Q 45: Materiewellenoptik

Zeit: Donnerstag 14:00–15:45 Raum: 3G

Q 45.1 Do 14:00 3G

Matter wave interferometry on potassium molecules — •Sha Liu, Ivan Sherstov, Horst Knöckel, Christian Lisdat, and Eberhard Tiemann — Institut für Qantenoptik, Gottfried Wilhelm Leibniz Universität Hannover, 30167 Hannover, Deutschland

We operate a matter wave interferometer on K_2 molecules in a Ramsey-Bordé configuration. The two exits of this interferometer with molecules in either the excited state or the ground state, give complementary detection schemes for the interference signal. Under certain geometric conditions, observed interference signal is composed of two interference patterns, the Ramsey interference formed by two laser beam splitters, the Ramsey-Bordé interference pattern with four laser beam splitters. These two interference patterns can be separated in frequency domain. For a better understanding, we observe Ramsey fringe alone directly and analyze the contrast dependence on the transversal velocity distribution. The Ramsey-Bordé interferometer will be used in further applications, thanks to its higher phase stability compared to the Ramsey interference. By introducing a near resonant laser field to the molecules in either the excited state or the ground state between the beam splitters, the transition matrix element can be determined. Furthermore, by changing the collision characteristics of the K atoms in the K_2 molecular beam, the collision between potassium atoms and molecules can be investigated. The density of K atoms is varied by deflecting atoms through resonant laser field out of the molecular beam. The actual status of the experiment will be presented.

Q 45.2 Do 14:15 3G

Diffraction of helium atom beams from a micro-structured reflection grating — •Bum Suk Zhao[1], Stephan Schulz[2], Gerard Meijer[1], and Wieland Schöllkopf[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany — [2]Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, 89069 Ulm, Germany

We have observed high-resolution diffraction patterns of a thermal-energy helium-atom beam reflected from a micro-structured surface grating at grazing incidence. The grating has a periodicity of 20 μm and consists of 10-μm-wide Cr stripes patterned on a quartz substrate. Fully-resolved diffraction peaks up to the 7-th order are observed at grazing incidence angles up to 20 mrad. With changes in de Broglie wavelength or incidence angle the relative diffraction intensities show significant variations which are attributed to the atom-surface Casimir-van der Waals potential. In addition, the overall probability of coherent reflection is found to increase with increasing de Broglie wavelength and decreasing incidence angle. We discuss whether this behavior indicates quantum reflection at the long-range attractive branch of the atom-surface potential.

Q 45.3 Do 14:30 3G

Matter wave Talbot-Lau interferometry beyond the eikonal approximation — •Stefan Nimmrichter[1,2] and Klaus Hornberger[1] — [1]Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München — [2]Physikalisches Institut, Universität Wien

We present a generalized phase-space description of matter wave Talbot-Lau interference experiments allowing to incorporate arbitrary grating interactions and realistic beam characteristics. These setups are being used to demonstrate the wave nature of complex molecules [1,2]. Typically they consist of three gratings and operate in the near field regime where the different diffraction orders interfere among each other. Unlike in far field diffraction, the interaction between the interfering particle and the grating crucially affects the interference contrast. The eikonal approximation used so far is expected to cease to be valid in upcoming experiments with more massive particles. Our theoretical model admits a general description of the grating interaction process using scattering theory. Based on this, we develop a semiclassical correction to the eikonal approximation.

[1] L. Hackermüller et al, Phys. Rev. Lett. 91, 090408 (2003)
[2] S. Gerlich et al, Nature Physics 3, 711 (2007)

Q 45.4 Do 14:45 3G

Bell test for the motional state of free massive particles — •Clemens Gneiting and Klaus Hornberger — Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München

We propose a simple and robust way of generating and verifiying entanglement in the motional state of two free, macroscopically separated atoms. It is based on the concept of 'dissociation-time entanglement', allowing to formulate a special type of continuous variable entanglement in a two-dimensional state-space in analogy with the entangled spin-singlet state. We describe an interferometric setting, based only on linear elements of matter-wave optics, which reflects the general spin measurements required in the original spin-based Bell experiment. It thus allows to verify the entanglement by the violation of a Bell inequality using only single-particle interference without post-selection. The dissociation-time entangled state can be generated by the Feshbach-induced dissociation of a molecular BEC. In particular, the shape of the magnetic pulse can be used to taylor the generated wave packets as to minimize the effect of dispersion.

Q 45.5 Do 15:00 3G

Decoherence in atom interferometry — •Scott Sanders[1,2,3], Florian Mintert[2,3], and Eric Heller[2] — [1]Massachusetts Institute of Technology, Cambridge, MA, United States — [2]Harvard University, Cambridge, MA, United States — [3]Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

We consider decoherence of an atom due to scattering from a free gas. Our analysis explains why a free gas can serve as a refractive medium that gives rise to a phase shift in atom interferometry, without acquiring which way information on the interfering particles.

Q 45.6 Do 15:15 3G

The relevance of internal states in molecular de Broglie interferometry — •Michael Gring[1], Stefan Gerlich[1], Lucia Hackermüller[1,4], Klaus Hornberger[2], Hendrik Ulbricht[1], Marcel Müri[3], Jens Tüxen[3], Marcel Mayor[3], and Markus Arndt[1] — [1]Faculty of Physics, University of Vienna, Boltzmanngasse 5, A-1090 Wien, Austria — [2]Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München, Theresienstrasse 37, 80333 München, Germany — [3]University of Basel, Department of Chemistry, St Johannsring 19, CH-4056 Basel, Switzerland — [4]Present address: Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55099 Mainz, Germany

We present recent matter wave interferometry results with perfluoroalkyl-functionalized azobenzene molecules. These long molecular chains are interesting for future decoherence and metrology experiments since they can be optically switched between two different conformers. We discuss the question under which conditions one can identify different molecular conformations using the Kapitza-Dirac-Talbot-Lau interference scheme that was recently developed in our group. We further examine the influence of state-dependent molecular properties such as the polarizability or dipole moment on the interference pattern and the experimental modifications required to reveal these properties also in various other molecular systems.

Q 45.7 Do 15:30 3G

Towards quantum optics with biomolecular clusters — •Philipp Haslinger, Markus Marksteiner, Hendrik Ulbricht, and Markus Arndt — Faculty of Physics, University of Vienna, Austria

We present recent progress towards matter wave experiments with large biomolecular clusters. All successful experiments on macromolecule interferometry so far, with fullerenes [Nature1999], fullerene derivates [PRL2003] and large perfluoroalkyl-functionalized azobenzenes [Nature2007] used effusive beam sources. In order to prepare experiments with molecules of biological interest, we have implemented a pulsed laser desorption source. The combination of UV laser desorption into an intense noble gas jet and single-photon ionization by a VUV excimer laser (157nm) allows us to observe intense neutral jets of amino acids, nucleotides and polypeptides. We recently discovered a new method for producing large and neutral amino acid-metal complexes, such as for instance Ca@Trp2...Ca@Trp30, with masses exceeding 6000 amu. The addition of alkaline Earth salts in the desorption process leads to the inclusion of at least one metal atom per complex and is sufficient to catalyze the cluster formation process. We discuss how interferometric deflectometry might help in obtaining additional information about the structure of such large molecular compounds.