Time evolution of terahertz-pumped heavy-fermion systems

Francisco Meirinhos[1] and Johann Kroha[1]

[1] *Physikalisches Institut & Bethe Center for Theoretical Physics, Universität Bonn, Germany*

The search and characterisation of new quantum phases of matter has recently been intensified by the application of terahertz (THz) spectroscopy in the time domain to heavy-fermion systems [1-3]. It was experimentally shown that a single-cycle terahertz laser pulse disrupts the strongly correlated (Kondo) ground state in heavy-fermion compounds such as $CeCu_{6-x}Au_x$, which recover after a characteristic delay time τ_K^*, accompanied by the emission of a temporally confined terahertz echo pulse. In this way, time-domain terahertz spectroscopy provides direct access to both, the quasiparticle spectral weight and the characteristic time or energy scales, across a heavy-fermion quantum phase transition [1-2]. The transient nature of such non-equilibrium dynamics leads to new and interesting many-body physics, raising questions about the established properties of quasiparticles.

In the present work we develop the theoretical description of this heavy-fermion non-equilibrium dynamics. The electronic part of the system is captured by an Anderson model described by a time-dependent version of the non-equilibrium Non-Crossing Approximaton (NCA). The THz photons are treated as a quantum field with its own dynamics and are coupled to the heavy fermion-system by a dipole interaction. In this way, incident THz pulses with arbitrary pulse shape can be implemented as an initial condition. At the same time, the photon quantum dynamics allow for re-emission of radiation and, thereby, the necessary release of energy during the relaxation dynamics to the heavy-fermion ground state. These coupled dynamics are solved by a novel adaptive 2-time-stepping algorithm. We also discuss the thermalisation to ambient temperature in terms of a Lindblad-like coupling to the electromagnetic environment as a bath.

References:

[1] C. Wetli, S. Pal, J. Kroha, K. Kliemt, C. Krellner, O. Stockert, H. v. Löhneysen, and M. Fiebig, Time-resolved collapse and revival of the Kondo state near a quantum phase transition, Nature Phys. **14**, 1103 (2018)

[2] S. Pal, C. Wetli, F. Zamani, O. Stockert, H. v. Löhneysen, M. Fiebig, and J. Kroha, Phys. Rev. Lett. **122**, 096401 (2019)

[3] C.-J. Yang, S. Pal, F. Zamani, K. Kliemt, C. Krellner, O. Stockert, H. v. Löhneysen, J. Kroha, and Manfred Fiebig, Phys. Rev. Research **2**, 033296 (2020).