SQUEIS aims to establish new frontiers in atom interferometry by devising and applying, for the first time, entanglement-enhancement techniques based on squeezing to experiments in gravimetry, gradiometry and inertial sensing. SQUEIS explores quantum state engineering in free-fall and compact trapped interferometers, addressing different systems (rubidium, potassium and strontium atoms) and innovative squeezing-generation techniques based on atom-atom and atom-light interaction. The use of entanglement is made compatible with the stringent requirements of spatial delocalization and finite interrogation times.

Squeezing-Enhanced Inertial Sensing (SQUEIS)

state-of-the-art
(standard quantum limit)
\[ \Delta \theta = \frac{1}{\sqrt{N}} \]

SQUEIS
\[ \Delta \theta = \frac{\xi}{\sqrt{N}} < \frac{1}{\sqrt{N}} \]
\[ \xi^2: -2 \text{ to } -10 \text{ dB} \]

The achieved sensitivity gain \( \xi \) can be traded for reducing:
- interrogation time \( T \) (increasing the measurement rate)
- momentum \( \hbar k \) (decreasing the interferometer size)
- number of atoms (reducing systematic effects)

SQUEIS: a roadmap toward quantum-enhanced sensing

- squeezed-state creation
- advanced readout techniques
- metrological implementation of squeezing
- squeezed states
- optimal detection
- metrology schemes
- squeezing-enhanced measurements
  - accelerometry
  - gravimetry
  - inertial navigations
  - force gradiometry
  - inertial sensing

By pushing the performance of inertial sensors beyond the limitations of current devices, SQUEIS is expected to have a strong impact on all applications of high-precision atom interferometers, including tests of fundamental physics (such as the precise determination of the fine-structure constant and of the gravitational constant, test of the equivalence principle, search for dark matter and dark energy) applied physics (magnetometry, geophysics, navigation, oil and mineral extraction, and civil engineering, to name a few) and gravitational waves detection based on atom interferometers, where boosting the sensitivity can extend the number of detectable events.

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