Toward inertial guidance and navigation with cold atoms

Barrett Brynle[1], Cheiney Pierrick[1], Templier Simon[1], Battelier Baptiste[2], Napolitano Fabien[1], Bouyer Philippe[2]

1. iXblue
2. Institut d'Optique Graduate School

High-sensitivity, low-drift inertial sensors based on cold-atom interferometry are poised to revolutionize the field of inertial guidance and navigation. Recently, matter-wave accelerometers have been deployed in moving vehicles, both in air [1,2] and on the sea [3], and have demonstrated outstanding performance. Yet many challenges still remain before navigation with these devices can be realized. For instance, due to the slow data rate of atom interferometers, and the large bias drifts of mechanical accelerometers, hybridization between the two sensors will almost certainly be necessary [4]. In this talk, we present recent results on the hybridization of classical and quantum accelerometers in harsh environments by correlating the output of each sensor. Utilizing an optimal Kalman filter to estimate the full fringe pattern on each shot [5], we show that this method out-performs traditional least-squares sine fitting over the full band of phase noise. Finally, we discuss other ongoing work that is aimed at realizing quantum-aided navigation with cold atoms.

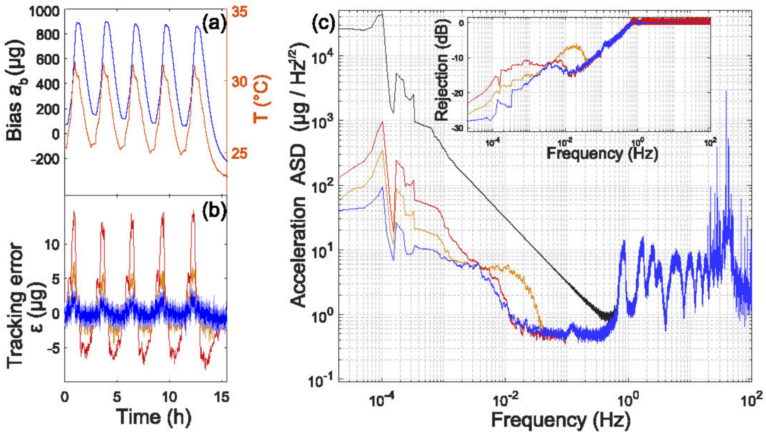

Figure 1: Results from a hybrid quantum-classical accelerometer in the presence of large bias variations and strong vibration noise. (a) Mechanical accelerometer bias determined by the Kalman filter algorithm (blue) and the sensor's temperature (red) as a function of time. The temperature modulation produces large bias variations of ~1 mg. (b) Bias tracking error using the Kalman filter (blue), and by sine-fitting with stacks of 8 (brown) and 25 (red) points. For the Kalman filter, the RMS value of the bias tracking error is 0.89 μg, while for the sine-fitting method this error increases by 4.1 dB and 8.2 dB for stacks of 8 and 25 points, respectively. (c) Amplitude spectral density of the standalone (black) and the hybrid accelerometers using the Kalman filter (blue), and sine-fitting with stacks of 8 (brown) and 25 (red) points. At low frequencies, the error rejection (inset) corresponds to a first order high-pass filter, and the Kalman filter out-performs the sine-fitting method over the full frequency band.

References:

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