Spectroscopic probing of Rydberg-surface interactions in vapour cells

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Thin vapor cells [1] have been used as platforms to probe Rydberg atoms with possible applications in quantum technologies. This interfaces Rydbergs with solid surfaces and highlights the need for a deeper understanding of Rydberg-surface interactions. Experiments were first performed with low-lying Rydberg states (n= 10-14), demonstrating the van der Waals law of interaction [2]. Nevertheless, more recent experiments with high-lying rubidium Rydbergs (n= 32-43) [1] were not in agreement with Casimir-Polder theory, sparking closer theoretical studies of Rydberg-surface interactions. In particular, quadrupole interactions that become important when the size of the atom compares to typical atom-surface distances [3] have not yet been experimentally investigated. Here we present preliminary selective reflection measurements on a cesium vapor cell that aim at measuring the interaction between Cs($15D_{3/2}$) atoms and a sapphire surface. The cesium atoms are first excited by a strong pump laser to the first cesium resonance ($6P_{1/2}$) and subsequently selective reflection is performed on the $6P_{1/2} \rightarrow 15D_{3/2}$ transition at $\lambda = 512nm$. The set-up is similar to the one described in [4]. In Fig.1 we show a selective reflection spectrum on the $6P_{1/2} \rightarrow 15D_{3/2}$ transition, along with the best theoretical fit assuming an interaction energy of -C_3/z^3 (C_3 is the van der Waals coefficient and z^3 the atom-surface distance). The measured C_3 coefficient is $\sim$ 6.5 MHz.μm^3 in agreement with the theoretical prediction $\sim$ 5 MHz.μm^3. We are currently improving our theoretical model whose approximations are not necessarily valid in the case of strong interactions. Additionally, we envisage probing higher-lying Rydberg states to test the limits of the dipole approximation [4].

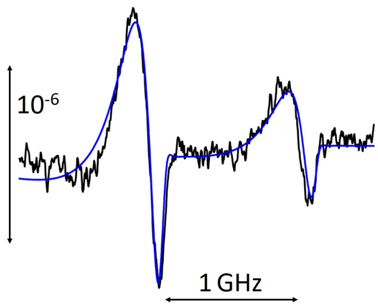

Figure 1. Frequency modulated selective reflection (black line), with the best theoretical fit (blue line) on the cesium $6P_{1/2} \rightarrow 15D_{3/2}$ line. The collisional broadening is $\Gamma = 140$ MHz.

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