Multi-axis inertial sensing with 2D-BEC arrays

K. Stolzenberg, C. Struckmann, S. Bode, A. Rajagopalan,
A. Herbst, D. Thomas, E. M. Rasel, N. Gaaloul, and D. Schlippert
Leibniz Universität Hannover, Institut für Quantenoptik,
Welfengarten 1, 30167 Hannover, Germany
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Single Mach-Zehnder type atom interferometers are commonly limited to a single sensitive axis for measuring accelerations. Expanding the dimensionality can only be achieved by subsequent measurements, sensor fusion with classical accelerometers or by utilising thermal clouds in point source atom interferometers.
By introducing 2D arrays of Bose-Einstein condensates and pairing them with Mach-Zehnder type atom interferometry driven by double-Bragg diffraction, we were able to measure acceleration, rotation rates and rotational accelerations simultaneously [1]. We furthermore envision our method as versatile tool for simple, high-precision multi-axis inertial sensing in dynamic environments.
The size of the array is 3×3 covering an area of $1.6\,\mathrm{mm}^2$ and it is initialised in a crossed optical dipole trap (ODT) featuring two 2D acousto-optical deflectors. Subsequently we release the array from the ODT and perform horizontal atom interferometry, inducing rotations by tilting the reference mirror thoughout the interferometer sequence using an amplified piezo. We scan the evolution time T and correlate the rows and the columns of the array, extracting the differential phases incorporating the three above mentioned inertial observables. In particular, we were able to reconstruct the tilting trajectory of the mirror. As of now the sensitivity of the single interferometers is limited to $6 \times 10^{-4}\mathrm{m\,s^{-2}}$, due to maximum achievable pulse separation times of $T < 5\,\mathrm{ms}$.

[1] K. Stolzenberg, C. Struckmann, S. Bode, R. Li, A. Herbst, V. Vollenkemper, D. Thomas, E. M. Rasel, N. Gaaloul, and D. Schlippert, “Multi-axis inertial sensing with 2d arrays of bose einstein condensates,” (2024), arXiv:2403.08762 [physics.atom-ph].