Siegman summer school/Kasevich lectures

Lecture 1: Tests of gravity and quantum mechanics with atom interferometry (Refs. 1-2)

Modern de Broglie wave interferometers separate atomic wavepackets by 0.5 m for times of 2 sec. This lecture will discuss the science and technology implications of these results, and describe the techniques employed to realize these instruments. Applications range from high resolution satellite geodesy to gravitational wave detection and test of quantum mechanics.

Lecture 2:  Quantum metrology (Refs. 3-6)

The process of phase estimation is central to the operation of interferometric sensors. This lecture will discuss quantum limits of phase estimation for precision atomic sensors and for electron microscopy, and the implications of these limits for instrument metrological performance. In particular, we will describe recent experiments that have demonstrated a nearly 20 dB metrological improvement in phase estimation for atomic sensors using spin-squeezed atomic ensembles, and a proposal for a multi-pass electron microscopy method which appears capable of yielding at 10-fold reduction in sample damage for phase-contrast images of nm-scale biological proteins.

References

1. Asenbaum, P. *et al.* Phase Shift in an Atom Interferometer due to Spacetime Curvature across its Wave Function. *Physical Review Letters* **118,** (2017).
2. Kovachy, T. *et al.* Quantum superposition at the half-metre scale. *Nature* **528,** 530–533 (2015).
3. Engelsen, N. J., Krishnakumar, R., Hosten, O. & Kasevich, M. A. Bell Correlations in Spin-Squeezed States of 500 000 Atoms. *Physical Review Letters* **118,** (2017).
4. Hosten, O., Krishnakumar, R., Engelsen, N. J. & Kasevich, M. A. Quantum phase magnification. *Science* **352,** 1552–1555 (2016).
5. Hosten, O., Engelsen, N. J., Krishnakumar, R. & Kasevich, M. A. Measurement noise 100 times lower than the quantum-projection limit using entangled atoms. *Nature* **529,** 505–508 (2016).
6. Juffmann, T. *et al.* Multi-pass transmission electron microscopy. *Scientific Reports* **7,** (2017).