Numerical calculations on selective reflection lineshapes for rydberg states

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We perform numerical calculations on selective reflection lineshapes for rydberg states. These states have a significantly stronger Casimir-Polder interaction with the cell wall, due to the increased dipole moments of transitions to nearby states. Due to this previous approaches to approximate the velocity distribution of the atoms as a flat function [1] do not give sufficient results anymore. We therefore implemented a numerical calculation including the full Maxwell-Boltzmann distribution. Using this we calculate lineshapes for both macroscopic as well as thin cells and fit them to experimental results. Furthermore we study effects of higher order multipole contributions to the Casimir-Polder interaction [2].

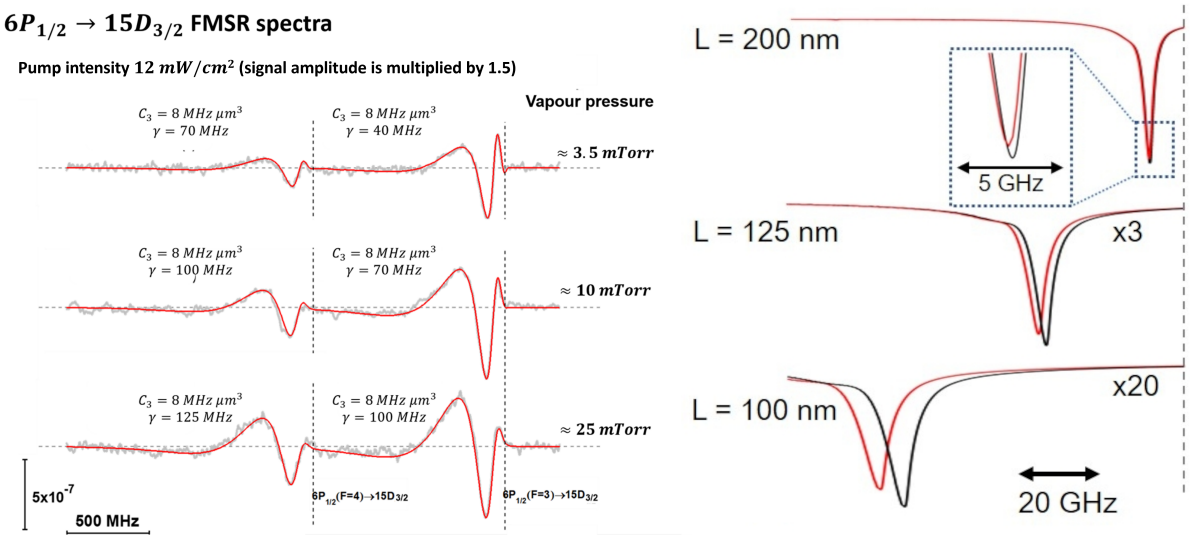

Figure 1. Left: Fit of experimental spectra in a macroscopic cell with our theoretical lineshapes.
Right: Theoretical thin-cell spectra for different thicknesses limited to the dipole-dipole interaction (black) and including quadrupole-quadrupole interactions (red).

[1] M. Ducloy., & M. Fichet (1991). General theory of frequency modulated selective reflection. Influence of atom surface interactions. Journal de Physique II, 1(12), 1429-1446.
[2] B. Dutta, J. D. A. Carvalho, G. Garcia-Arellano, P. Pedri, A. Laliotis, C. Boldt, J. Kaushal, & S. Scheel (2024). Effects of higher-order Casimir-Polder interactions on Rydberg atom spectroscopy. Physical Review Research, 6(2), L022035.