Strapdown quantum sensor for Inertial Navigation

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Ixatom's team is a joint collaboration between the LP2N laboratory and the company Exail.
We are developing a new strapdown inertial navigation unit. By measuring acceleration to determine position, this device assists navigators in staying on course. This vehicle-mounted device could also be used for global gravity mapping.

Classical devices suffer from measurement bias, which necessitates regular calibration. By using atoms for the measurement of acceleration, we can obtain an absolute measure and thus providing our system with better accuracy and long term stability. Since the bandwidth of the atomic sensor is limited, we use a combination of classical and quantum accelerometers to produce the final measurement of acceleration.

We use atomic interferometry with counter-propagating pulses acting as mirrors and splitters operations like in a Mach-Zehnder interferometer. We are able to split and separate a cold cloud of rubidium atoms into 2 paths before recombining them. Finally, we observe the ratio of atoms in each of the two internal states. This ratio reveals the phase shift accumulated between the two paths due to external forces like gravity or rotation.

One challenge is that the vibrations of the mirror used for the counter-propagating pulses induce a parasitic phase shift, leading to significant measurement errors. The standard solution is to measure precisely the acceleration of the mirror and deduce the phase contributed by the vibrations.

Our system is able to achieve in static position an accuracy of $500ng$ and a long-term stability of $200ng$ for approximately 3 days, but in dynamic conditions thus stronger vibrations we need a better comprehension of the measurement errors associated with the mirror's acceleration.

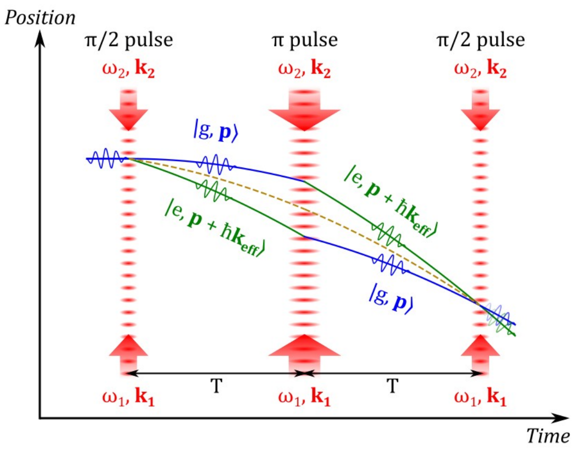

Figure 1: Scheme of the space time evolution of the atoms wave function during the interferometer under a gravitational field [1]

Reference :
[1] *Quentin d'ARMAGNAC de CASTANET (2023). Rotating Atom Interferometer for Onboard Quantum Accelerometry [Thesis]. University of Bordeaux.*