Old Domion University
Department of Physics

Virtual Colloquium

Thursday April 1, 2021
3:00 pm

"Approaching the Heisenberg limit with time-reversal Hamiltonian"

Dr. Simone Colombo
MIT

Abstract: State-of-the-art atomic sensors operate at (or near) the Standard Quantum Limit, where the device sensitivity scales with the square root of the number of involved atoms. The SQL is not a fundamental limit and quantum correlations (entanglement) between the involved atoms can lead to more favorable down-scaling of uncertainties. In the Quantum Realm, the ultimate scaling is bound to 1/N, known as Heisenberg Limit (or bound), and it is imposed by Heisenberg-like uncertainty relations.

The creation of exotic quantum states that allow atomic sensors to operate beyond the SQL and near the Heisenberg Limit for many-article systems has been a long-sought goal in Quantum Metrology. Gaussian Spin Squeezed States have been used to overcome the SQL in atomic sensors but offer limited quantum metrological advantages. To approach the Heisenberg Limit, Non-Gaussian Entangled States (NGES) with larger entanglement have to be engineered. However, the fragility of highly entangled states against decoherence and single-particle state resolution requirements have made difficult their experimental realization and application to atomic sensors with today's technology.

I will present the implementation of a robust Signal Amplification through Time-reversal INteraction (SATIN) protocol, that allows for the generation of NGESs and the efficient use of their quantum resource. We demonstrate an angular resolution of 12.8 dB beyond the SQL for a system of ~370 ytterbium-171 atoms (and 12.6 dB away from the Heisenberg limit), Heisenberg scaling with atom number, and a record-breaking phase-sensitive measurement of 11.8 dB beyond the SQL. We plan to transfer these NGESs to the optical-clock transition of ytterbium-171.

BIO: Simone Colombo is currently a postdoctoral associate working on a project led by Prof. Vladan Vuletić at the Massachusetts Institute of Technology (MIT). His research focuses on the engineering and control of entangled many-body states and their application to quantum metrology and simulation. Before joining MIT in 2017, Simone completed his Ph.D. in Physics at the University of Fribourg, Switzerland, with Prof. Antoine Weis. In Fribourg, he worked on the development of atomic magnetometers for applications in biosensing and bioimaging.

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