Atom Interferometer Observatory and Network: towards enhancement of large momentum transfer for fundamental physics

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In cold atom interferometry, momentum kicks from laser pulses are used to separate and recombine atomic matter waves. Due to their exceptional sensitivity as an inertial sensor, modern atom interferometers have significance for use as both probes of fundamental physics and for commercial sensing applications. The Atom Interferometer Observatory and Network (AION) project[1] is a consortium focused on the construction and operation of very-long-baseline atom interferometers as probes for ultra-light dark matter and mid-frequency gravitational waves. Working as a consortium has facilitated the parallelised development of five ultra-cold strontium labs towards state-of-the-art performance[2].

As part of the AION consortium, we are investigating the application of large momentum transfer (LMT) for atom interferometry. This technique enhances the interferometric sensitivity by increasing the momentum transfer to induce a larger separation between the two paths of the atomic wavefunction. The sensitivity goals for AION require a momentum separation of over 10,000 $\hbar k$ which is an improvement of two orders of magnitude from the current state-of-the-art for strontium[3]. This will require the use of various advanced techniques simultaneously, such as pulse engineering, wavefront control and the use of hybrid schemes which benefit from the use of both the long-lived 698nm clock transition and the strongly coupled 689nm intercombination transition. In my talk, I will provide an overview of AION and the experimental progress towards LMT we have achieved thus far. Additionally, I will describe our theoretical exploration of LMT, which includes two respective modelled proposals which could enable state-of-the-art LMT: polychromatic atom optics[4] and circulating pulse cavity enhancement[5].

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