SYAI 1: Trends in atom interferometry

Time: Monday 14:00–16:00 Location: e415

Invited Talk SYAI 1.1 Mon 14:00 e415

Atom interferometry and its applications for gravity sensing — •Franck Pereira dos Santos, Luc Absil, Romain Caldani, Xiaobing Deng, Romain Karcher, Sébastien Merlet, Raphaël Piccon, and Sumit Sarkar — LNE-SYRTE, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, 61 avenue de l'Observatoire, 75014 Paris, France

The measurement of gravity, gravimetry, or its gradients, gradiometry, allows for static and dynamical studies of mass distributions, from local to global scales. Applications of gravimetry cover many disciplinary fields, such as geophysics, natural resources exploration, hydrology, geodesy, inertial navigation, fundamental physics and fundamental metrology.

Gravity measurements are performed with different kinds of relative and absolute sensors, which measure the gravity acceleration g and its variations, or its gradients. Among these, quantum gravity sensors, based on cold atom interferometry techniques, reach excellent sensitivities and accuracies, and outperform in many respects current state of the art commercially available technologies.

In my talk, I will review state of the art quantum gravity sensors, and discuss their limits in performances, both in terms of stability and accuracy. I will discuss solutions currently explored to overcome these limits, such as based on the use of ultracold atom sources and large momentum transfer beamsplitters, as well as some of their present and future applications.

Invited Talk SYAI 1.2 Mon 14:30 e415

Atom interferometry for advanced geodesy and gravitational wave observation — •Philippe Bouyer — LP2N, IOGS, CNRS and Univ. de Bordeaux, 33400 Talence, France

In 2016, one century after Einstein predicted theirexistence, scientists made the first observation gravitationalwaves (GW). Since this first observation, many more eventshave been detected, confirming that GW opens a new windowfor studying the cosmos. There is today a growing interest inGW astronomy;The scientific potential of is enormous, in termsof providing a deep view into the past of our universe, andcomplement other observation windows such as radio telescopesor infrared observatory. The success of this new astronomyrelies on our faculty to expand our observation frequencywindow to other frequencies. The Laser Interferometer SpaceAntenna (LISA) to investigate frequency sources at very lowfrequency gives a partial, long term answer to this challenge.Nevertheless, it leaves a large gap, the infrasound (mHz to tensof Hz) band, uncovered. An underground gravitational waveantenna can provide a quick response to this problem and wouldnaturally complete and enhance the present and future set ofGW observatories. MIGA is a long baseline, mid-frequency,GW observation infrastructure relying on quantum sensorstechnology to study space-time and gravitation. We willpresent the progress of this first step towards a Laboratory forGravitation and Atom-interferometric Research in Europe.

Invited Talk SYAI 1.3 Mon 15:00 e415

Fundamental physics with atom interferometry — •Paul Hamilton — University of California, Los Angeles, USA

Astrophysical evidence for dark matter and dark energy suggest there is new physics beyond the Standard Model of particle physics. Models describing this new physics generally have interactions that can lead to new forces on atoms. I will discuss two experiments using the ability of atom interferometry to make precise force measurements to constrain these possible new forces.

The first experiment uses interferometry of freely falling cesium atoms to search for a new force near a test mass in ultra-high vacuum. The resulting constraints have ruled out a large range of parameter space for several dark energy theories which predict forces that are typically screened in the presence of matter. The second experiment will use an optical cavity to continuously monitor ytterbium atoms trapped in an optical lattice. A force on the atoms leads to periodic Bloch oscillations in their wavefunction which can be detected in the transmission of light through the cavity. I will discuss a proof-of-principle experiment measuring the temperature of the ytterbium gas in microseconds by using the cavity to monitor sub-optical wavelength changes in the atomic distribution as well as future plans to search for new oscillating forces from ultralight dark matter.

Invited Talk SYAI 1.4 Mon 15:30 e415

Atoms and molecules interacting with light — •Lucia Hackermüller — School of Physics and Astronomy, University of Nottingham, University Park, Nottingham, NG7 2RD, UK

Large, complex and massive particles can show interference effects in a Talbot-Lau interferometer reaching beyond 10000 amu. I will detail the operation principle and touch upon recent records achieved in the group of M. Arndt and discuss interferometry applications for cold atoms.

For quantum information applications efficient atom-photon interactions are important. For this we have constructed an atom-light interface, where cold atoms are introduced into an orthogonal hole in an optical fibre. This method allows the construction of a highly compact and robust interface that is compatible with many existing waveguide and chip technologies. For this caesium atoms are cooled in a magneto-optical trap, transferred to an optical dipole trap and positioned inside a transverse, 30μm diameter through-hole in an optical fibre, created via laser micromachining. We trap about 300 atoms at a temperature of 140μK. When the guided light is on resonance with the caesium D2 line, up to 87% of it is absorbed by the atoms. We also discuss the influence of hole shapes on transmission and prospects of adding a micro-cavity. Our techniques should be equally effective in optical waveguide chips and other existing photonic systems.