Squeezing-Enhanced Inertial Sensing (SQUEIS)

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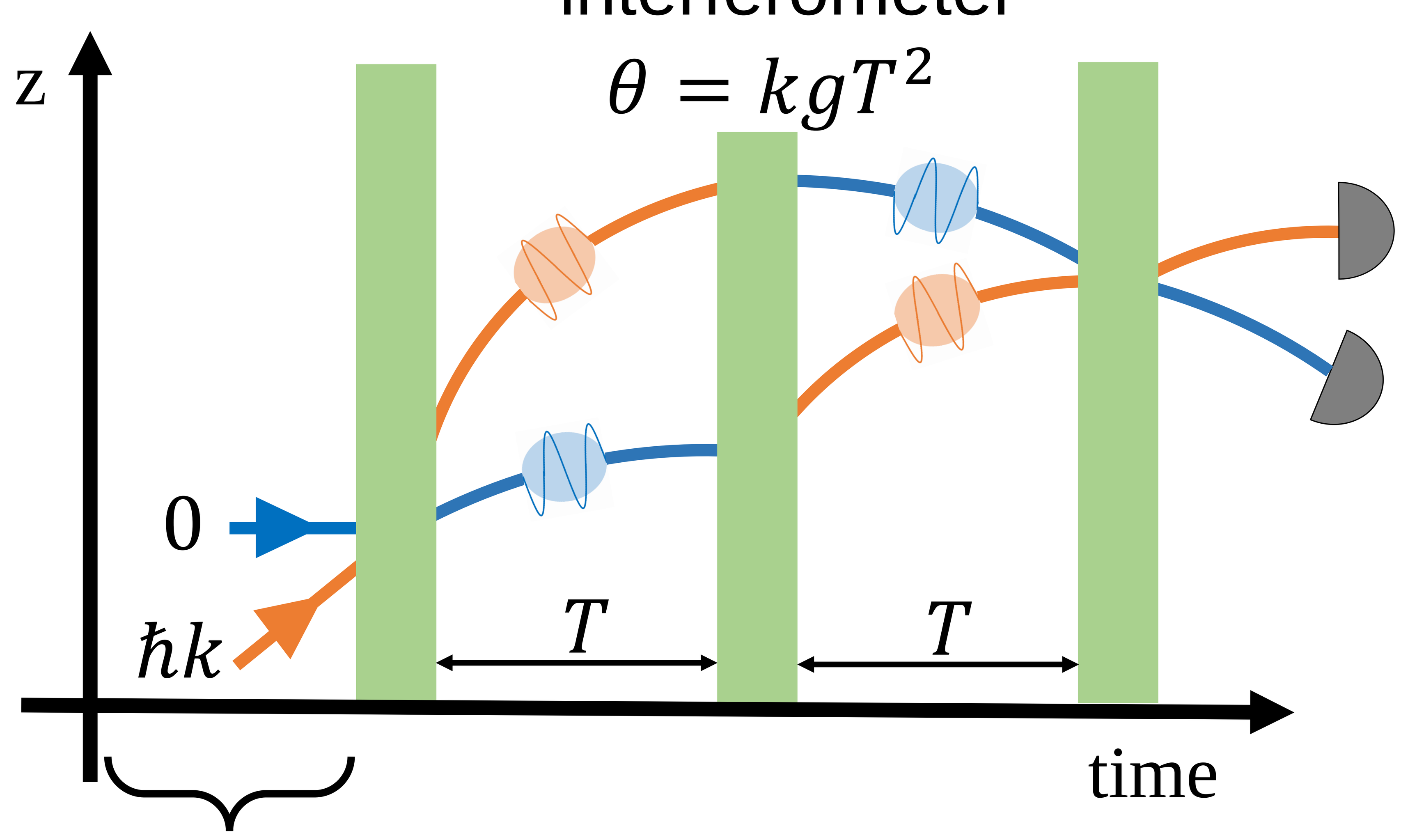
SQUEIS aims to establish new frontiers in atom interferometry by devising and applying, for the first time, entanglement-enhancement techniques based on squeezing to experiments in gravimetry, gradiometry and inertial sensing. SQUEIS explores quantum state engineering in free-fall and compact trapped 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.

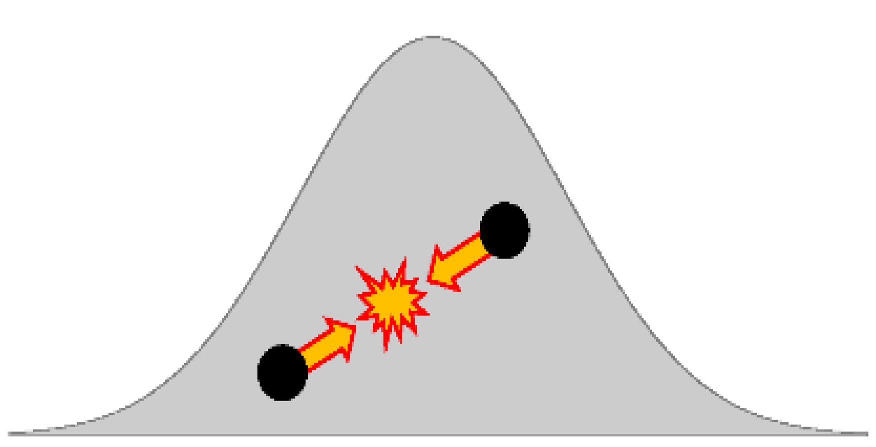
interferometer

$\theta = kgT^2$

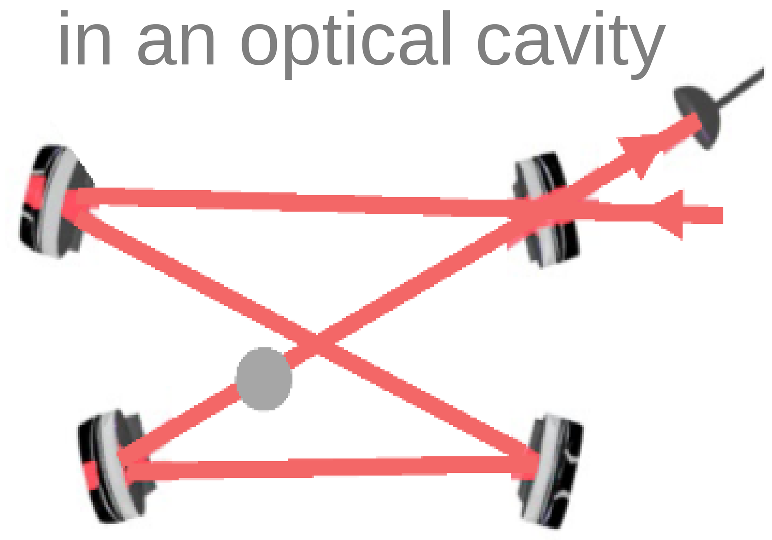


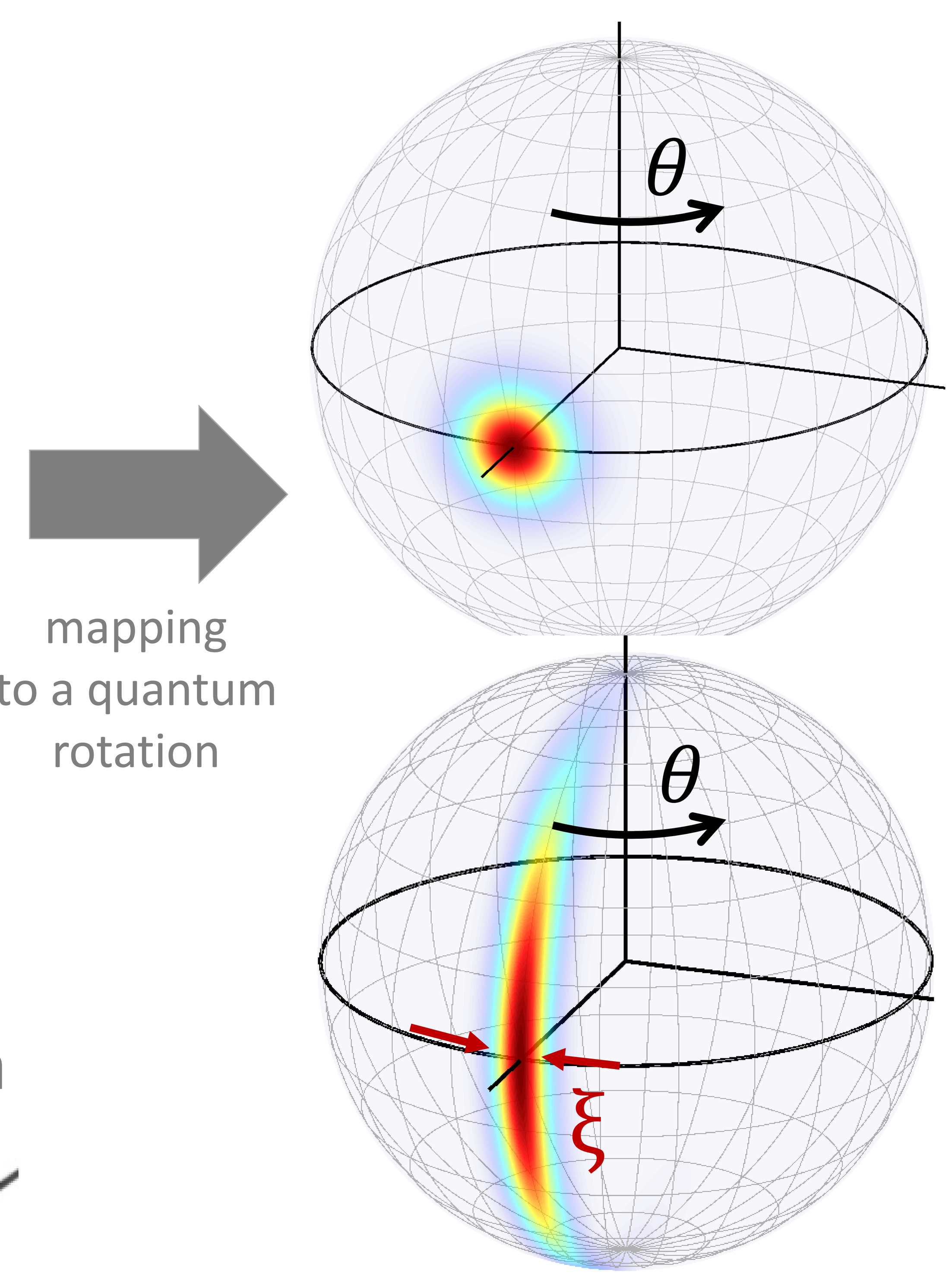
atomic squeezed-state preparation:

atom-atom interaction in a Bose-Einstein condensate



atom-photon interaction in an optical cavity





state-of-the-art

(standard quantum limit)

$$\Delta\theta = \frac{1}{\sqrt{N}}$$

SQUEIS

$$\Delta\theta = \frac{\xi}{\sqrt{N}} < \frac{1}{\sqrt{N}}$$

ξ^2: -2 to -10 dB

The achieved sensitivity gain ξ 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 → squeezed states →

advanced readout techniques → optimal detection →

metrological implementation of squeezing → 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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