Q 59: Quantum Effects: Interference and Correlations

Time: Friday 10:30–12:45 Location: SCH A01

Q 59.1 Fri 10:30 SCH A01

Measuring Quantum Superpositions of Different Structures of Ion Coulomb Crystals — •Jens Domagoj Baltrusch[1,2], Gabriele De Chiara[2,3], Tommaso Calarco[4], and Giovanna Morigi[1,2] — [1]Theoretische Quantenphysik, Universität des Saarlandes, Germany — [2]Grup d'Òptica, Universitat Autònoma de Barcelona, Spain — [3]Física Teòrica: Informació i Fenòmens Quàntics, Universitat Autònoma de Barcelona, Spain — [4]Institut für Quanteninformationsverarbeitung, Universität Ulm, Germany

We study the creation of quantum superposition states of different structural configurations in small ion Coulomb crystals by utilizing state-dependent potentials. In particular, we focus on the creation of a superposition between an ion crystal in the zigzag stable state and in the linear quantum ground state. The structural properties can be measured with the help of Ramsey interferometry [De Chiara et al. PRA 78, 043414 (2008)], whereby the visibility as a function of the time between the Ramsey pulses carries information about the autocorrelation function of the crystal. We present calculations of the visibility signal for different possible preparation methods, and discuss their experimental feasibility.

Q 59.2 Fri 10:45 SCH A01

Fidelity at quantum resonance for kicked atoms in a gravitational field — •Remy Dubertrand and Sandro Wimberger — Institut for Theoretical Physik, Heidelberg, Germany

We are interested in a generalisation of the kicked rotor system when a constant field term is added, modeling gravity in experiments. Such a difference has already shown significantly new consequences, especially the quantum accelerator modes observed by Oberthaler et al. [1]. We will first remind the pseudo-classical formalism introduced by Fishman et al. [2]. Then the fidelity of quantum kicked rotors at a quantum resonance will be derived. Lastly the experimental state of the art and our theoretical perspectives based on the mentioned pseudo-classical method along the lines of [3] will be shortly described.

[1] M. K. Oberthaler et al., Phys. Rev. Lett. 83, 4447 (1999)
[2] S. Fishman et al., J. Stat. Phys. 110, 911 (2003)
[3] M. Abb et al., Phys. Rev. E 80, 035206(R) (2009)

Q 59.3 Fri 11:00 SCH A01

Probing multimode squeezing with correlation functions. — •Andreas Christ[1,2], Kaisa Laiho[2], Andreas Eckstein[2], Katiúscia N. Cassemiro[2], and Christine Silberhorn[1,2] — [1]Applied Physics, University of Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Max Planck Institute for the Science of Light, Günther-Scharowsky Straße 1/Building 24, 91058 Erlangen, Germany

Broadband multimode squeezers constitute a powerful quantum resource with promising potential for different applications in quantum information technologies such as information coding in quantum communication networks or quantum simulations in higher dimensional systems. However, the characterization of a large array of squeezers that coexist in a single spatial mode is challenging. In this talk we tackle this problem and present a straightforward method to determine the number of squeezers and their respective squeezing strengths by using simple, broadband multimode correlation function measurements. These measurements employ the large detection windows of state of the art avalanche photodiodes to simultaneously probe the full Hilbert space of the generated state, which enables us to benchmark the squeezed states. Moreover, the measurements are loss-independent due to the structure of the normalized correlation function measurements. This is a significant advantage, since detectors with low efficiencies are sufficient. Our approach is less costly than full state tomography methods relying on multimode homodyne detection which builds on much more demanding measurement and analysis tools and appear to be impractical for larger Hilbert spaces.

Q 59.4 Fri 11:15 SCH A01

Decoherence effects in quantum walks: From ballistic spread to localization — •Andreas Schreiber[1], Katiúscia N. Cassemiro[1], Václav Potocek[2], Aurél Gábris[2], Igor Jex[2], and Christine Silberhorn[1,3] — [1]MPI for the Science of Light, IQO Group, Erlangen, Germany. — [2]Department of Physics, FNSPE, Czech Technical University in Prague, Praha, Czech Republic. — [3]University of Paderborn, Applied Physics, Paderborn, Germany.

Quantum walks describe the evolution of quantum particles in a discretized environment. This universal model serves not only as an explanation for coherent procedures in nature, like the energy transport in photosynthesis, but also offers a foundation for a new type of quantum computing. In both scenarios it is crucial to investigate the impact of decoherence on the system.

Here we present an all optical implementation of an one-dimensional quantum walk with a controllable source of decoherence. We demonstrate a fully coherent spread of a photon's wavepacket in a quantum walk of up to 28 steps. Furthermore, we generated three classes of decoherence, changing the evolution to a fast ballistic quantum walk, a diffusive classical walk and the first Anderson localization in a discrete quantum walk architecture.

Q 59.5 Fri 11:30 SCH A01

Separability criterion for modular variables — •Clemens Gneiting and Klaus Hornberger — Max Planck Institute for the Physics of Complex Systems, Noethnitzer Str. 38, 01187 Dresden

In the spirit of Young-type interference experiments in the single-particle case, one can establish bipartite entanglement in the motion of material particles by nonlocal spatial interference patterns. I introduce a natural class of non-Gaussian states which yield such nonlocal interference patterns under position measurements and violate a suitable separability criterion. The latter is formulated in terms of modular variables, a concept adapted to interference phenomena and thus capable to capture the expressed correlations.

Q 59.6 Fri 11:45 SCH A01

Trapping particles in bent waveguides — •Emerson Sadurni and Wolfgang Schleich — Institut fuer Quantenphysik, Ulm Universitaet, Albert-Einstein Allee 11 89081 Ulm - Germany

Is it possible to trap a quantum particle in an open geometry? In this work we deal with the boundary value problem of the stationary Schroedinger (or Helmholtz) equation within a waveguide with straight segments which form a sharp angle. We show that the presence of bound states, which has no counterpart in a ray-tracing picture, originates from the diffracting boundary alone. Conformal mapping proves to be useful in the derivation of analytic results. An analogy with a problem involving rigid molecules is established.

Q 59.7 Fri 12:00 SCH A01

Many-particle Quantum Walks — •Klaus Mayer[1], Malte C. Tichy[1], Florian Mintert[1,2], Thomas Konrad[3], and Andreas Buchleitner[1] — [1]Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Strasse 3, 79104 Freiburg, Germany — [2]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität Freiburg, Albertstrasse 19, 79104 Freiburg, Germany — [3]School of Physics, University of KwaZulu-Natal, Private Bag 54001, Durban 4000, South Africa

We study quantum walks of many non-interacting particles in a beam splitter array, as a paradigmatic testbed for the competition between single-particle and many-particle interference [1].

We derive a general expression for multi-mode particle number correlation functions, valid for initially entangled or non-entangled fermions and bosons, and infer pronounced signatures of many-particle interferences in the multi-mode counting statistics. The latter permits the differentiation of mere quantum statistical from pure many-particle interference effects.

[1] K. Mayer et al., arXiv: 1009.5241 (2010)

Q 59.8 Fri 12:15 SCH A01

Single photon sources: the disastrous second photon — •Karl Otto Greulich — Fritz Lipmann Institute Beutenbergstr.11 D 07745 Jena

Double - and triple - slit experiments for confirming wave particle properties of light, or experiments on entanglement for proving non - locality strictly require single photons or single photon pairs. Often multiatom light sources such as pump lasers are involved and it is assumed that the attenuation is sufficient to safely work in the single photon limit. A few pulses containing a second photon cannot be definitely excluded, but this is often thought to be acceptable. Detailed numerical evaluation quantifies the risk that contaminating sec-

ond photons may invalidate interpretations of, at least, non - locality experiments - and perhaps also single photon double slit experiments.

1 K.O. Greulich Single molecule experiments challenge the strict wave particle dualism of light 2010 Int J Mol Sci, 11, 304 - 311

2 K.O. Greulich Another loophole for Bell inequalities 2009 Proc. SPIE 2009 7421 2301-2307

3 http://www.fli-leibniz.de/www_kog/ Then click the symbol for Physics

Q 59.9 Fri 12:30 SCH A01

Entanglement measures and interference contrast — •Federico Levi and Florian Mintert — Freiburg Institute for Advanced Studies (FRIAS), Albert-Ludwigs-Universität Freiburg, Albertstr. 19, 79104 Freiburg.

Both entanglement and interference are phenomena that display the difference between a quantum system and its classical counterpart. They both originate from the quantum superposition principle, and they have been related to each other qualitatively e.g. in interference of photon pairs [1]. However, a clear, conceptual or quantitative connection between these two features of quantum mechanics has yet to be established, and quantifications of either of these features appear rather differently; the fringe contrast provides a clear experimental quantification of interference, whereas entanglement measures are typically rather abstract and do not offer any physical insight into the nature of entanglement.

With the goal to shed some light on the relationship between entanglement and quantum interference, we aim to construct entanglement measures in terms of the fringe contrast.

[1] M.A.Horne, A.Shimony, A.Zeilinger, Phys. Rev. Lett. **62**, 2209 (1989).