Internship Laser Locking

Proposal

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December 8, 2025

1 Saturated Absorption Laser Locking

QUBION is a student team that develops educational quantum computing setups. Our first project is the Magneto-Optical Trap (MOT), a setup used to cool atoms to the micro-kelvin level. The cooling of atoms can be divided into two components, velocity- and position-dependent cooling. Velocity dependent cooling focuses on removing all velocity components from the atoms, whereas positionally dependent cooling results in the atoms ending up in a controlled position. For this internship, we focus on the stabilization of the laser used for cooling.

For the velocity dependent cooling, laser cooling is employed. Laser cooling functions by illuminating the atoms with photon-energy near the transitions of the atom. If these photons are tuned slightly below the transition frequency, the atom cannot absorb the photon unless the energy is raised. When the atom is moving towards the photon source, the photon frequency is Doppler-shifted to a higher frequency and is able to be absorbed. The resulting atom has the impulse of the original atom and the photon combined. When the atom decays due to spontaneous emission, the atom is left with its previous impulse minus the impulse of the emitted photon. When illuminating the atom from opposing directions the net impulse change will be negative and the atom will lose all impulse in the direction of the beams. Repeathing this process in all spatial directions leaves the atoms with little to no impulse.

To achieve Doppler cooling the laser frequency needs to be finely tuned to slightly below the transition frequency. This requires sub-Doppler resolution on the transition energies, achieved via a process called Saturated Absorption Spectroscopy (SAS). SAS works by saturating the transitions of a sample using an intense beam in one direction. When a second beam, facing the opposite direction, is used to measure the spectrum of atoms, atoms with no velocity in the direction of the probe beam will have been saturated and will not show up in the spectrum. These spectra are used to calculate a sub-Doppler resolution of the transitions.

This internship will focus on assembly and alignment of the SAS setup and measuring the sub-Doppler transitions. These measurements will be used to lock the central laser frequency on an atomic transition. This includes a lot of experimental work on the optics of the setup, as well as an exciting engineering challenge in control systems. Laser locking is an essential technology in quantum tech and experimental atomical physics.

Formally, the internship will take place at the Fontys Lecotraat, with QUBION as client. QUBION is in possession of all material, including a laser, that is needed for this internship. Work will be carried out in the QUBION lab, or at Fontys, with guidance from both Fontys and the TU/e.