



Contribution ID: 98

Type: **Focus session invited talk**

Compact, Resilient, and Quantum: The Future of Atom-Based Inertial Sensors

Monday 1 December 2025 12:00 (30 minutes)

Atom interferometry has emerged as a powerful tool for precision inertial sensing, with applications ranging from gravimetry to navigation and geophysics. In this talk, I will explore recent advances that push the boundaries of sensitivity and robustness in atom interferometers, with a particular focus on techniques relevant for real-world deployment.

A central theme will be the use of spatial fringe detection, which enables operation beyond the conventional two-mode paradigm. This approach facilitates multiparameter estimation and enhances resilience against external motion—an essential feature for field-deployable quantum sensors.

I will also discuss the implementation of quantum squeezing to surpass the standard quantum limit. By boosting sensitivity, squeezing allows for shorter interrogation times and more compact devices, reducing susceptibility to environmental noise. This is a key enabler for portable and scalable quantum technologies.

Finally, I will present recent developments in combining spin-squeezing with spatial fringe techniques. This hybrid approach leverages the strengths of both modalities, offering a pathway to high-performance atom interferometers that are both sensitive and robust.

Together, these innovations represent a significant step toward practical quantum sensors capable of operating outside the laboratory, with implications for fundamental science, resource exploration, and navigation.

[1] S Szigeti, S Nolan, J Close, S Haine, “*High Precision Quantum-Enhanced Gravimetry with a Bose-Einstein Condensate*”, *Phys. Rev. Lett.* **125**, 100402 (2020).

[2] S Szigeti, O Hosten, S Haine, “*Improving cold-atom sensors with quantum entanglement: Prospects and challenges*”, *Applied Physics Letters* **118**, 14501, (2021).

[3] Y Ben-Aicha *et al*, “*Dual Open Atom Interferometry for Compact and Mobile Quantum Sensing*”, *Phys. Rev. Lett.* **133**, 263403 (2024).

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Session Classification: Focus Session: Ultra-cold atoms and quantum technology

Track Classification: Focus sessions: Ultracold Atoms and Quantum Technology