A Double Magneto-Optical Trap for Hg and Rb

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We present an experimental set-up of two species Hg-Rb magneto-optical trap (MOT). Rubidium atoms are very convenient for variety of experiments with ultracold samples including BEC, magnetic Feshbach resonances, photoassociation and many more [1]. The experimental methods for cooling and trapping Rb atoms are well developed and commonly used in many laboratories. On the other hand Hg atoms have a rare combination of features that makes them very interesting for cooling and trapping experiments: diversity of bosonic and fermionic isotopes, no hyperfine or fine structure in ground state, meta-stable states with extremely long life times, low Doppler and recoil temperatures. Moreover, due to very high weight Hg atom is a very good candidate for experimental tests of fundamental physics [2,3]. Because of small black body radiation shift and relatively high frequency of the clock transition it is also attractive for optically based metrology of time [5]. Nevertheless, experiments with cold Hg atoms are challenging due to very inconvenient wavelength (254 nm) of the cooling transition.

In bosons with the s^2 configuration the clock transition $^1S_0 -^3 P_0$ 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 Hg-Rb MOT, the presence of cold Rb atoms can be used to broaden the $^1S_0 -^3 P_0$ clock transition in Hg. It was recently demonstrated [4] 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.

The preliminary studies of interactions in Hg MOT and between Hg and Rb MOTs are presented. The particular attention is given to the measurements of the scattering properties in various isotopes of the Hg atoms, such as thermalization rates, which provide information about the interaction potential, essential to predict the collisional shift of the Hg $^1S_0 -^3 P_0$ clock transition [5–7]. The information about the interaction potential can also be obtained from loading curves of the MOT and from a photoassociation spectroscopy close to the $^1S_0 -^3 P_1$ trapping transition. One of the goals of the presented experimental set-up is controlled production of ultracold homo- and heteronuclear molecules by the light-assisted photoassociation. We plan to take advantage of the Rb $5S - 7S$ two-photon line at 760 nm as the photoassociation transition. The absolute frequency of this transition was measured recently by our group with the highest accuracy [8].

References

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