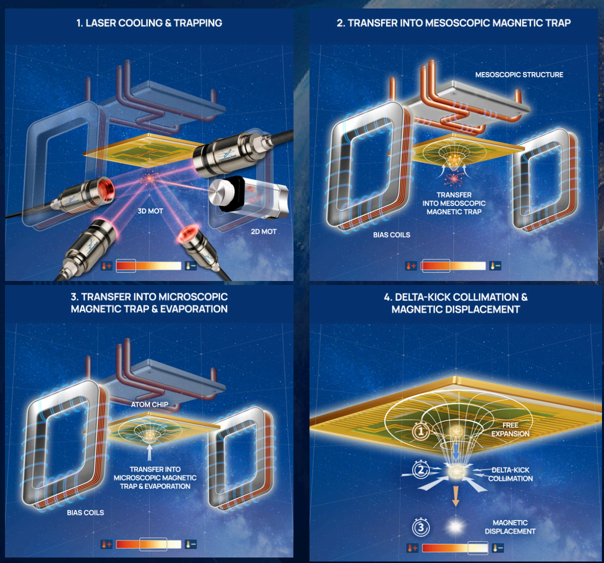
CARIOQA-PMP

CARIOQA mission technologies and key challenges related to their deployment in space

Factsheet 8: December 2025

The CARIOQA mission instrument and its specific features :

To overcome the limitations of current inertial sensors, it has become necessary to explore more sensitive technologies. Atomic interferometry, used within the CARIOQA mission, offers precisely this potential.
For this purpose, the instrument, positioned at the satellite's centre of mass, measures non-gravitational acceleration along a single axis. The quantum sensor relies on a cloud of ultracold rubidium atoms, forming a Bose-Einstein condensate, manipulated by lasers using Raman transitions. Microgravity enables a longer atomic interrogation time, significantly enhancing the targeted sensitivity (10^{-10} m/s^2/$\sqrt{\ }$Hz).



Scheme of the Bose-Einstein condensate creation and quantum state engineering

Its overall architecture comprises four main subsystems: the Physics Package (vacuum chamber, atom chip, magnetic and optical fields for atom manipulation), the laser system for cooling, interferometry and detection, the microwave source for controlling atomic transitions, and the ICPU (Instrument Control and Power Unit) for managing experimental sequences and power distribution. The entire system is designed to be compact, robust and stable, meeting the spatial constraints of vibration, microgravity and centre-of-mass positioning, in order to demonstrate the feasibility of an onboard quantum accelerometer for future space geodesy missions.

Source : "CARIOQA: definition of a Quantum Pathfinder Mission," Proc. SPIE 12777, International Conference on Space Optics – ICSO 2022, 127773L (12 July 2023)

Main challenges related to the space deployment of the instrument

The specific environment of a satellite, together with the performance expected from a future spaceborne quantum accelerometer, imposes strict requirements that demand further technological developments beyond the current state of the art.
Simulations carried out within the project show that residual rotational fluctuations of the satellite can induce phase noise in the interferometer, potentially limiting its sensitivity. These results demonstrate that, for a cold-atom interferometer operated in space, it is essential to design a highly accurate rotation-compensation system in order to avoid loss of contrast, since reduced contrast makes the interference fringes less distinguishable and therefore limits the precision with which the phase can be extracted, ultimately degrading the overall sensitivity of the instrument.

Source : Rotation related systematic effects in a cold atom interferometer onboard a Nadir pointing satellite. NPJ Microgravity. (2023)

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