# Experimental set-up for study of collisions of cold mercury atoms for optical frequency clocks

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We present an experimental set-up of two species mercury-rubidium magneto-optical trap (MOT). The preliminary studies of interactions in mercury MOT and mercury-rubidium MOT are presented. The particular attention is given to the measurements of the scattering properties in various isotopes of the mercury atoms, such as thermalization rates, which provide information about the interaction potential, essential to predict the collisional shift of the mercury $^1S_0$-$^3P_0$ clock transition[1]. The information about the interaction potential can also be obtained from loading curves of the MOT and from a photoassociation spectroscopy close to the $^1S_0$-$^3P_1$ trapping transition.

In bosons with the $s^2$ configuration the clock transition $^1S_0$-$^3P_0$ is strictly forbidden. The commonly used method to overcome this problem is to induce a coupling with $^3P_0$ state which is optically accessible. In the mercury-rubidium MOT, the presence of cold Rb atoms can be used to broaden the $^1S_0$-$^3P_0$ clock transition in mercury. It was recently demonstrated[2] in an analogical SrRb system that the molecular states supported by the clock transition are dipole allowed at short range. Therefore, also the shifts and widths of the atomic transitions might be modified by a presence of the cold Rb atoms.

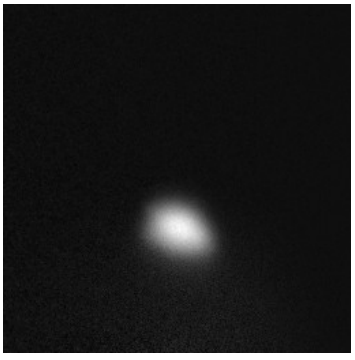

Fig. 1: The fluorescence image in deep UV of the cold cloud of mercury atoms in the magneto-optical trap.

1 H. Hachisu et al., “Trapping of Neutral Mercury Atoms and Prospects for Optical Lattice Clocks”, Phys. Rev. Lett. **100**, 053001 (2008), J. J. McFerran et al. “Neutral atom frequency reference in the deep ultraviolet with a fractional uncertainty = $5.7 \times 10^{-15}$”, Phys. Rev. Lett. **108**, 183004 (2012), P. Villwock et al., “Magneto-optical trapping of neutral mercury”, Eur. Phys. J. D **65**, 251–255 (2011)

2 P. S. Żuchowski, et al., “Ground and excited state properties of the polar and paramagnetic RbSr molecule: a comparative study.” arXiv:1402.0702, 2014