Velocity preserving energy transfer mechanisms between highly-excited atoms in vapor cells

J.C. de Aquino Carvalho[1], I. Maurin[1], H. Failache[2], D. Bloch[1] and A. Laliotis[1]

[1]Laboratoire de Physique des Lasers, CNRS, UMR 7538, Université Sorbone Paris Nord, F-93430, Villetaneuse, France

[2] Instituto de Fisica, Facultad de Ingeniera, Universidad de la Republica, Montevideo, Uruguay

Interatomic collisions, interaction with black body radiation (BBR) and de-excitation by spontaneous emission are possible mechanisms of energy transfer between excited state atoms. Collisional transfer has been studied for low-lying alkali states, like the 6P levels of cesium [1]. It was shown that resonant exchange collisions thermalize the initial, velocity selected excitation, within the 6P hyperfine manifold. The interaction of atoms with BBR has been mainly studied with Rydberg atoms that present couplings with energies comparable to the thermal energy even at room temperatures [2]. Here, we discuss BBR and collision redistribution mechanisms, from cesium 7P levels [3], in the volume of a sapphire cell. The main body of the cell can be heated to high temperatures, up to 1000 K, while the cesium density is almost independently regulated via the cesium reservoir temperature. The high-lying 7P levels are coupled with numerous neighboring states, in contrast to the low-lying 6P states [1]. In our experiments we use a c.w pump laser (459nm or 455nm), exciting atoms to the $7P_{1/2}$ or the $7P_{3/2}$ level respectively [3] (Fig.1). The laser selects the atomic velocity along the beam propagation axis. At low cesium densities we study velocity preserving BBR transfer to the 6D states by probing the 6D $\rightarrow$ 7F transitions (Fig.1). Our studies extend to temperatures up to 1000 K. We also study collisional redistribution within the fine and hyperfine 7P manifolds by probing the $7P_{1/2} \rightarrow 10S_{1/2}$ transition at 1530nm (Fig.1). Our experiments allow measurements of the velocity distribution of the excited state population. We observe the existence of fine and hyperfine structure changing collisions that preserve the velocity selection, involving two excited atoms. We also discuss the possibility of high resolution spectroscopy on nG states using this experimental set-up.

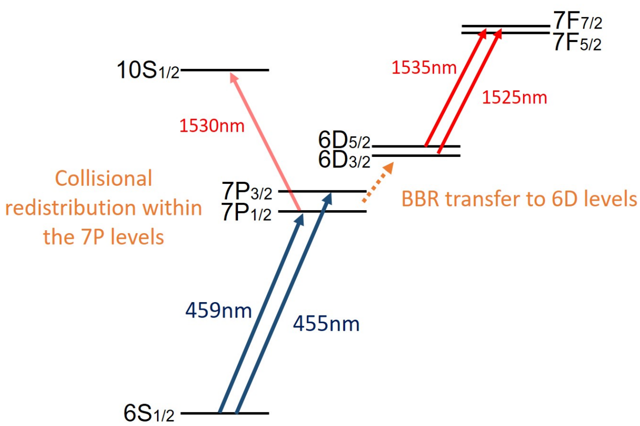

Fig. 1 Relevant cesium energy levels.

[1] J. Huennekens et al. Phys. Rev. A, 51, 4472, (1995)
[2] T. F. Gallagher and W. E. Cooke, Phys. Rev. Lett., 42, 835, (1979).
[3]J. C. de Aquino Carvalho et al., J. Phys. B, /article/10.1088/1361-6455/abd532 (2020).