated to laser spectroscopy of a Caesium atoms thermal vapour using two unusual configurations:

-The first configuration explores atoms in close vicinity of a nanostructured metallic meta-surface. We will show that the hyperfine sub-Doppler spectrum of the $6^2S_{1/2} - 6^2P_{3/2}$ resonance transition at 852 nm is strongly affected by the coupling to the plasmonic resonance of the nanostructure, and show a Fano-like spectral lineshape [1],[2], see Fig. 1(a-k). Fine tuning of dispersion and positions of the atomic lines in the near-field of plasmonic metamaterials can be used to tune the atom-surface Casimir-Polder interaction [3] .

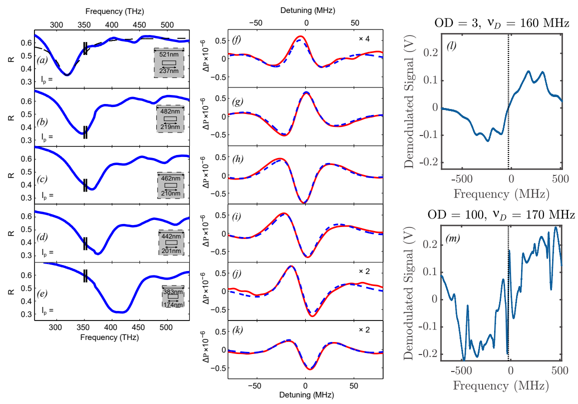

Figure 1: Reflection spectra of plasmonic metamaterial/caesium atom vapour hybrid samples. (a)-(e) Broad frequency scan showing the plasmonic resonance lineshape for different metamaterial. The resonance position is indicated on each graph. Insets show sketches of the individual slits of the metamaterial array. Double vertical lines indicate the position of the D_2 line on the plasmon resonance reflectivity dip profile. On (a), the black dashed curve represents a fit of the reflection curve. (f)-(j) Details of the spectra at the caesium D_2 line. Each graph is associated to its left inside counterpart. The red curves correspond to the experimental data whereas the blue dashed curves are fits of the relative reflectance ΔR. The frequency origin corresponds to the resonance of the hyperfine transition $F = 4$ to $F = 5$ of the caesium D_2 line. (k) relative reflectance ΔR of a dielectric window subtract, *i.e.* without metamaterial. (l) FM-spectrum with a small optical depth (OD). The main contribution come from the vapour Doppler broadening. (m) FM-spectrum with large OD. We observe clear sub Doppler feature. In panels (l-m), μ_D is the frequency Doppler broadening.

-In the second configuration, we explore large modulation index frequency modulation (FM) spectroscopy applied on a large optical depth atomic medium. FM-spectroscopy is a common method to measure weak signals of radiative ensembles with moderate modulation index. When the optical depth of the medium is large, the signal drops exponentially and the technique becomes ineffective. In this situation, we show that a signal can be recovered when a larger modulation index is applied [4]. Noticeably, this signal can be dominated by the natural linewidth of the resonance, regardless of the presence of inhomogeneous line broadening, see Fig. 1(l-m). This work opens the door towards measurement of cooperative emission effects in bulk atomic ensemble.

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