Long Baseline Molecular Interferometry

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High-mass matter-wave interferometry is of interest due to the uniquely macroscopic nature of the quantum wave-functions produced as well as the range of sensitive sensing applications for which it is well suited. On the fundamental side, matter-wave interferometry enables new tests of the equivalence principle [1] and spontaneous collapse models [2], and is potentially even sensitive to a certain class of dark matter particles [3]. On the more applied side, interference with molecules allows for sensitive measurements of molecular properties in free flight. By measuring the deflection or reduction of the interference fringes due to electric, magnetic or optical fields, the associated molecular properties can be measured with a high level of precision [4].

We report on the development and first results of the Long Baseline Universal Matter-wave Interferometer (LUMI) in Vienna. LUMI is a near-field, Kapitza-Dirac-Talbot-Lau type interferometer [5] with a baseline of two meters. The order of magnitude increase in length over previous molecular interferometers should allow the experiment to demonstrate interference of particles beyond 100,000 amu. The connection between mass and length in Talbot-Lau type interferometers arises due to the Talbot condition, $L_T = d^2/\lambda$, where λ is the de Broglie wavelength. The interferometer length also makes LUMI more sensitive for metrological applications.

LUMI has recently shown its first high contrast interference signal with C60 and C70 fullerenes beyond the 40th Talbot order. This has allowed for the fine-alignment of the interferometer and preliminary metrology experiments which already indicate an improvement in resolution and accuracy. The strong fullerene signal also provides a testbed for the development of techniques required for reaching interference of molecules and clusters of up to 100,000 amu, such as compensation of the Coriolis effect.

References

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