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Chapter 1 : Photo-excited charge carriers suppress sub-terahertz phonon mode in silicon at room temperat

Chapter 6 THE ROLE OF THE ELECTRON-PHONON INTERACTION IN METALLIC MAGNETISM In the preceding chapter we saw how phonon and elastic properties of a metal are dictated by its magnetic property through the electron-phonon.

We therefore make some drastic assumptions. The terms involving the Fermi function are expected to be small compared to the terms involving the derivatives of the Fermi function. Thus, we have seen that modi"cation brought about by the "eld dependence of electron self-energy is cancelled by the mass enhancement, and thus there is no net e! This agrees with some previous results [5,6]. Based on the above discussions, we wish to parameterise Eq. This was done in view of the fact that g is quite large [21] in heavyfermion systems, addressed in this problem. As in the case of the spin susceptibility, the e! In other words, the damping of quasiparticles is negligible compared to spin uctuations. The values of c and d are taken to be 0. In our earlier work c and c were assumed to be equal arbitrarily. For the parameters chosen ; was found to be 8. Our results are plotted in Fig. In this case the non-linearity is pronounced and the system shows a metastable phase between two critical "elds H "8. For example, for f"2. In the last case, however, the e! Therefore, within a physical range of 0 to! This decreases to 0. Thus the average jump in the range of values for f between 0 and 3. The slope of m! Furthermore, from thermodynamics "eld magnetic susceptibility and the high-"eld magnetisation. In both cases it is found to suppress the Coulomb correlation e! In case of exchangeenhanced Pauli susceptibility, it reduces the enhancement and in case of metamagnetism it also reduces the e! We believe, therefore, that the e! The evidence of significant phonon e! The weakness of the model is the mean "eld approximation. The major advantage of this approximation is that it is very easy to work with, and the major disadvantage is that it is uncontrolled and its region of validity, if any, is unclear. Despite some of its shortcomings, the present work, we believe, outlines a di! Sahu for computer facilities.

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Chapter 2 : New perspectives in magnetism of metals / Duk Joo Kim. book online read or download

In the preceding chapter we saw how the phonon and elastic properties of a metal are dictated by its magnetic property through the electron-phonon interaction (EPI). In this chapter we discuss the opposite problem; we explore how phonons are involved in determining the magnetic properties of a metal.

Received Mar 29; Accepted Sep 5. To view a copy of this license, visit http: Abstract There is a growing interest in the mode-by-mode understanding of electron and phonon transport for improving energy conversion technologies, such as thermoelectrics and photovoltaics. Whereas remarkable progress has been made in probing phononâ€"phonon interactions, it has been a challenge to directly measure electronâ€"phonon interactions at the single-mode level, especially their effect on phonon transport above cryogenic temperatures. Here we use three-pulse photoacoustic spectroscopy to investigate the damping of a single sub-terahertz coherent phonon mode by free charge carriers in silicon at room temperature. Building on conventional pumpâ€"probe photoacoustic spectroscopy, we introduce an additional laser pulse to optically generate charge carriers, and carefully design temporal sequence of the three pulses to unambiguously quantify the scattering rate of a single-phonon mode due to the electronâ€"phonon interaction. Our results confirm predictions from first-principles simulations and indicate the importance of the often-neglected effect of electronâ€"phonon interaction on phonon transport in doped semiconductors. First-principles simulations partially provide this ability 1 , 2 , 3 , although they have hitherto been limited to relatively simple material systems. On the experimental side, recent developments in ultrafast photoacoustic spectroscopy 4 , 5 , 6 , inelastic neutron scattering 7 and quasiballistic phonon mean-free-path spectroscopy 8 , 9 , 10 enabled progress in probing phononâ€"phonon interaction strength of individual phonon modes or the distribution of phonon modes with respect to phononâ€"phonon-interaction-limited mean free paths. These tools can provide guidance for designing nanostructured thermoelectric materials The same level of insight is also desirable for electronâ€"phonon interaction, which is among the most important interactions of quasi particles in condensed matter physics and material science. Electronâ€"phonon interaction is the major contributor to electrical resistance in most inorganic metals and semiconductors 12 above cryogenic temperatures, plays the central role in the microscopic theory of superconductivity 13 and forms the basis of polaron formation and transport in conjugated polymers Given its paramount importance, numerous experimental techniques have been developed to probe the electronâ€"phonon interaction in various materials directly or indirectly, with most of them examining the effect of electronâ€"phonon interaction on electrons. For example, the collective effect of the interactions among all phonons and electrons that participate in transport can be inferred from electrical transport experiments 12 , Alternatively, the average electronâ€"phonon coupling strength can be directly measured by investigating the timescale of equilibration of electrons and phonons in ultrafast optical pumpâ€"probe experiments 16 , In addition, the angle-resolved photoemission spectroscopy can directly map out the electronic band structure near the material surface, and the linewidths of the electronic states provide specific information of the interaction strength between a single-electron state with all phonon modes 18 , On the other hand, the effect of electronâ€"phonon interaction on phonons has been less studied, both theoretically and experimentally. In most cases the change is small due to the small energy scale of magnetic fields, and most measurements were done at cryogenic temperatures. An alternative way to probe the phonon-specific information of electronâ€"phonon interaction in metals is through superconducting tunnelling spectroscopy However, it is limited to superconductors and cannot resolve individual phonon modes. Similarly, inelastic neutron scattering was used to measure and compare phonon linewidths of metals in the normal and superconducting states 23 , the difference between which gives the phonon damping due to electronâ€"phonon interaction in the normal state. The change of phonon damping in metals across the superconductor transition has also been studied by ultrasonic attenuation experiments 24 , 25 , 26 , 27 in the megahertz frequency range. Early experiments on semiconductors mostly focused on the effect of carriers introduced by doping on the thermal conductivity 28 , One difficulty of these experiments is to separate the contributions to phonon scattering from carriers themselves and from the impurities introduced by doping. The same difficulty stands in inelastic neutron-scattering measurements 30 and ultrasonic attenuation experiments 31 of doped semiconductors. An alternative way of introducing carriers is by electrostatic gating. Owing to the short screening length typically a few nanometres in semiconductors , the induced carriers are confined in a thin layer and cannot effectively scatter phonons because of the short interaction time. And thus, measurements of phonon damping due to electrostatically induced carriers have only been carried out at cryogenic temperatures 32 , Furthermore, the calculations in ref. However, an experimental verification of these findings has been lacking. In this article, we use a three-pulse femtosecond photoacoustic technique to quantify the effect of the electronâ€"phonon interaction on the lifetime of a single-coherent phonon mode in a silicon membrane at room temperature and achieve good agreement between experimental results and first-principles calculations for the phonon lifetime as a function of the carrier concentration. Building on conventional femtosecond photoacoustic spectroscopy 4 , 5 , 35 , we introduce an extra excitation beam to optically generate electronâ€"hole pairs, and carefully design the temporal sequence of the three pulses to add extra damping due to electronâ€"phonon interaction to the second acoustic arrival the echo of the first pulse after a round trip inside the membrane while not affecting the first arrival. By comparing the magnitudes of the first and the second arrivals of the acoustic pulse, the effect of electronâ€"phonon interaction on phonon damping can be unambiguously quantified. With this design, we completely rule out the effect of phonon-impurity scattering, as free charge carriers are introduced optically rather than by doping. Furthermore, we optically excite carriers uniformly through the thickness of the sample, so that the phonon mode has enough time to interact with the carriers, which allows a sufficiently strong effect to be measured at room temperature. Thus, our method overcomes the previously stated difficulties that have prevented direct quantification of the effect of electronâ€"phonon interaction on phonon transport, and our measurement results show good agreement with the first-principles calculations of ref. Results Experimental set-up In conventional ultrafast photoacoustic spectroscopy 4 , 6 , 35 , 36 , an acoustic strain pulse is launched in a thin sample by an ultrafast optical pump pulse. This optical pump pulse is absorbed through electronic transitions, and then an acoustic strain pulse is released by relaxation of the strain generated either by photo-excited carriers or thermal expansion. Subsequently, this acoustic strain pulse travels back and forth inside the thin sample and is recorded by an ultrafast optical probe pulse. The optical response in the probe pulse is generated through the photoelastic response of the material to the strain pulse If the probe penetration depth is relatively large on the order of the wavelength in the medium or larger , the transient reflectivity signal is typically dominated by high-frequency Brillouin oscillations, resulting from the interference of light reflected from the sample surface and from the strain pulse 36 , 37 , This process is illustrated in Fig. By comparing the amplitudes of the frequency components of the acoustic pulse at different propagation lengths, the acoustic damping due to losses during the propagation inside the membrane can be quantified. In the conventional pumpâ€"probe set-up, the phonon damping is caused by phononâ€"phonon interaction in the bulk of the sample and scattering by surface roughness 4 ,

Chapter 3 : Electronâ€“phonon interaction and field-induced metamagnetism - PDF Free Download

We show that the effect of the electron-phonon interaction in the ferromagnetic state of an itinerant electron ferromagnet results in an effective magnetic field and modifies the spin splitting of the electron energy bands.