Trapping a single atom at 100 nm of the surface of a microresonator.

Master Arbeit in the group Applied Quantum Optics of Pr. Arno Rauschenbeutel

Whispering-gallery-mode (WGM) resonators confine light in a small volume by means of total internal reflection and provide ultra-high optical quality factor. The confinement of the light fields for an extended amount of time in such a cavity enables to realize a coherent interaction between a single atom and a single photon: the atom will successively absorb and reemit a photon in the cavity mode.

Coupling a single Rb atom to the **evanescent field** of a WGM bottle-microresonator (BMR) allows our group to reach the strong coupling regime of light matter interaction [1].We recently employed this system to realize a new type of quantum device [2]. However, in our current configuration, the atom-resonator interaction time is extremely short, because the atoms only couple to the resonator during their transit in the vicinity of the resonator, which lasts few µs. This prevents us from manipulating the state of the atom. Therefore, in order to realize advanced quantum information protocols, it is necessary to trap the atom close to the resonator.

The evanescent field of the resonator decays with a characteristic length of $\lambda_{at}/2\pi$, where in our case λ_{at}=780 nm is the wavelength of the atomic transition used to probe the atoms. In order to trap a single atom, a **confining potential has to be created at the extreme vicinity of the resonator**. In order to obtain such a configuration, we plan to realize a standing wave dipole trap by retroreflecting a beam of wavelength λ_{trap} tightly focused on the BMR surface (method similar to [3]). If the light is red-detuned to the atomic transition, the atom will be attracted to the intensity maximum of the light where it can be trapped. The first trapping site is therefore located at $\lambda_{trap}/4$ of the surface, as depicted on Fig 1.

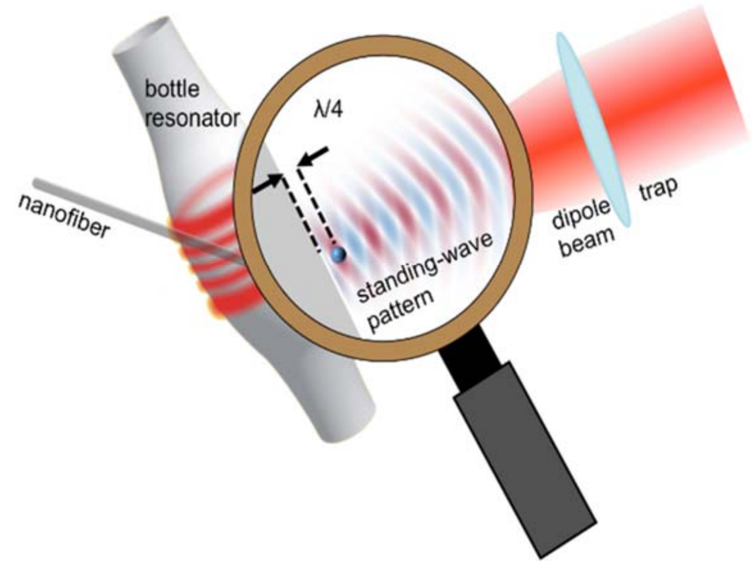

Fig. 1 : Scheme of the trap at the vicinity of the bottle-microresonator.

The student will **participate in the implementation of such a trapping scheme**.
The impact of a strongly focused laser beam on the resonator has never been studied, and the task of the student will thus first be to set up an experiment enabling to test the effect of the trap on the properties of the modes of a BMR (the laser has already been set up) in terms of frequency shift of its resonances and impact its quality factor on an existing set-up in free space.

The student will then use the knowledge he/she gained to implement this trap on a system placed under ultra-high vacuum, which is required to work with atoms, where the heat dissipation mechanism will be different.
Finally, he/she will be in charge of designing and implementing a system dedicated to the stabilisation of the resonator modes, to counteract the effects of the trapping laser.

For more information, contact Prof. Rauschenbeutel arno.rauschenbeutel@ati.ac.at or J. Volz jvolz@ati.ac.at.

[1] C. Junge et al. Phys. Rev. Lett. 110, 213604 (2013),
[2] M. Scheucher et al. Science 354, 1577 (2016),
[3] J. D. Thompson et al. Science 340, 1202 (2013).