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Matter-Wave Interferometer for Large Molecules

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We demonstrate a near-field Talbot-Lau interferometer for C_{70} fullerene molecules. Such interferometers are particularly suitable for larger masses. Using three free-standing gold gratings of 1 μm period and a transversally incoherent but velocity-selected molecular beam, we achieve an interference fringe visibility of 40% with high count rate. Both the high visibility and its velocity dependence are in good agreement with a quantum simulation that takes into account the van der Waals interaction of the molecules with the gratings and are in striking contrast to a classical moiré model.

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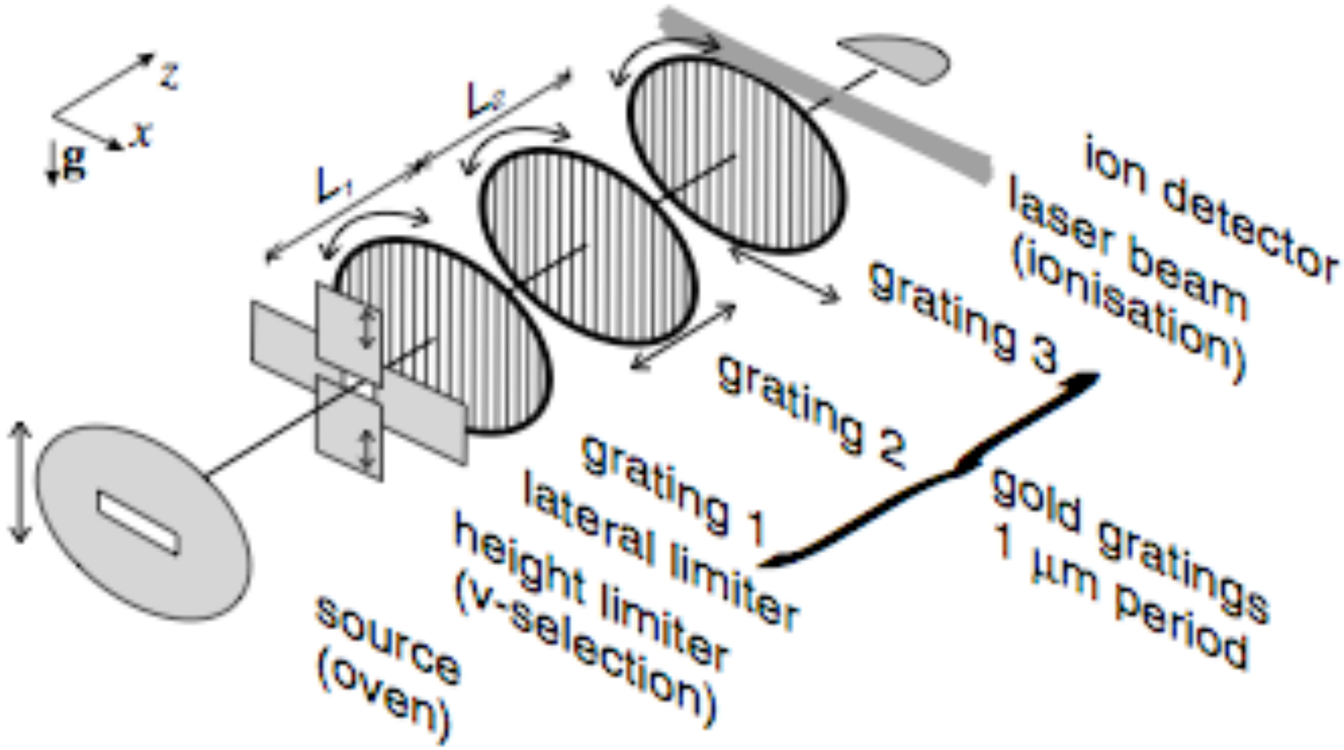
The fullerene "Bucky ball" molecule

Fig. 2. The fullerene molecule C_{60}, consisting of 60 carbon atoms arranged in a truncated icosahedral shape, is the smallest known natural soccer ball.

De Broglie wavelength ~pm impractical for conventional interferometry



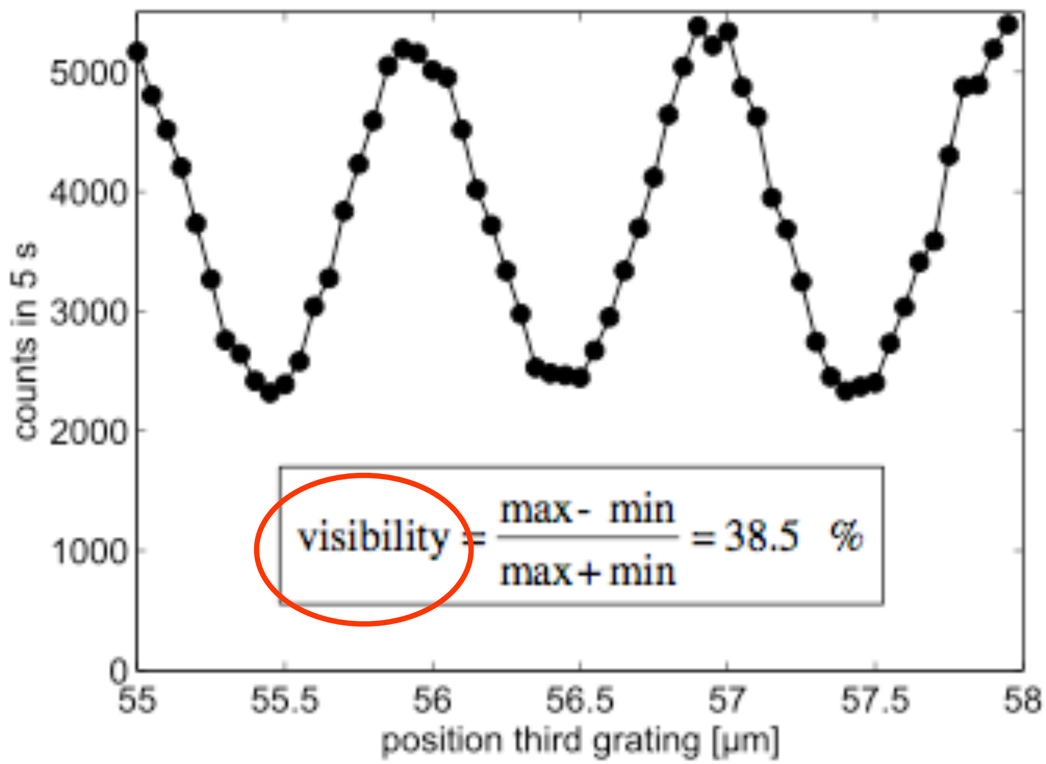
oven T=650 °C , v_p = 200 m/s

oven to detection plane 2.4 m

distance between gratings 0.22 m

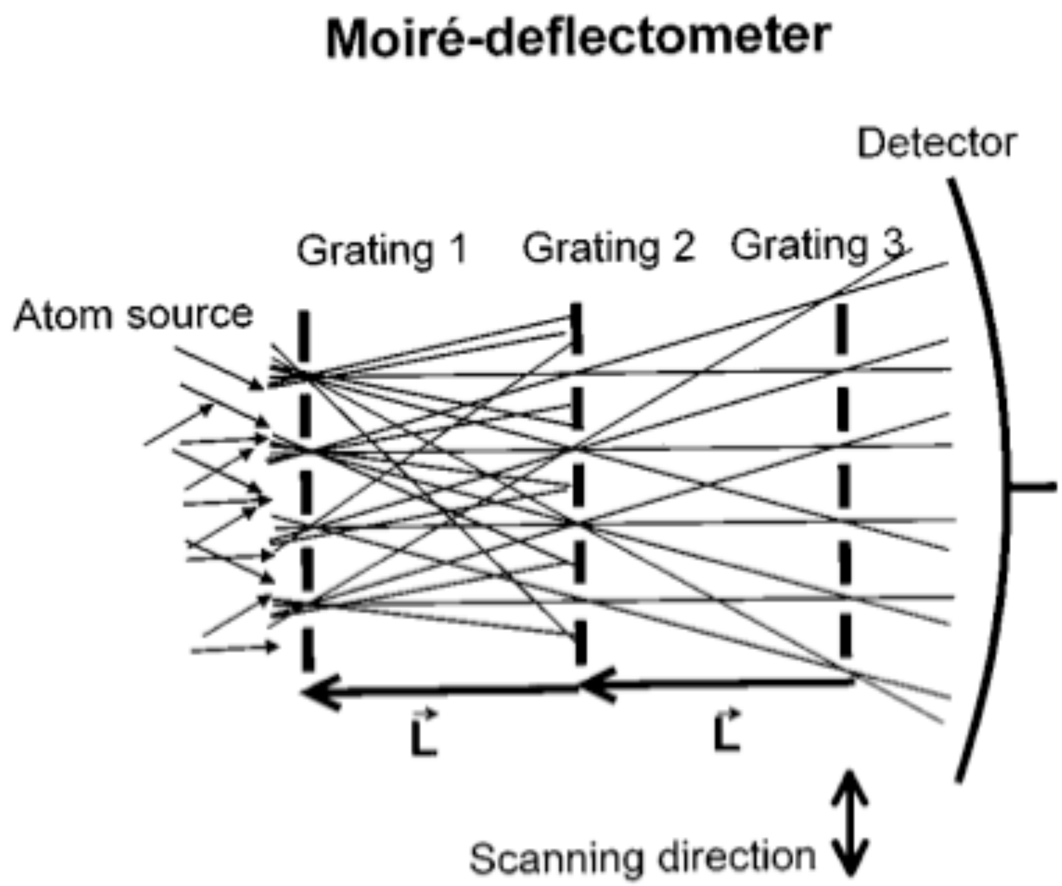
gold gratings with d=990 nm

Observed Counts versus Position



v=115 m/s

Classical (Geometric) Trajectories Produce an Image of Gratings



Observed sine-wave pattern does not prove that Quantum interference has been observed.

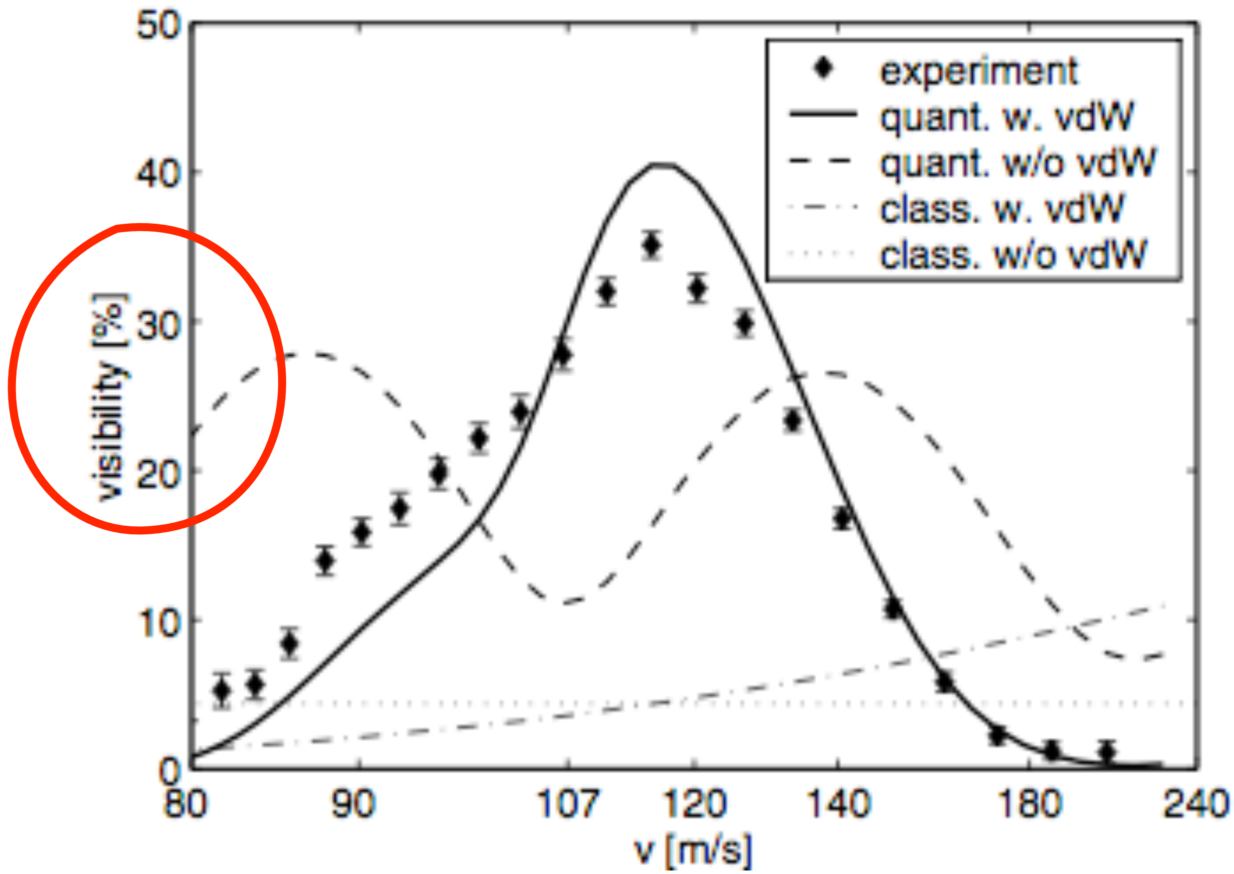
must demonstrate $p=h/\lambda$

Pattern produced by geometrical trajectories will not depend on velocity (weak dependence on v due to van der Waals force)

Classical ballistic trajectory used to select speed of molecules

$80 < v_p < 215$ m/s
$5.9 < \lambda < 2.2$ pm

Quantum interference is observed by dependence on velocity (de Broglie wavelength)



QM calculation includes van der Waals (vdW) interaction between molecules and grating modeled as a r^{-3} potential