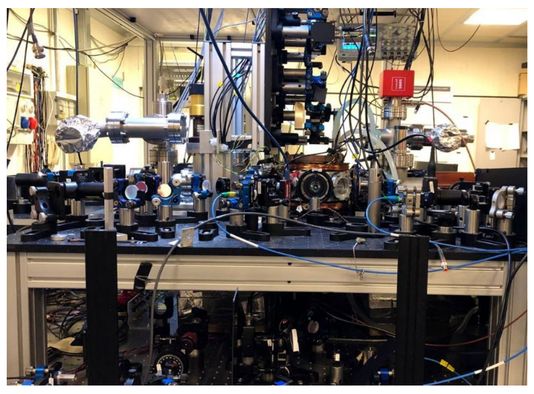
Theses in Quantum Technologies

We are the **Atomic Frequency Standards** group at INRIM, part of the **Quantum Metrology and Nanotechnology** division. Our team consists of around **20 members**, including permanent staff and students, and we are actively involved in a **strong international research network**. We maintain one of only eight **Cesium atomic fountains** in the world, which serve as the primary realization of the second in the International System of Units (SI).

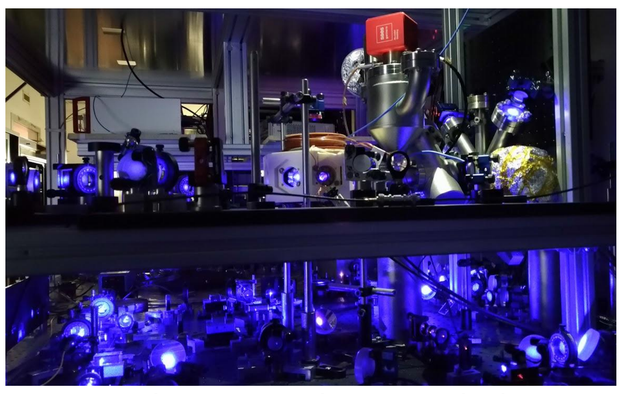
Our research focuses on advancing frequency standards beyond the current state of the art, while also exploring innovative theories and technologies, including **optical lattice clocks**, **time scale generation**, **optical frequency combs**, **optical fiber links and sensing**, as well as **compact, chip-scale clocks** for transportable and space applications. We offer a large variety of thesis topics covering different aspects of time & frequency metrology and physics

INRIM campus at Strada delle Cacce 91

The Cs cryogenic atomic fountain



The Yb Optical Lattice Clock



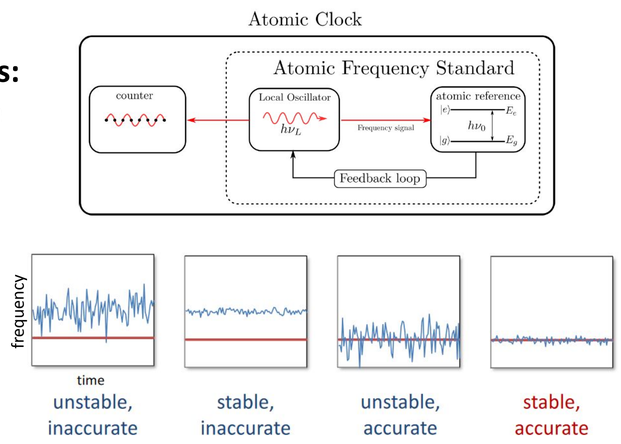
The Sr Optical Lattice Clock

Atomic Clocks & Applications

Clock main ingredients:

1) A very reproducible oscillation
2) A device able to count it

Clock Performance:
Stability and Accuracy



Precise clocks and their importance

Navigation systems

Telecommunications / VLBI

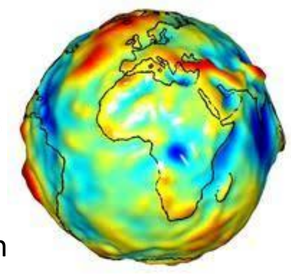
Transports

Atomic clock are most precise time keepers in the world!

State of the art relative systematic uncertainty ~ 10^{-18}!

Atomic Clocks as precision sensors

- Earth Geodesy with Fiber infrastructure
- Fundamental research: Variation of fundamental constant & search for Dark Matter



gravity map of the Earth

Research Areas

Optical Lattice Clocks

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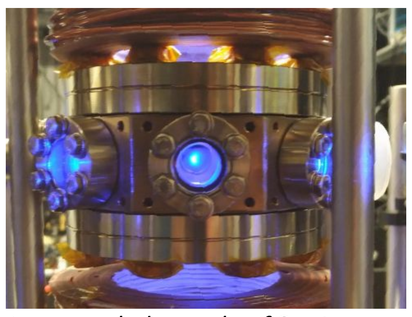
keywords: Ytterbium and Strontium atom, laser cooling & trapping, Ultra-low noise laser source, ultrastable cavity, lattice laser source, frequency stabilization, quantum non-demolition detection,

Yb Optical Lattice Clock laser system



Laser cooled sample of Sr atoms

Available theses:

- Development of a homodyne detection system for the "quantum non demolition" detection of collective atomic states
- Narrow-line laser Doppler cooling of ^{87}Sr atoms for an optical lattice clock
- Ultra-low noise laser with high Q Fabry-Pérot resonator
- Characterization of the laser source and development of optical setup for the realization of an optical lattice at the magic wavelength for Yb atoms
- Use of Optical clocks for advanced time scale and time-keeping

Fiber Links & Fiber Sensing

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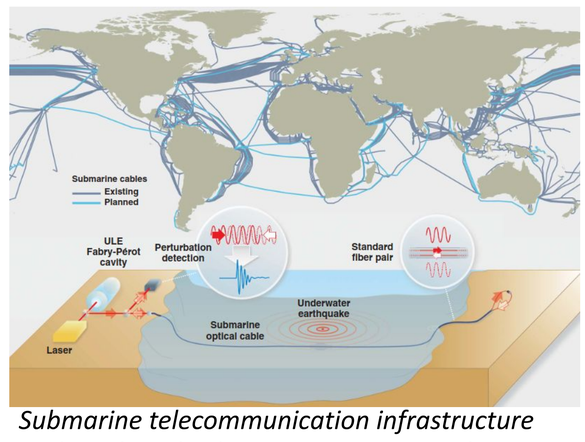
Keywords: narrow-linewidth lasers, laser interferometry, optical fibers, quantum key distribution, earthquake detection, data mining



Submarine telecommunication infrastructure and earthquake detection experimental setup

Available theses:

- Realization of integrated laser systems for laser interferometry on optical fibers for earthquake detection
- Advanced signal processing of geophysical signals collected by optical fibers using AI and analytical models
- Development of experimental devices for quantum communication based on ultrastable lasers, interferometry with single-photon detectors, and advanced phase modulation

Compact & Chip-Scale Atomic Clocks

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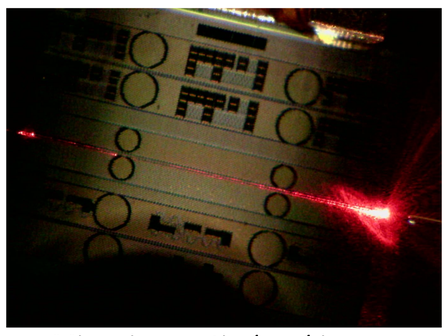
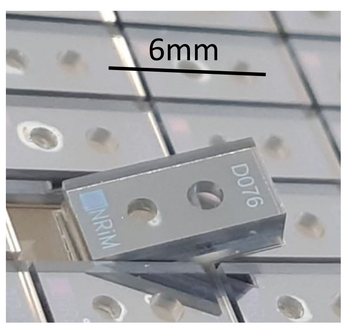
Keywords: Hot vapors, microcell, compact clock, two-photon transition, micro-resonators and comb generation, Microfabrication techniques



Microrings optical probing



Rb-MEMS cell produced @ INRIM

Space qualified of Rb-POP

Available theses:

- Two-photon laser spectroscopy for the realization of a chipscale Rb clock
- Optical frequency combs on a chip for space applications
- Advanced techniques for space qualified microwave clocks
- Microfabrication techniques for time and frequency

Quantum many-body Theory

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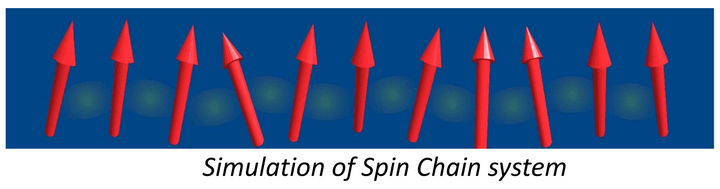
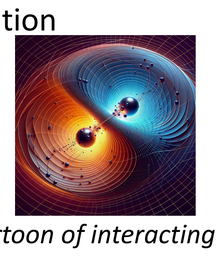
Keywords: Quantum Monte Carlo; atomic clocks; density shifts; light shifts; Bosons and fermions; nonperturbative interaction effects; quantum optics of atoms in optical cavities; Lindblad equation; Schrodinger equation; parallel simulation



Simulation of Spin Chain system



Cartoon of interacting atoms

Available theses:

- Developing a parallel quantum Monte Carlo code for the study of interaction effects in Bose or Fermi trapped atomic gases under Rabi coupling
- Cumulant approximation study of entanglement generation in cavity-enhanced atomic clocks under dissipative conditions
- Employing QuTiP and quantum Monte Carlo algorithms for the parallel simulation of the quantum Lindblad dynamics of cavity coupled atomic ensembles and their entanglement

Why working with us

Opportunities

- Working in cutting-edge experiments in photonics and atomic physics
- Experienced mentors and collaborative environment
- Access to state of the art facilities
- Collaborations with academic and industrial partners
- Strong international research network

What you will learn

- Managing complex experiments
- Experimental hard skills: Optics, electronics, computer science, data analysis , mechanical design, photonic design …
- Atomic manipulation techniques
- Photonics and Microfabrication methods
- Theoretical approaches for next. gen atomic clocks

Contact Us

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- Call us for a lab tour
- PhD and Postdoc open position!