In its upcoming issue the science magazine ***Nature Physics*** (Advance Online Publication) will publish the article:

A Kapitza-Dirac-Talbot-Lau interferometer for highly polarizable molecules

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*The article describes the implementation of a new **interferometer for matter waves**. The novel experimental design enables the study of wave-particle dualism with objects in an unpredecented region of mass and complexity. As a first result, a new world record was achieved for showing that azobenzene derivatives closely obey the rules of quantum physics on their way through the experiment. These molecules are in fact **four times longer** than the Fullerene C_{70} which was utilized in previous experiments of the Viennese scientists, **making the new particles the currently most-extended molecule chains world-wide to show quantum interference.***

The theory of quantum mechanics constitutes a cornerstone of modern physics and is probably the most accurate theory mankind has so far created to describe the structure of our universe. Many features inherent to quantum mechanics, however, stand in striking conflict to our intuition and to our everyday experience.

A central element of quantum physics is the principle of superposition. It implies that matter under certain experimental conditions behaves like a wave and may *delocalize*. In general, it is therefore not possible to describe the center of mass of a molecule as a spatially well defined spot. In fact, experiments can be realized where the center of mass is delocalized over a distance thousand times longer than the diameter of the molecule itself. In this case, the propagation of the molecule is described by a spatially extended wavefunction. This can be demonstrated experimentally via interference, that is the annihilation and amplification of the nodes and antinodes of the quantum wavefunction that occurs when the wave encounters a spatially modulated obstacle, for example when it simultaneously penetrates multiple slits of a grating.

Although quantum theory is believed to be valid on all scales, such delocalization has never been observed with macroscopic objects – a person just cannot simultaneously walk through two doors that are separated by 1000 meters. But what makes the difference between microscopic and macroscopic objects and under which circumstances is it possible to snatch a glance on the quantum nature of the latter?

The Viennese team of scientists led by Markus Arndt is investigating these questions: ”How large, heavy and complex may an object be that still obeys the rules of quantum mechanics?”

The difficulty of such experiments is routed in the smallness of the wavelength which decreases with higher masses. In the Viennese experiments the researchers have to deal with wavelengths only a billionth of a millimeter and a thousand times smaller than the molecules themselves.

Extremely precise grating structures are required to manipulate such tiny quantum waves. The gratings employed in the experiment in Vienna were manufactured by Tim Savas at the Massachusetts Institute of Technology, Cambridge, USA. The production process had to assure that the mean spacing of the grating slits is accurate to within the radius of a single hydrogen atom!

As a consequence of their polarizability, heavy molecules often tend to stick together. In order to create intensive beams of massive particles anyhow, new molecules, which are highly volatile despite their large length, were specially synthesized in the group of chemist Marcel Mayor at the university of Basel.

The explanatory power of experimental results is highly dependent on the availability of a precise, quantitative prediction, which was provided via a fruitful collaboration with the theoretical physicist Klaus Hornberger of the LMU Munich.

A major challenge on the side of experimental quantum physics was due to the fact that large molecules are subject to strong interaction with other matter in their vicinity - a property that severely impedes the detection of quantum behavior.

The team of physicists around Markus Arndt has now for the first time found a way to overcome this handicap:
Stefan Gerlich, Lucia Hackermueller and their colleges developed a new type of interferometer around a “bright” idea: they utilize a grating made solely of laser light instead of matter and thereby avoid the perturbing interaction between the molecules and the grating walls.

The physicists verified that this concept does not only work, but by far supercedes the capability of all previous designs by demonstrating quantum interference of azobenzene derivatives, the most-extended molecule chains ever to show quantum interference – and yet these particles are still on the lower end of the capability of the new device!

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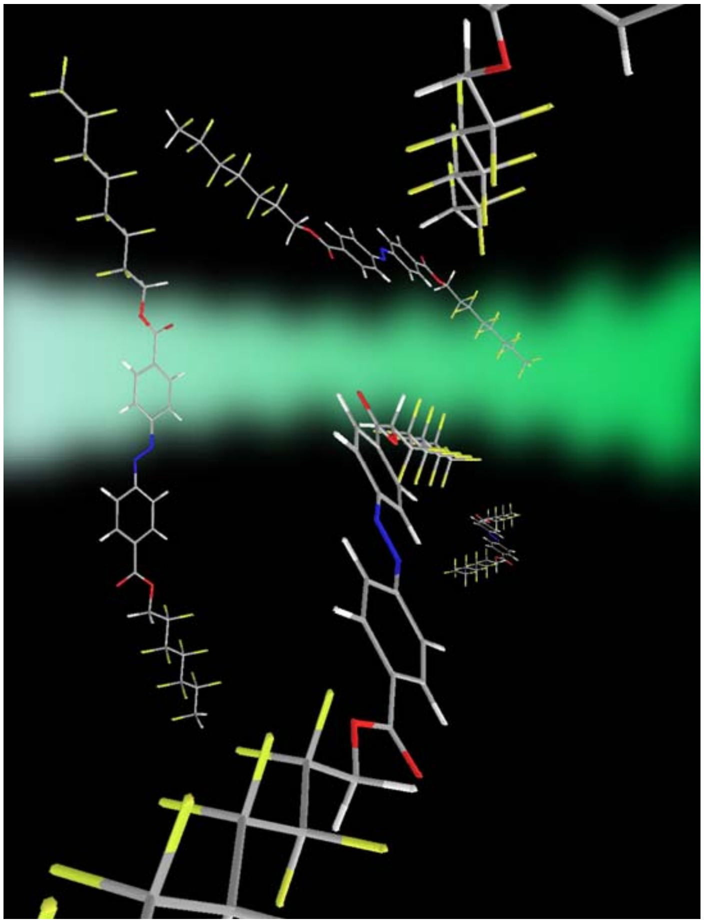
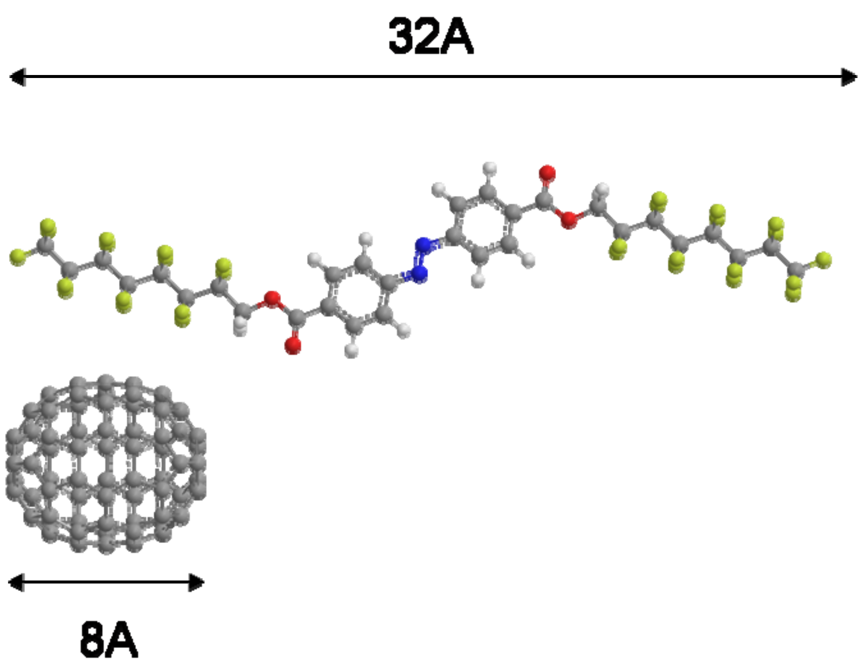
Dr. Tim Savas :http://www.rle.mit.edu/contact/contact_maps.html

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