CFEL SCIENCE

SEMINAR

1st July 2015 - 2:00 p.m.

CFEL-bldg. 99, seminar room IV

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Theoretical studies of non-equilibrium spectroscopy

Quantum materials have already become intrinsic elements in "futuristic" materials of today. To be able to use them to their full potential, we first need to understand their electronic properties both in and out of equilibrium. A powerful emerging method for doing so is perturbing the system into a non-equilibrium state using a “pump” laser pulse, and examining the subsequent temporal dynamics which often exhibit oscillations and decay reflecting the underlying physics. This technique is rapidly growing in use, and has many exciting capabilities for both understanding and controlling quantum materials, but still needs a solid theoretical footing.

In this talk, I will discuss several theoretical achievements regarding pump-probe spectroscopy of quantum materials. First, we study the response of a system of electrons and phonons, and what can be learned by analyzing the return to equilibrium after excitation by a laser pulse. Using a non-equilibrium Keldysh formalism, we make a connection between the observed return to equilibrium and the underlying interaction, expressed through the self-energy. We find that the dynamics and self-energy are fluence- and time-dependent due to the modification of the electron population, which in turn modifies the interactions.

Second, I will present some aspects of non-equilibrium physics in BCS superconductors. We solve the Nambu-Gor’kov equations for superconductivity, obtaining a full dynamic description of non-equilibrium BCS superconductivity. The temporal behavior after a pump exhibits characteristic 2Δ oscillations, which we attribute to the Higgs, or amplitude mode. Finally, motivated by recent experiments, I will illustrate how superconductivity can be enhanced or suppressed through non-linear phononics. By modifying the physical parameters, we can model the driving of a lattice distortion, leading to an enhanced Tc.

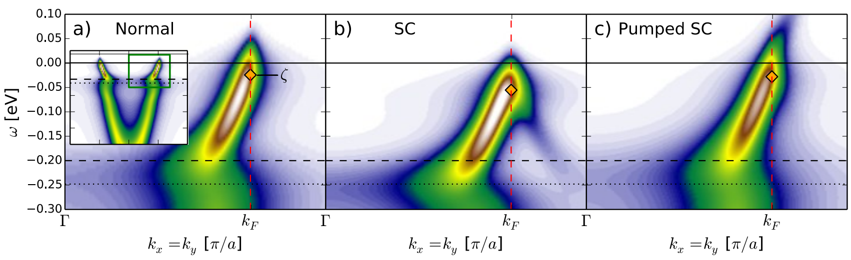

Figure 1: Theoretical simulation of single-particle spectra, as can be measured by time- and angle-resolved photoemission spectroscopy.

Host: Angel Rubio – MPSD-CFEL Theory Department