Advanced quantum systems for precision measurement technologies

Imperial College, London, Blackett Laboratory, room 539
Tuesday, December 3rd, 2019, 9:30 am – 2 pm,
*Please, **register** for your free place, coffee and lunch.*

Project USOQS - *Ultra-stable optical oscillators from quantum coherent and entangled systems.*

Introduction

Filippo Levi

Italian National Institute for Metrology INRIM, Milan, Italy

9:30 to 9:45

A brief overview on how atomic clocks can be used to perform fundamental physics research, and what are the future perspectives in this direction.

Improvement of atomic clock stability with joint interrogation, squeezing and artificial intelligence

Luca Pezze

National Institute of Optics INO-CNR & LENS, Florence, Italy

9:45 to 10:10

Firstly, I will show how we can increase the stability of atomic clocks by the joint interrogation of two out-of-phase atomic ensembles sharing the same local oscillator. We also include the effect of squeezing of the atomic ensemble and repeated non-destructive measurements. Secondly, I will discuss a machine learning approach to phase estimation. The protocol implements a Bayesian estimation where the prior knowledge about the phase is a-priori determined by the training of the artificial intelligence algorithm. I will adapt the protocol to frequency estimation aided by squeezing.

Ion trap technology for scalable entanglement

Guido Wilpers

National Physical Laboratory, Teddington, UK

10:10 to 10:35

Trapped ion experiments have reached world-leading fidelity in controlled quantum-information processing operations, utilised entanglement for improved optical clocks and to tailor spectroscopic sensitivity. We are operating a linear segmented ion trap with outstanding low motional heating rate from our in-house monolithic wafer-level fabrication process. Preparations to demonstrate scalability in entanglement-enhanced quantum metrology with optical qubits using the Mølmer-Sørensen scheme are under way.

10:35 to 10:55 - Coffee break

Quantum sensors for gravimetry and inertial navigation

Joseph Thom

M Squared Lasers Ltd, Glasgow, UK

10:55 to 11:20

Abstract: Quantum sensors based on atom interferometry are set to significantly enhance the precision and accuracy of measurement applications such as gravimetry and inertial navigation. Whilst laboratory-based interferometers have been demonstrated with very high sensitivities, our work is focused on engineering sensing devices that will be suitable for field applications. In this talk, M Squared's suite of quantum sensors are presented, along with results from recent field tests.

Optical clocks and quantum technologies, part I

Richard Hobson

National Physical Laboratory, Teddington, UK

11:20 to 11:45

Optical lattice clocks can resolve the passage of time to 18 decimal places. We address the accuracy and stability achieved in our strontium system. Here the frequency instability is fundamentally limited by the "quantum projection noise" (shot noise) when the atomic state is measured. We are investigating new methods using Rydberg atoms to reduce this noise, by entangling the atoms in a spin squeezed state

Optical clocks and quantum technologies, part II

Jérôme Lodewyck

SYRTE, Observatoire de Paris, France

11:45 to 12:10

We will present some of the applications of optical lattice clocks in metrology, fundamental physics and applied physics. Results of international comparisons will be included. We will then explain how weak QND measurements can help improving the clock stability by generating spin-squeezed states.

12:10 to 12:50 - Lunch break

Active atomic clocks, part I

Stefan Alaric Schäffer

Niels Bohr Institute, University of Copenhagen, Denmark

12:50 to 13:15

Optical atomic clocks with ultracold atoms can achieve high precision at long averaging times. At short times this is limited by noise from the interrogating laser and the sample preparation dead times. Systems based on atoms in optical cavities can virtually eliminate the dead-time by using superradiant lasing or cavity-mediated saturation spectroscopy on a continuous stream of cold atoms.

Active atomic clocks, part II

Michal Zawada

National Laboratory of Atomic, Molecular and Optical Physics, Uniwersytet Mikołaja Kopernika, Torun, Poland

13:15 to 13:40

We will present some existing and possible realisations of continuous superradiant clocks, focusing on the $^1S_0$-$^3P_0$ ultranarrow transition in strontium.

13:40 to 14:00 – Closing remarks and chat

EMPIR EURAMET

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