# A universal matter-wave interferometer with optical gratings in the time domain

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Over the last century matter-wave interferometry has been an enormously growing research field. New experimental schemes and setups have been developed. On the one hand, atomic matter-waves have been coherently split, guided and recombined [1] with laser pulses for up to 0.5 seconds with a separation distance of 8.8 mm. On the other hand, high contrast interference patterns of massive molecules (6910 amu, consisting of 430 atoms) have shown that quantum superposition of complex structures with more than 1000 internal degrees of freedom can be realized [2]. New experimental advances have allowed us to devise new molecular sources [3], interferometer arrangements [4], diffraction structures [4] and detection methods [3] that enable new experiments to test the linearity of quantum mechanics for massive macroscopic particles. Our recent demonstration of the all optical time-domain ionizing matter-wave (OTIMA) interferometer [4] showed the merits of time-domain interferometry for complex particles. Grating structures made by standing light waves, unlike material gratings, don't create dispersive potentials (particle-grating wall interaction - van der Waals force), which were up to now a main drawback for matter-wave interferometry with massive molecules. Standing light waves of $\lambda = 157$ nm ionize the neutral particles in the antinodes and form a transmission grating in time and space. The optical ionization gratings in the VUV range are nearly independent of any specific internal level structure and are therefore universal applicable. These pulsed gratings are applied three times with a well-define pulse delay on the free falling molecules in order to prepare a sufficiently wide spatial coherence (1st grating), to diffract them (2nd grating) and to resolve/detect the appearing interference pattern (3rd grating). In time-domain interferometry, quantum interference is not only imprinted in the sinusoidal interference pattern but also in the mass dependent transmission through the interferometer, which strongly depends on the delays between the laser gratings. On the applied side, time-domain interference patterns are not influenced by the particles velocities and provide therefore a tool for velocity-independent high-precision deflectometry experiments.

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[4] T. Juffmann et al. Nature nanotechnology 7, 297–300 (2012)