Experimental set-up for loading Sr atoms into a hollow-core fibre

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Many quantum technologies are built around the manipulation of isolated atoms in ultra-high vacuum systems. Yet, the source of these atoms generally comes in the form of an "oven" which operates at elevated temperatures and under much higher pressures, leading to increased background gas load and unavoidable contamination of surfaces in the vicinity of the source. In many cases, mitigating the potential contamination results in a much larger device footprint than would technically be required - simply to allow for sufficient differential pumping and isolate between "core" and "loading" sections of an apparatus. Our way to solve this problem is the development of a fiber-based delivery system for atoms based on laser guiding through a hollow-core crystal fibre. Almost all this type of experiments to date are based on the alkali element rubidium [1], [2]. However the advanced computation and sensing machines like optical lattice clocks, trapped-ion based quantum computers and quantum simulators are built on the class of alkaline-earth-metal atoms (e.g., calcium, strontium, ytterbium, or mercury). Strontium atoms have a level structure with narrow intercombination lines, which allow for second-stage laser cooling to temperatures in the range of a few μK. This lower temperature promises to reduce the required trap depth inside the fibre, which is a great advantage.

In our project we develop an experimental setup to trap ^{88}Sr atoms in magneto-optical trap (MOT) and transfer them spatially with assist of optical dipole potential inside a hollow-core fibre. We focus on the delivery of atoms from a preparation area that consists double stage cooling by $^1S_0 -^1 P_1$ and $^1S_0 -^3 P_1$ transitions into the measurement area on the other side of the fibre. We want to experimentally determine the optimal cooling and loading strategy for Sr. During guiding we aim to increase atom lifetime (mostly related to vacuum quality) to the range of 1 s by reducing the heating rate, and employing targeted cooling schemes.

References

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