A 11: Atomic Systems in External Fields I

Time: Tuesday 11:00–13:00 Location: N 2

Invited Talk A 11.1 Tue 11:00 N 2

Dichroic Electron Emission Patterns from Oriented Helium Ions — •Niclas Wieland[1], Klaus Bartschat[2], Filippa Dudda[1], Michael Meyer[3], and Markus Ilchen[1] — [1]University of Hamburg, Hamburg, Germany — [2]Drake University, Des Moines, USA — [3]European X-Ray Free-Electron Laser Facility

We report a joint experimental and theoretical study using a combination of polarization-controlled free-electron-laser (FEL) and near-infrared (NIR) pulses in a synchronized two-color photoionization scheme. Excited He+ ions, created by extreme ultraviolet (XUV) circularly polarized radiation from the XUV-FEL FERMI in the oriented 3p (m = +1) state, are exposed to circularly polarized 784-nm NIR radiation with peak intensities from 10^12 W/cm^2 to 10^13 W/cm^2. The angular distribution of the ejected electrons exhibits a strong dichroism depending on the NIR intensity. While the co-rotating case is defined by a single path, for the counter-rotating case, there are two dominant pathways whose relative strength and phase difference are determined.

A 11.2 Tue 11:30 N 2

Coherent control of helium photoelectron emission using ω–2ω SASE FEL pulses — •Harijyoti Mandal[1], Muwaffaq Ali Mourtada[1], Alexander Magunia[1], Weiyu Zhang[1], Yu He[1], Hannes Lindenblatt[1], Florian Trost[1], Lina Hedewig[1], Cristian Medina[1], Arikta Saha[1], Gergana D. Borisova[1], Steffen Palutke[2], Evgeny Schneidmiller[2], Mikhail Yurkov[2], Stefan Düsterer[2], Rolf Treusch[2], Chris H. Greene[3], Yimeng Wang[3], Robert Moshammer[1], Ulrike Frühling[2], Christian Ott[1], and Thomas Pfeifer[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Deutsches Elektronen Synchrotron DESY, 22607 Hamburg, Germany — [3]Purdue University, West Lafayette, IN 47907, USA

Extreme-ultraviolet (XUV) free-electron lasers enable nonlinear ionization and interference between multiple excitation pathways, providing a platform for coherent control in the few-photon regime. We demonstrate phase-controlled ω-2ω photoionization of helium using stochastic SASE pulses at FLASH2, DESY Hamburg. Interference between one-photon (2ω) and two-photon ($\omega + \omega$) channels produces a tunable left-right asymmetry in the photoelectron angular distribution. Thin aluminium foils (100-300nm) imprint a calibrated dispersive phase shift between the fundamental ($\omega = 21.2$eV) and second harmonic ($2\omega = 42.4$eV). Fully differential momentum distributions were recorded with a reaction microscope and correlated shot-by-shot with spectral diagnostics, revealing asymmetry dependence on instantaneous photon energy, pulse intensity, and relative $\omega/2\omega$ content.

A 11.3 Tue 11:45 N 2

Modeling dissipation in quantum active matter — Alexander P. Antonov[1], Sangyun Lee[2], Benno Liebchen[3], Hartmut Löwen[1], Jannis Melles[1], Giovanna Morigi[4], Yehor Tuchkov[2], and •Michael te Vrugt[2] — [1]Institut für Theoretische Physik II, Weiche Materie, Heinrich-Heine-Universität Düsseldorf — [2]Institut für Physik, Johannes Gutenberg-Universität Mainz — [3]Institut für Physik der kondensierten Materie, Technische Universität Darmstadt — [4]Theoretische Physik, Universität des Saarlandes

Active particles, such as flying birds and swimming bacteria, are a widely studied class of systems in classical soft matter physics. Recently, there have been a variety of suggestions for how to realize activity on a quantum level in cold atom systems. Here, we investigate one particular way in which such quantum active matter may differ from its classical counterpart, namely the way in which it is influenced by dissipation. We find that the choice of the quantum heat bath strongly influences the dynamics of quantum active matter at short timescales, which is the regime in which quantum effects are most relevant.

A 11.4 Tue 12:00 N 2

Trapped Rydberg ions as quantum simulators for coupled exciton-phonon dynamics — •Simon Euchner[1], Mathias B. M. Svendsen[1], and Igor Lesanovsky[1,2] — [1]Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — [2]School of Physics and Astronomy and Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, The University of Nottingham, Nottingham NG7 2RD, United Kingdom

Trapped Rydberg ions combine electronic and motional degrees of freedom, which can be coupled in a controllable fashion. This opens opportunities for the quantum simulation of molecular processes native to light-harvesting complexes, such as excitation energy (exciton) transport influenced by exciton-phonon (vibronic) coupling. We investigate how such a simulator could be designed, thereby highlighting its feasibility with state-of-the-art technology. Subsequently, we focus on a simplified model for the simulator. Based on this model we study finite temperature effects and the impact of different motional initial states on the dynamics. Moreover, we find that for certain motional states, two-phonon processes become relevant which can facilitate the exciton transport.

A 11.5 Tue 12:15 N 2

Extracting pairs of time-bin entangled photons from resonance fluorescence — •xinxin hu, gabriele maron, luke masters, arno rauschenbeutel, and jürgen volz — Department of Physics, Humboldt Universität zu Berlin, 10099 Berlin, Germany

Photon-photon entanglement and photon antibunching are fundamental manifestations of the quantum nature of optical light fields, but are typically regarded as distinct phenomena. Here, we experimentally demonstrate that pairs of narrow-band time-bin entangled photons can be naturally extracted from resonance fluorescence. We split the collected fluorescence of a single trapped atom on a 50:50 beamsplitter, resulting in strong temporal correlations between photons at the beamsplitter outputs. A time-bin coincidence between the two output modes then projects their state onto a maximally entangled Bell state. This entanglement is evidenced by violating the CHSH-Bell inequality as well as by reconstructing the density matrix of the photon pair. Importantly, we show that the entanglement persists both for weak and strong excitation of the emitter. Our results establish resonance fluorescence as an efficient source of time-bin entangled photon pairs, i.e., a practical and scalable resource for quantum communication and photonic quantum technologies.

A 11.6 Tue 12:30 N 2

On classically mediated quantum entanglement — •Sebastian Ulbricht[1,2], Andrés Darío Bermúdez Manjarres[3], and Marcel Reginatto[2] — [1]Institut für Mathematische Physik, Technische Universität Braunschweig, Mendelssohnstraße 3, 38106 Braunschweig, Germany — [2]Physikalisch-Technische Bundesanstalt PTB, Bundesallee 100, 38116 Braunschweig, Germany — [3]Universidad Distrital Francisco José de Caldas, Cra. 7 No. 40B-53, Bogotá, Colombia

The question of whether quantum states can become entangled when they interact via a classical mediator is still a matter of ongoing discussion. This lively debate is deeply interwoven with the question of whether entanglement studies can prove the quantum - or classical - nature of gravity. In recent years, there have been numerous statements and no-go theorems, supporting one or the other position. However, while appearing to be universal, no-go theorems 'forbidding' classically mediated quantum entanglement do depend on the used quantum-classical hybrid theory. In this talk, we show that in Hybrid van Hove theory [1] two initially uncorrelated spins can become entangled even if they are only coupled via a classical harmonic oscillator. We further demonstrate that the spin-spin correlations and the entanglement of the spins closely resemble the fully quantum case. Our investigation shows that existing no-go theorems are not universal. It further implies that consistent quantum theories featuring classical gravity cannot be categorically ruled out by quantum entanglement studies. [1] M. Reginatto, A.D. Bermúdez Manjarres, and S. Ulbricht, J. Phys.: Conf. Ser. 3017 012037 (2025)

A 11.7 Tue 12:45 N 2

Estimating quantum entropies using a quantum circuit and a neural network — •Sangyun Lee[1], Hyukjoon Kwon[2], and Jae Sung Lee[3] — [1]Institut für Physik, johannes gutenberg university — [2]School of Computational Sciences, Korea Institute for Advanced Study, Seoul 02455, Korea — [3]School of Physics, Korea Institute for Advanced Study, Seoul, 02455, Korea

Entropy is one of the key quantities in physics. In particular, it plays important roles in phase transitions, heat engines, information processing, and entanglement. However, estimating entropy is difficult because it is not a standard physical observable and requires access to the full probability distribution of the system. To address this challenge, we propose a method that combines a quantum circuit with a neural network. Our approach is applicable to von Neumann entropy and Rényi entropy. We validate our method on an XXZ chain model and find that it can sensitively estimate the model*s entanglement entropy.