DY 56: Many-body Quantum Dynamics II (joint session DY/TT)

Time: Friday 9:30–10:30 Location: A 151

DY 56.1 Fri 9:30 A 151

Cavity control of quantum materials — •Daniele Fausti — Friedrich Alexander University of Erlangen-Nuremberg

This seminar will focus on the potential of cavity electrodynamics in shaping material properties, opened by on our recent investigation into cavity-mediated thermal control of the metal-to-insulator transition in 1T-TaS2, which demonstrated the feasibility of reversible cavity manipulation of a phase transition in a correlated solid-state material. By immersing the charge density wave material 1T-TaS2 into cryogenic tunable terahertz cavities, we unveil a remarkable shift between conductive states. This transition, triggered by a substantial alteration in sample temperature, is controlled by mechanical adjustments of the distance between cavity mirrors and their alignment[1]. The discussion will extend to unpublished data on vibrational strong coupling within higher frequency cavities, emphasizing the position-dependent coupling strength that underscores the influence of the mode structure on the observed effects. Our findings rationalized in a scenario reminiscent of the Purcell effects, wherein the spectral profile of the cavity significantly shapes the energy exchange between the quantum material and the external electromagnetic field unfolds promising opportunities for tailoring the thermodynamics and macroscopic transport properties of quantum materials through strategic engineering of their electromagnetic surroundings. The seminar will discuss some perspectives for cavity control of material functionalities in correlated complex quantum materials.

[1] Nature 622, pages 487*492 (2023)

DY 56.2 Fri 9:45 A 151

Phase transition driven by ultrashort laser pulses in the charge-density-wave material $K_{0.3}MoO_3$ — •Rafael T. Winkler[1,2], Larissa Boie[1], Yunpei Deng[2], Matteo Savoini[1], Serhane Zerdane[2], Abhishek Nag[2], Sabina Gurung[1], Davide Soranzio[1], Tim Suter[1], Vladimir Ovuka[1], Janine Zemp-Dössegger[1], Elsa Abreu[1], Simone Biasco[1], Roman Mankowsky[2], Edwin J. Divall[2], Alexander R. Oggenfuss[2], Mathias Sander[2], Christopher Arrell[2], Danylo Babich[2], Henrik T. Lemke[2], Paul Beaud[2], Urs Staub[2], Jure Demsar[3], and Steven L. Johnson[1,2] — [1]Institute for Quantum Electronics, Physics Department, ETH Zurich, Zurich, Switzerland. — [2]SwissFEL, Paul Scherrer Institute, Villigen, Switzerland. — [3]Faculty - Institute of Physics, Johannes Gutenberg-University Mainz

Blue Bronze ($K_{0.3}MoO_3$) is a quasi 1D material exhibiting a charge density wave with a periodic lattice distortion (PLD). In a time resolved x-ray experiment at SwissFEL, we study the dynamics of the PLD by pumping $K_{0.3}MoO_3$ with short laser pulses and probing it using x-ray diffraction. We construct reciprocal space maps (RSM) of superlattice reflections at different delays. The RSM along the surface normal gets broader at the delay equal to half the amplitude mode oscillation period, indicating a transient inversion of the PLD. For longer delays, this broadening is not visible. However, the diffracted x-ray intensity drops below the unpumped value indicating a molten CDW near the surface.

DY 56.3 Fri 10:00 A 151

Equilibrium parametric amplification in Raman-cavity hybrids — •Hector Pablo Ojeda Collado[1,2], Marios H. Michael[3], Jim Skulte[1,2], Angel Rubio[3,4], and Ludwig Mathey[1,2] — [1]Center for Optical Quantum Technologies and Institute for Quantum Physics, University of Hamburg, 22761 Hamburg, Germany — [2]The Hamburg Center for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Max Planck Institute for the Structure and Dynamics of Matter, Luruper Chausse 149, 22761 Hamburg, Germany — [4]Center for Computational Quantum Physics, The Flatiron Institute, 162 Fifth Avenue, New York, New York 10010, USA

Parametric amplification have led to extraordinary photo-induced phenomena in recent pump-probe experiments. While these phenomena manifest themselves in out-of-equilibrium settings, in this work, we present the striking result of parametric amplification in equilibrium. We demonstrate that quantum and thermal noise of a Raman-active mode amplifies light inside a cavity when the Raman mode frequency is twice the cavity frequency. This noise-driven amplification leads to the creation of an unusual parametric Raman polariton with smoking gun signatures in Raman spectroscopy. We show distinctive properties of this polariton, including localization and static shift of the Raman mode, together with an increase of quantum light fluctuations within the cavity. Our study suggests a resonant mechanism for controlling Raman modes and thus matter properties by cavity fluctuations. We conclude by outlining how to compute the Raman-cavity coupling, and suggest possible experimental realizations.

DY 56.4 Fri 10:15 A 151

Real-time transport of short electron pulses trough an impurity on a 1D quantum wire — •Thomas Kloss[1,2], Yuriel Nunez Fernandez[1,2], and Xavier Waintal[2] — [1]Univ. Grenoble Alpes, CNRS, Institut Néel, 38000 Grenoble, France — [2]Université Grenoble Alpes, CEA, Grenoble INP, IRIG, Pheliqs, F-38000 Grenoble, France

We study the transmission of pulses which are propagating through a weakly coupled impurity site, which is located on an infinitely long 1D tight-binding chain. For short pulses, the number of transmitted charges deviates from the adiabatic regime and shows a periodic dependence on the number of injected charges. In the limit of ultrashort pulses an analytic formula can be derived which matches perfectly the results obtained by numerical simulations using the Tkwant software. In a next step, a Hubbard-like interaction with strength U is added on the impurity site. Onside density and currents are obtained in a perturbative expansion in U using a real-time Green function approach. We apply a tensor-train technique to integrate over the high-dimensional integrals, which has been shown to outperform diagrammatic quantum Monte Carlo by orders of magnitude in speed an accuracy. The results are compared to self-consistent mean-field calculations and to the non-interacting limit.