SYAD 1: Symposium SAMOP Dissertation-Prize 2015

Time: Tuesday 11:00–13:00 Location: C/HSW

Invited Talk SYAD 1.1 Tue 11:00 C/HSW

Temporal quantum correlations and hidden variable models — •Costantino Budroni — Universität Siegen, Walter-Flex-Straße 3, 57068, Siegen, Germany

In classical physics, randomness can be explained by hidden, or simply impossible to control, variables, which determine the dynamics of a system. In the quantum case, several types of hidden variable models have been shown to be in contradiction with theoretical predictions and experiments.

In my talk, I first review the main approach to the characterization of the set of classical probabilities, known as the correlation polytope approach, for different scenarios, namely, hidden variable models discussed by Bell (local), Kochen and Specker (noncontextual), and Leggett and Garg (macrorealist). Then, I discuss the computational difficulties associated with the method and how to overcome them in several nontrivial cases. For the quantum case, I provide a general method to analyze quantum correlations in the sequential measurement scenario, which allows one to compute the maximal correlations. Such a method has a direct application for computation of maximal quantum violations of Leggett-Garg inequalities and it is relevant in the analysis of noncontextuality tests. Finally, I discuss possible applications of the results for quantum information tasks and a possible experimental implementation of Leggett-Garg and noncontextuality tests on cold atoms and nanomechanical oscillators.

Invited Talk SYAD 1.2 Tue 11:30 C/HSW

Towards a quantum internet — •Andreas Reiserer — Max-Planck-Institut für Quantenoptik, Garching, Germany — Kavli Institute of Nanoscience, TU Delft, Netherlands

A future quantum network will consist of quantum processors that are connected by quantum channels, just like conventional computers are wired up to form the Internet. In contrast to classical devices, however, the information that can be encoded in a quantum network grows exponentially with the number of nodes, and entanglement of remote particles gives rise to non-local correlations. Exploring these effects facilitates fundamental tests of quantum nonlocality and the quantum-to-classical transition. In addition, quantum networks can be applied in distributed quantum information processing to fundamentally enhance computational power and to ensure unbreakable encryption over global distances using quantum repeaters.

The realization of a large-scale quantum network requires an efficient interface between the nodes and channels. We have implemented such interface by trapping single atoms in optical resonators. With full experimental control over the atomic state, we have demonstrated the distribution and processing of quantum information in an elementary network consisting of two nodes. More specific, we have reversibly transferred the quantum state of a photon onto an atom, entangled distant atoms, teleported quantum states between them, nondestructively detected optical photons and demonstrated a quantum logic gate between an atom and one or several photons. These experiments pave the way for the realisation of global quantum networks.

Invited Talk SYAD 1.3 Tue 12:00 C/HSW

X-ray Imaging of Ultrafast Dynamics in Single Clusters — •Daniela Rupp — IOAP, Technische Universität Berlin

Extremely bright and ultrashort x-ray pulses from free-electron lasers have initiated new fields of research. One of the pioneering projects is capturing molecular movies, i.e. imaging single molecules and ultrafast molecular processes with atomic resolution in time and space. The most challenging task is to record a scattering image before electronic changes and ionic motion within the molecule blur the pattern. In order to approach this goal, we strive towards a profound understanding of ultrafast radiation damage. Atomic clusters have been successfully used as ideal model systems to study laser-matter interaction. We have recently developed single cluster imaging and simultaneous ion spectroscopy as a novel method delivering unprecedented insight into the FEL-induced ionization and plasma dynamics. Knowing the size of the cluster and the FEL exposure power density from the scattering patterns allows for experiments with extremely well defined initial conditions. In recent measurements at the FLASH-FEL single large xenon clusters were irradiated by intense soft x-ray pulses. The scattering images of the single clusters revealed the ultrafast built-up of an inhomogeneously charged nanoplasma. The ion spectra of the same, size-selected clusters indicate that after the interaction with the pulse, the outermost shells of the cluster blast off while most of the dense cluster plasma recombines to neutral atoms. The results emphasize how this combination of tools is able to address different timescales of a complex process and gain a more complete picture of the dynamics.

Invited Talk SYAD 1.4 Tue 12:30 C/HSW

Coherent ultrafast imaging in the extreme ultraviolet - from cancer cell classification to optical vortex generation for phase-structured illumination — •Michael Zürch — Friedrich-Schiller-University Jena, Institute of Optics and Quantumelectronics, Jena, Germany

According to Ernst Abbe, the resolution of an ideal imaging system is limited by the wavelength of the illuminating light source, which is in the order of 1μm for visible light. Recent progress in laser physics led to the development of table-top laser driven high harmonic generation sources emitting coherent radiation in the extreme ultraviolet (XUV) with sufficient photon flux for coherent imaging. The typical illumination wavelengths in the order of a few tens of nanometers turn microscopy into nanoscopy. In this talk we will report on our recent progress in coherent high-resolution imaging, reaching sub-wavelength resolution close to the Abbe limit. As a first application of such table-top XUV microscopes, we demonstrated a novel scheme to classify breast cancer cells based on their specific coherent XUV diffraction pattern. Intriguingly, this method allows distinguishing even cancer cells that just exhibit different cell expression profiles. This may soon speed up cancer diagnosis and allow monitoring the treatment more accurately. For pushing the imaging resolution even further, experimental findings for producing phase structured illumination in the XUV by generating an optical vortex beam will be discussed. Such beams may soon allow XUV super-resolution microscopy and spectroscopy of electronically forbidden transitions.