Spectroscopy and hyperfine clock frequency shift measurements in Cs vapor cells coated with octadecyltrichlorosilanes (OTS).

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The detection of long-lived spin polarized alkali atoms in vapor cells is of critical importance for the development of high-performance atomic clocks or magnetometers. Two main techniques are used to slow down the fast wall-induced depolarization of atoms. The first method is to dilute the alkali vapor with a pressure of buffer gas. In this so-called Dicke regime [1], slight collisions between buffer gas and alkali atoms increase the time for alkali atoms to collide against the cell walls and allow consequently to reduce the linewidth of the detected resonance. Drawbacks of the presence of buffer gas are to induce shift and broadening of the optical resonances and a collisional frequency shift of the clock transition. The second method consists in coating the glass walls with an anti-relaxation material. In this case, atoms experience multiple bounds against the cell walls before destruction of the population or coherence. Parafin and alkene-based coatings are known to exhibit excellent anti-relaxation properties with the demonstration of 10^4 to 10^6 bounces [2,3]. Most of the time, these coatings are used in magnetometry or quantum information experiments where Zeeman population or coherences are observed. Thus, understanding what the wall-coating mechanism actually relaxing the microwave clock coherence, how it operates and what the best material to use is, is far to be fully clear. Additionally, their drawback is their low temperature melting point preventing them to be used in chip scale atomic devices. At the opposite, octadecyltrichlorosliane (OTS) layers, thermally stable up to 170°C in presence of Rb vapor, are interesting candidates for miniature devices [4].

We report here the realization and characterization using coherent population trapping spectroscopy of a centimeter-scaled Cs vapor cell coated with octadecyltrichlorosilane (OTS). The dual structure of the resonance lineshape, with presence of a narrow structure at the top of a Doppler-broadened structure, is observed. We performed measurements of clock resonance linewidths and clock frequency shifts. The results show that cesium atoms collide about 12 times with the cell walls before relaxation of the CPT coherence. The adsorption energy, that relates to the kinetic energy an atom must have to escape the surface attraction, is measured to be 0.42 eV (+/- 0.03 eV), in good agreement with results reported in [2]. The zero-intensity CPT resonance linewidth in the Cs-OTS cell is measured to be a factor 2.4 higer than in a buffer-gas filled cell of similar dimensions. The Zeeman population lifetime T_1 is measured to be about 1.6 ms using the Franzen technique while the lifetime T_2 of the microwave coherence is about 500 us. Ramsey spectroscopy is also performed on this cell. Potential applications of OTS coatings to the development of a vapor cell atomic clock is discussed.

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