MULTI-SPECIES COLD ATOM INTERFEROMETRY FOR INERTIAL MEASUREMENTS

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Abstract

Using wave properties of matter, cold atoms can become tiny quantum sensors with high stability and sensitivity to inertial quantities, such as rotation or acceleration. The principle is the following: an atomic cloud is laser cooled (a few μK) in a magneto-optical trap and then free fall in an ultra-high vacuum chamber, submitted to the Earth gravity g. While they're falling, the atoms are probed with lasers in a so-called interferometry sequence: carefully-tuned laser put in place π and $\frac{\pi}{2}$ pulses and transfer momentum to the atoms which results in the matter wave being separated, deflected and recombined, as in a Mach-Zehnder interferometer. At the end of the sequence, one can get the value of g by measuring the phase of the atoms, by fluorescence.

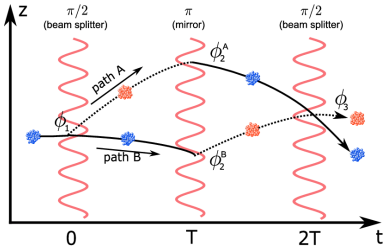

Figure 1: Mach-Zehnder atom interferometer sequence

Contrary to their classical counterpart, cold-atom accelerometers suffer from dead times between each measurement and a limited measurement range. However, they do benefit from an unrivalled stability and allow to perform absolute measurements [1]. Since classical and atomic sensors have complementary strengths and weaknesses, they're both commonly combined to create hybrid sensors. But there could be another way to make the best of the atomic accelerometer: manipulating different atomic species simultaneously [2].

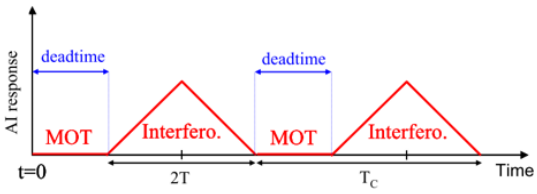

Figure 2: Acceleration sensitivity function of a single species gravimeter

Indeed there are insightful configurations using 3 atomic species(Rb^{85}, Rb^{87} and Cs^{133}) instead of one. One could decrease dead times by "juggling" between the 3 species such that while one is being laser-cooled, the other is free-falling and the third species is being detected. Another configuration could enable simultaneous 3D acceleration measurements. The challenge is to set up ingenious configurations to exploit the full potential of the triple species gravimeter.

References

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[2] Alexis Bonnin, Clément Diboune, Nassim Zahzam, Yannick Bidel, Malo Cadoret, and Alexandre Bresson. New concepts of inertial measurements with multi-species atom interferometry. *Applied Physics B*, 124(9), August 2018.