Ultracold strontium research group (WZI)

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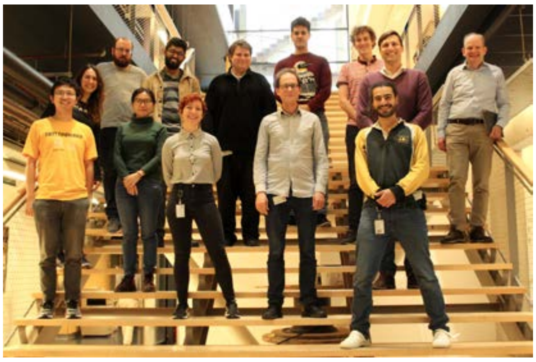

Research theme. We are creating quantum sensors, simulators and computers using the unique properties of ultracold strontium gases, for example building clocks that would go wrong by only one second over the lifetime of the universe, or exploring many-body quantum physics beyond the reach of classical simulations. We can offer various master projects, executed within teams of two to four people. If you join us, you will learn a lot about atomic physics, quantum mechanics, lasers, electronics, and how to design and realize complex cutting-edge high-tech devices. You will be prepared for a PhD in atomic, molecular or optical physics or for many exciting technology jobs in industry. An example project is given below. Don't hesitate to come talk to us about this or other possibilities in our group.

Project: Towards continuous superradiance for active optical clocks

Supervisors: Ananya Sitaram and Florian Schreck

Sheng, Benedikt and Ananya, the mHz superradiant clock team, in front of their machine.

A clock measures time by counting the cycles of a frequency reference. Since the precision of this frequency reference dictates the accuracy of the clock, today's best clocks are based on ultra-narrow optical transitions of atoms, which provide a fixed frequency standard anywhere in the world. The best atomic clocks in the world measure the frequency of an optical transition with an uncertainty at the 10^{-18} level, corresponding to only a few seconds over the age of the universe. An ultrastable laser is used to interrogate the atoms and measure the frequency of the atomic transition in question. Thus, the precision of atomic clocks is limited by the coherence time and stability of this "clock laser". The current state-of-the-art involves locking the clock laser frequency to the length of an optical resonator, linking the stability of the clock to the stability of the cavity's length.

Superradiance is a phenomenon that can allow lasing directly from narrow clock transitions. Thanks to this property, steady-state superradiant lasers have been proposed as candidates to realize a new generation of frequency references: active optical clocks. In our lab, we investigate two approaches of achieving continuous superradiance in different temperature regimes: (1) a thermal beam and (2) an ultracold, uK sample of strontium atoms. The first approach lends itself to producing simple and compact optical frequency references for a wide range of scientific and industrial applications, while the second challenges the state-of-the-art of short-term frequency standards. The nature of the superradiant phase transition offers many opportunities to study open questions in highly-correlated many body physics.

In this project, you will have the opportunity to work on projects contributing to both approaches to continuous superradiance. Possible tasks include: characterizing cavity QED and collective emission effects of thermal atoms in a linear cavity; building an injection-locked laser for a "magic" wavelength moving optical lattice and implementing the optical lattice in the experiment; locking the magic wavelength laser to a bowtie cavity and characterizing the system. The project will be tailored according to your interests and abilities.