Combining pump/probe PES and electronic Raman scattering to test for the thermalization of hot electrons

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In a pump/probe experiment, the sample is hit with an intense electromagnetic pulse that excites electrons to a nonequilibrium state and then another pulse is applied after some time delay to probe the system. This allows one to study the relaxation processes of different excitations which are present in the system. Here, we propose a practical *in situ* method that can directly test for whether elecrons have thermalized. The underlying idea is that effective temperatures of all the bosonic and fermiomic excitations must be the same when the system is in thermal equilibrium. These effective temperatures can be directly extracted from the photoemission spectra (single-particle excitations, fermionic) and the electronic Raman scattering cross section (two-particle excitations, bosonic) and compared to each other on an ultrafast time scale.

To illustrate how this works, we solve for the time-resolved nonresonant electronic Raman scattering cross section in the B_{1g} symmetry channel and compare this to similar time-resolved photoemission. The calculations are exact for the spinless Falicov-Kimball model within nonequilibrium dynamical mean-field theory. We perform calculations for different Coulomb interactions which determine different phases of the model in equilibrium (strongly correlated metal or insulator).