Masterarbeiten
Master thesis projects

AG Quantenmetrologie
Quantum Metrology research group

Prof. Simon Stellmer

Quantum frequency conversion

We envision a future quantum computer as a hybrid architecture with various components, very much like a classical computer. Photons are used to transfer information from one component to another, and their wavelength needs to be converted to match the resonance frequencies. We are developing the photonic devices that allow for wavelength conversion without loss of quantum information.

The master thesis project: You will explore a novel approach to quantum frequency conversion, namely a resonant four-wave mixing process in high-pressure hydrogen, all taking place inside a hollow-core fiber.

Your experience: In this project, you will learn a lot about photonics and especially optical fibers and photodetectors, you will get a solid understanding of nonlinear processes and the basics of quantum information.

What else? This project is part of the Cluster of Excellence *ML4Q* and of the European *QuantumGuide* project, and includes collaborations with partners in Bonn and Jülich.

Interested? Contact us: stellmer@uni-bonn.de

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Integration and remote accessibility of a ring laser gyroscope

Measuring rotations with a laser? That's what we love to do: our group operates a handy 25-cm ring laser gyroscope that sits on a turntable. The interference between two counter-propagating laser beams tells us the rotation rate of the device, and the comparison with a mechanical sensor allows us to hunt for systematic errors. We use this system for technology development and training purposes alike.

The master thesis project: You will upgrade the system's performance, integrate all system components to make it fully fiber-coupled, and write a user interface to make the entire setup online accessible for remote operation. Afterwards, you will draft a manual that allows students and researchers to operate it.

Your experience: You will get to know a lot of lasers and optics, some electronics and RF technology, quite a bit of coding, and certainly a lot of fun.

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Setup of a laser system at 254 nm

Developing laser systems for ultraviolet wavelengths is still a formidable challenge. Our group already operates half a dozen laser systems between 214 nm and 370 nm, and we aim to fuse all our experience into the development of a new, very robust and powerful system to drive the 254-nm transition in mercury.

The master thesis project: You will lock a novel VECSEL laser system at 1016 nm to an ultrastable reference cavity, and then set up two consecutive frequency doubling stages to arrive at a wavelength of 254 nm. The system will then be shipped to Heidelberg for characterization, and finally installed at the Institut Laue-Langevin in Grenoble to aid neutron EDM measurements.

Your experience: You will learn a lot about lasers, electronics, cavities and optics in general. This project includes extended visits to Heidelberg and to Grenoble.

What else? This is a very collaborative project and embedded into the European *quMercury*, *UVQuanT*, and *panEDM* collaborations.

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A three-dimensional passive ring laser gyroscope

Gyroscopes are used to measure rotation rates, and they come in literally all shapes and sizes. Our group already operates a variety of one-dimensional ring laser gyroscopes, in active and passive mode, in sizes between a few cm and many meters, and for very different purposes.

The master thesis project: Based on our experience with one-dimensional ring lasers, you will set up the world's first three-dimensional ring laser gyroscope. This will also be the world's smallest ring laser to measure Earth's rotation… two world record in one project!

Your experience: You will learn a lot about optics, lasers, electronics, cavities, and fast FPGA-based RF electronics. Plus the data acquisition and analysis to extract the signal. And FEM-simulations of the stability of the device… for sure, it won't be boring.

What else? This project is part of the European *GyroRevolution* initiative and is embedded into various other ring laser development projects.

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Design of a transportable Strontium MOT

The magneto-optical trap (MOT) was invented some 40 years ago, won a Nobel Prize in 1997, and is now the standard tool to cool atoms in hundreds of labs around the world. But compact and robust setups that can be operated outside the lab are rare, are setups in which the atoms can be seen by the naked eye are very rare.

The master thesis project: You will design a complete MOT setup that is transportable and can be displayed at exhibitions, in schools, and presented to the general audience. In this way, we will carry fascinating quantum physics straight into society.

Your experience: You will study a lot of literature on already existing setups, learn the atomic physics background, and then design the optics, electronics, and vacuum parts. Once we have a convincing design, we will actually start to build the setup!

What else? This project is also suitable for a team of two or three master students, where each of you will then focus on a different aspect.

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High-precision spectroscopy on Calcium

Calcium is *the* one element that appeals to both the nuclear physics community and the atomic physics and quantum optics communities: it offers a complete chain of stable nuclei between two nuclear shell closures, and it offers a range of narrow optical transitions to probe the nucleus' properties through its interaction with the electron cloud. We are currently setting up a new apparatus to precisely measure the isotope shift on two clock transitions.

The master thesis project: Together with a PhD student, you will perform first measurements on the two clock transitions in a heat pipe. Afterwards, you will design and begin to set up a sophisticated vacuum chamber to perform simultaneous, co-located Ramsey-Bordé spectroscopy on pairs of isotopes. The motivation of all this: finding new particles!

Your experience: During this project, you will learn a lot about optics, lasers, electronics, cavities, vacuum technology, RF electronics.
Plus a fair share of atomic physics and precision measurements.

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