



CRC 1227
Designed Quantum States of Matter



GUEST LECTURE

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(Guest of Prof. Dr. Klemens Hammerer and Dr. Naceur Gaaloul)

Leibniz Universität Hannover
DQ-mat Colloquium
11 November 2021, 3.00 pm
(via Zoom-Meeting)

"Quantum-enhanced atom interferometry"

The possibility to overcome the standard quantum limit (SQL) by engineering specific quantum correlations between the atoms is attracting increasing interest in the field of atom interferometry. Recently, Bose-Einstein condensates (BECs) have been pinpointed as optimal candidates for the realization of entanglement-enhanced atom interferometers with spatially separated arms either in trapped [1] or free-fall [2] configurations. However, either due to the presence of residual interactions during the interferometer sequence or due to the fast expansion of the BEC during the state preparation, only a modest sub-SQL sensitivity gain is predicted.

To overcome these problems, we recently proposed a novel method we refer to as Delta-Kick Squeezing (DKS) [3]. This method involves the rapid action of an external trap focusing the matter-waves to significantly increase the atomic densities during a preparation stage. This method is explored in the two relevant cases of Raman or Bragg scattering light pulses. In the second case, we demonstrated the possibility to implement a non-linear readout scheme making the sub-SQL sensitivity highly robust against imperfect atom counting detection [4,5]. We predict more than 30 dB of sensitivity gain beyond the SQL, assuming realistic parameters and millions of atoms in the BEC.

In this colloquium, the main differences between Raman and Bragg interferometry sequences will be introduced as well as their respective impact in the generation of squeezing through the "One-axis twisting dynamiques". The advantages of the Delta-kick Squeezing method will then be discussed. Last but not least, I will highlight preliminary results on quantum-enhanced differential atom interferometry based on distributed quantum sensing.

References:

- [1] R. Corgier, L. Pezzè and A. Smerzi, PRA 103 (2021). Nonlinear Bragg interferometer with a trapped Bose-Einstein condensate
- [2] S. S. Szigeti, S. P. Nolan, J. D. Close, and S. A. Haine, PRL 125 (2020). High Precision quantum-enhanced gravimetry with a Bose-Einstein condensate
- [3] R. Corgier, N. Gaaloul, A. Smerzi and L. Pezzè, PRL 127 (2021). Delta-kick Squeezing
- [4] E. Davis, G. Bentsen, and M. Schleier-Smith, PRL 116, 053601 (2016). Approaching the Heisenberg limit without single-particle detection.
- [5] O. Hosten, R. Krishnakumar, N. J. Engelsen, and M. A. Kasevich, Science 352 (2016). Quantum phase magnification

All DQ-mat members and all interested are cordially invited to attend.