What is a quantum inertial sensor?

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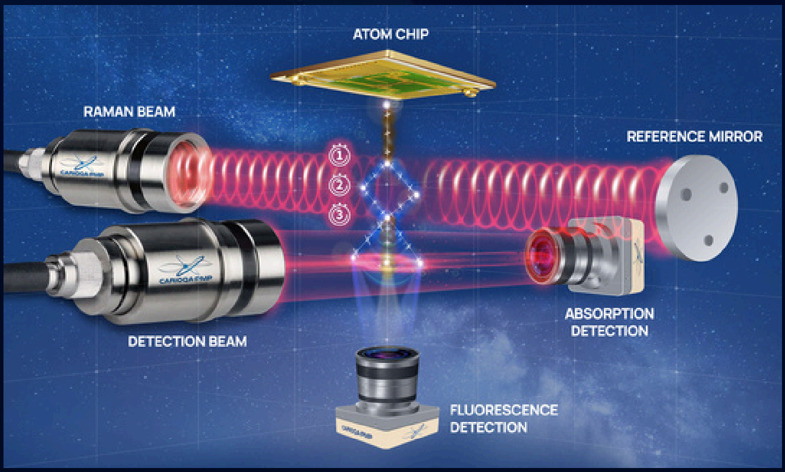
What are inertial sensors ?

Inertial sensors are a large family of apparatus that enable to measure the motion. They are mainly split between accelerometers that provide acceleration measurements [in m.s-2] and gyroscopes that provide rotation rate measurements [in rad.s-1].
From basic smartphones to aircrafts and satellites, these sensors are essential to a large scale of applications. CARIOQA-PMP intends to develop an accelerometer in which the measurement is based on a new promising quantum technology. This apparatus would be particularly useful to measure and map the global Earth's gravity field from satellites.

Cold atoms: a reference for motion measurement

The principle of an accelerometer consists in measuring the motion of the instrument with respect to an internal reference (called inertial frame) which is, as far as possible, isolated from any acceleration. The choice of this inertial reference is determining for the sensitivity and the accuracy of the measurement.
In the quantum inertial sensors developed in CARIOQA-PMP, the reference for the acceleration measurement is a Bose-Einstein Condensate (BEC). This BEC is an atomic cloud of Rubidium, cooled down to the temperature of 100 pK (i.e. the coldest state of the matter).
On-board the satellite, this atomic cloud will be completely isolated from any external forces, except gravity, and therefore perfectly free-falling. The accelerometer will then measure the acceleration between the satellite frame and this BEC, used as an inertial reference.

BEC key figures :
Number of atoms: **100000** atoms of rubidium
Temperature: **0,000000000001** K
Size: **0,01** mm



Atom Interferometry: A sensitive way to measure the motion

Atoms are quantum particles whose nature is both corpuscular and wave. In the CARIOQA-PMP instrument, the atoms that constitute the BEC are so cold that their wave behavior is particularly exacerbated. Therefore, it becomes possible to realize interferences with the wave-packets associated to the atoms. The result of these interferences (called "interference fringes") provides extremely precise information on the relative motion of the atoms with respect to the satellite, making the acceleration measurement possible. The sensitivity of this measurement will depend on the duration for which the atomic waves interferes with themselves. The longer the duration, the more precise the measurement will be. In space, the micro-gravity conditions on-board a satellite will allow to observe interference for 2 s offering a promising sensitivity of the order of 0.0000000001 m.s-2 comparable to the state-of-the-art space instruments and paving the way for further improvements.

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