Collective modes in THz pump-probe spectroscopy: from phonons to electronic excitations

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The latest advances in time-resolved spectroscopic techniques, based on the generation of intense ultra-short THz pulses, have paved new intriguing ways for the investigation of collective phenomena in many complex systems. As an example, recent experiments showed the possibility to selectively excite electronic collective modes in superconductors [1,2], which lead to well-defined oscillation in the measured signal that strongly resemble the coherent excitation of Raman-active phonons in insulating and metallic compounds [3,4]. Despite the great interest and the huge experimental progress, a clear theoretical paradigm for the description of these experiments is still lacking. In this talk I will present a general scheme we recently developed to describe step-by-step the processes behind the pump-probe detection of collective excitations, that can be equally well applied to ordinary phonons as well as to electronic excitation [5]. I will then discuss a direct application of our interpretative scheme to the light-induced excitation of superconducting collective modes, ranging from low-energy plasma waves in cuprates [6] to the so-called Higgs (amplitude) mode in BCS superconductors [7,8], addressing the issue of its visibility both in the clean case as well as in the presence of disorder.

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