Midterm review

CEBBEC: Controlling EPR and Bell correlations in Bose-Einstein condensates

Chris Westbrook, Laboratoire Charles Fabry, Palaiseau
Consortium

Institut d'Optique, Laboratoire Charles Fabry (LCF)
Leibniz Universität Hannover, Institut für Quantenoptik (LUH)
Technische Universität Wien (TUW)
University of the Basque Country (BILBAO)
Consiglio Nazionale delle Ricerche (INO-CNR)
Idea: correlated atom pairs (2 mode squeezing)

LUH: spin changing collisions
LCF: collisions in a lattice
TUW: collisions in an elongated trap

CNR, Bilbao: theory of entanglement witnesses, measurement protocols

Create spatial separations, seek applications to interferometry
Realizations: spin changing collisions

Entangled atoms created in spatially separated modes (LUH).
Observations using collective spin measurements.
~ 5000 atoms
Especially tailored entanglement criterion due to collaboration between LUH and BILBAO. 3σ violation

\[
\left[ (\Delta J_z^+)^2 + \frac{1}{2} \right] \left[ (\Delta \tilde{J}_x^-)^2 + (\Delta \tilde{J}_y^-)^2 \right] \geq f \left( \mathcal{J}^{(l)}, \mathcal{J}^{(r)} \right)
\]
Entangled atoms created opposite momentum states LCF
Observations use an interferometer and correlations between outputs
Demonstration of entanglement, future test of Bell inequalities
Dussarrat et al. PRL 2017
Measurements of atom statistics
Perrier et al. SciPost 2019

\[ |\Psi\rangle = \frac{1}{\sqrt{2}} (|p, -p\rangle + |p', -p'\rangle) \]
Entanglement of 2 atoms in different wells (TUW). Observation of correlated momenta after expansion. Bonneau et al. PRA 2018
Investigate how protocols using large particle numbers might be used to make measurements beyond the quantum limit.

Improve data collection to violate CHSH inequalities

Implement alternative entanglement witnesses

Thanks
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 731473.