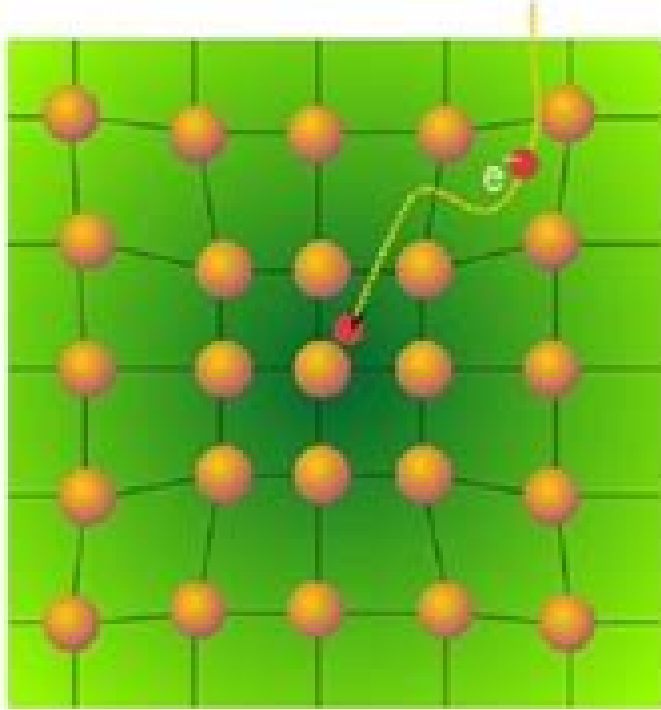


Conventional superconductivity

Electron-phonon interaction



$$\text{BCS: } k_B T_c = \hbar \omega \exp\left(-\frac{1+\lambda}{\lambda}\right)$$

Isotope effect:

$$T_c \simeq M^{-\alpha}$$

Image courtesy of B. Valenzuela

What is the role of EPI in high- T_c ?

Manifestations Of The Electronphonon Interaction 2nd Cinvestav Superconductivity Sym

Rafael Baquero



Manifestations Of The Electronphonon Interaction 2nd Cinvestav Superconductivity Sym:

Manifestations Of The Electron-phonon Interaction - Proceedings Of The Second Cinvestav Superconductivity Symposium Rafael Baquero, 1994-12-24 These proceedings cover the possible manifestations of electron phonon interactions in understanding high T_c superconductivity The results of measurements of different experimental methods have been analysed and the role played by electrons in superconductivity taking into account the van Hove singularity has also been discussed The pairing of electrons by other bosonic excitations as well as the effects of strong local electron lattice interactions are reviewed Another important point is the ab initio calculations discussed by several authors that remark the importance of electron phonon effects for high T_c superconductivity

Electron-phonon Interaction In Oxide Superconductors - Proceedings Of The First Cinvestav Superconductivity Symposium Rafael Baquero, 1991-12-31 Contents Lattice Vibrations of the Cuprate Superconductors W Reichardt et al Evidence of Strong Electron Phonon Interaction from the Infrared Spectra of YBa₂Cu₃O₇ T Timusk D B Tanner Electron Phonon Interaction and Infrared Spectra of High Temperature Superconductors O V Dolgov et al Tunneling Studies of Bismuthate and Cuprate Superconductors J F Zasadzinski et al Phonon Mechanism of the High T_c Superconductivity Based on the Tunneling Structure D Shimada et al Lattice Instabilities in High Temperature Superconductors The X Tilt Point Energy Surface for La₂ xBa_xCuO₄ W E Pickett et al Structural Instability and Strong Coupling in Oxide Superconductors N M Plakida On the Isotope Effect J P Carbotte Electron Phonon Coupling Oxygen Isotope Effect and Superconductivity in Ba₁ xK_xBiO₃ C K Loong et al Weak Coupling Theory of the High T_c Superconductors Based on the Electron Phonon Interaction J Labb Phonon Self Energy Effects in Migdal Eliashberg Theory F Marsiglio Electron Phonon Interaction and Superconductivity in BaK₁ xBiO₃ K Motizuki et al The Effect of Strong Coulomb Correlations on Electron Phonon Interactions in the Copper Oxides Implications for Transport J H Kim et al Zinc Substitution Effects on the Superconducting Properties for La₁ 85Ce₀ 15CuO₄ V Garc a V zquez et al Manifestations of the e ph Interaction A Summary R Baquero Readership Condensed matter physicists applied physicists chemists electrical engineers and materials scientists keywords

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Energy Research Abstracts , 1993 **Forthcoming Books** Rose Arny, 1994 **Books in Print** , 1991 Proceedings of the International Conference on Materials and Mechanisms of Superconductivity, High Temperature Superconductors IV , 1994 **Index of Conference**

Proceedings, 1992 **Electron-phonon Interaction in Oxide Superconductors** R. Baquero, 1991 Electron-phonon Interaction and Lattice Dynamics in High Tc Superconductors Han Zhang, 2019 Electron Lattice Interaction and Its Impact on High Tc Superconductivity V Z Kresin and S A Wolf Through a Lattice Darkly Shedding Light on Electron Phonon Coupling in the High Tc Cuprates D R Garcia and A Lanzara Electron Phonon Coupling Effects Explored by Inelastic Neutron Scattering L Pintschovius Phonon Anomalies and Dynamic Stripes D Reznik Oxygen Isotope Effect in Cuprates Results from Polaron induced Superconductivity S Weyeneth and K A Mller Oxygen Isotope Effect on the Effective Mass of Carriers from Magnetic Measurements on $\text{La}_2\text{xSrxCuO}_4$ G M Zhao K K Singh A P B Sinha and D E Morris Isotope Effects and Possible Pairing Mechanism in Optimally Doped Cuprate Superconductors G M Zhao V Kirtikar and D E Morris Isotopic Fingerprint of Electron Phonon Coupling in High Tc Cuprates H Iwasawa J F Douglas K Sato T Masui Y Yoshida Z Sun H Eisaki H Bando A Ino M Arita K Shimada H Namatame M Taniguchi S Tajima S Uchida T Saitoh D S Dessau and Y Aiura Kink Structure in the Electronic Dispersion of High Tc Superconductors From the Electron Phonon Interaction S Koikegami and Y Aiura Theory of High Temperature Superconductivity in Doped Polar Insulators A S Alexandrov High Temperature Superconductivity The Explanation A S Alexandrov Polaronic Effect and Its Impact on Tc for Novel Layered Superconducting Systems V Z Kresin Fine Structure in the Tunneling Spectra of Electron Doped Cuprates No Coupling to the Magnetic Resonance Mode G M Zhao Identification of the Bulk Pairing Symmetry in High Temperature Superconductors Evidence for an Extended S Wave with Eight Line Nodes G M Zhao Block Model and Origin of Strong Anisotropy in High Tc Superconductors H Zhang

Electron-Phonon Interaction in Conventional and Unconventional Superconductors Pegor Aynajian, 2011-01-19 The problem of conventional low temperature superconductivity has been regarded as solved since the seminal work of Bardeen Cooper and Schrieffer BCS more than 50 years ago However the theory does not allow accurate predictions of some of the most fundamental properties of a superconductor including the superconducting energy gap on the Fermi surface This thesis describes the development and scientific implementation of a new experimental method that puts this old problem into an entirely new light The nominee has made major contributions to the development and implementation of a new experimental method that enhances the resolution of spectroscopic experiments on dispersive lattice vibrational excitations the glue responsible for Cooper pairing of electrons in conventional superconductors by more than two orders of magnitude Using this method he has discovered an unexpected relationship between the superconducting energy gap and the geometry of the Fermi surface in the normal state both of which leave subtle imprints in the lattice vibrations that could not be resolved by conventional spectroscopic methods He has confirmed this relationship on two elemental superconductors and on a series of metallic alloys This indicates that a mechanism qualitatively beyond the standard BCS theory determines the magnitude and anisotropy of the superconducting gap The Electron-Phonon Interaction from First Principles Jesse Dean Noffsinger, 2011 In this thesis the ground state electronic properties lattice dynamics electron phonon coupling and superconductivity of a

variety materials are investigated from first principles The first chapter provides an introduction to the material and concepts of this thesis as well as motivation for the work done herein Additionally an overview is given on the theoretical background governing the calculations of this work This includes overviews of the topics of density functional theory the pseudopotential approximation density functional perturbation theory and applications of these approaches to the calculations of superconductivity In the second chapter the mechanics of actually performing calculations within the methodology of chapter one are explained This is accomplished through a detailed description of the computer software EPW This software has been developed to allow computationally efficient approaches for calculating the electron phonon interaction A description of the software package the particular quantities which it calculates and example calculations are given The following two chapters present the results of calculations regarding electron phonon coupling and superconductivity in bulk carbon compounds The occurrence or absence of superconductivity is found to be related in these compounds to Fermi surface nesting and carrier concentrations In chapter five we investigate the role of the fluorine dopant in the recently discovered 1111 Fe pnictide superconductors Contrary to the results of the literature published shortly after the discovery of these compounds the presence of the dopant is found to actually result in a net decrease in the electron concentration on the Fe plane within the local density approximation to density functional theory In the two chapters which follow we investigate the limits of two dimensional superconductivity in the recent experiments on ultra thin Pb samples Chapter six details calculations on freestanding Pb slabs constructed as thin as two monolayers A useful formula predicting the electron coupling strength and therefore estimating the superconducting transition temperature is developed While in the next section a superconducting system is investigated wherein the important Pb Si 111 interaction in ultra thin Pb layers is taken into account The observed superconductivity is explained by electron phonon coupling and isotropic Migdal Eliashberg theory The observance of superconductivity in the nearly two dimensional material is shown not to conflict with the predictions of the Mermin Wagner theorem In the final chapter the phonon assisted absorption of bulk silicon is calculated from first principles The calculated results are found to be in excellent agreement with experiment and lead the way for the possibility of many first principle studies on phonon assisted optical processes in important technological devices

Theory of Multipole Fluctuation Mediated Superconductivity and Multipole Phase Rina Tazai, 2021-05-18 A strong spin orbit interaction and Coulomb repulsion featuring strongly correlated d and f electron systems lead to various exotic phase transition including unconventional superconductivity and magnetic multipole order However their microscopic origins are long standing problem since they could not be explained based on conventional Migdal Eliashberg theorem The book focuses on many body correlation effects beyond conventional theory for the d and f electron systems and theoretically demonstrates the correlations to play significant roles in mode coupling among multiple quantum fluctuations which is called U VC here The following key findings are described in depth i spin triplet superconductivity caused by U VC ii being more important U VC in

f electron systems due to magnetic multipole degrees of freedom induced by a spin orbit interaction and iii s wave superconductivity stabilized cooperatively by antiferromagnetic fluctuations and electron phonon interaction contrary to conventional understanding The book provides meaningful step for revealing essential roles of many body effects behind long standing problems in strongly correlated materials

The Electron-phonon Interaction in Graphitic Materials and Superconductors Anthony Davenport, 2014

Nonequilibrium Electrons and Phonons in Superconductors Armen Mamikonovich Gul'ian, Geli' Frolovich Zharkov, 1999-08-31 This book introduces the main concepts of nonequilibrium phenomena in superconductors The authors cover both experimentally well understood topics and problems which physicists could challenge more in view of current theoretical understanding Some of these topics include thermoelectric phenomena influence of laser radiation as well as fluctuations in superconductors

Exploring Electron-electron and Electron-phonon Interactions in Strongly Interacting Quantum Systems Bo Xiao, 2020 Electron electron and electron phonon interactions play fundamental roles in condensed matter physics Strong correlations among electrons and between electrons and phonons lead to beautiful emergent phenomena both in materials and in the models used to describe them Unfortunately the complexity induced from the combination of interactions and large numbers of degrees of freedom makes analytically solving these models very difficult even when greatly simplified As a consequence many important questions in many body physics remain open For example the discoveries of charge density wave CDW in the pseudogap phase of the unconventional high temperature cuprate superconductors motivate on going research on electron phonon interactions and its effects on the off diagonal long range order ODLRO In conventional superconductors the attractive interaction between electrons which is mediated by the electron phonon interaction is essential for the formation of Cooper pairs However if the electron phonon interaction is sufficiently strong charge order emerges near commensurate filling to compete with superconductivity In this thesis we use a combination of numerical and analytical methods to understand this sort of interplay between different types of order in the microscopic and macroscopic behavior of many body systems In Chapter 1 we introduce the Hubbard and Holstein Hamiltonians and the some of the exotic phases and phase transitions which they describe We also build up some of the connections between numerical solutions of these models and experimental results for superconducting charge and spin order In Chapter 2 and 3 we set up the frameworks of quantum Monte Carlo QMC algorithms and machine learning ML methods We show how to translate a quantum mechanical problem into an algorithm with analytical analysis encoded in it which can be widely applied to various models and physics In Chapter 4 and 5 we quantitatively determine the phase diagrams of one dimensional electron phonon models where electrons have a long range coupling to phonons as well as repulsive electron electron interactions We analyze the resulting metallic Mott insulator Peierls insulator phases as well as the phase separation which we show often arises from momentum dependent electron phonon coupling Although much work has been done on the extended Hubbard model our research on including electron phonon interactions pushes the field in a

new direction In Chapter 6 we describe the first study of the interplay between electron phonon interaction and the effects of randomness Our central result is a somewhat unexpected one the suppression of the charge density wave correlations in the half filled Holstein model by disorder can stabilize a superconducting phase In Chapter 7 we use QMC and cutting edge ML methods to identify phase transitions involving off diagonal order parameters using diagonal order parameter descriptors Our study has implications for the exploration of strong correlations using quantum gas microscopy QGM Chapter 8 summarizes some of the key results of this thesis and points areas of investigation which would be important to pursue further The material presented in Chapters 3 4 and 5 of this dissertation is based on two published articles in Physical Review B references 1 2 and one manuscript which has been submitted and is under review at Physical Review Letters reference 3 Chapter 7 is based on reference 4 which is in preparation

Numerical Studies of Electron-phonon Mediated Superconductors Benjamin Lee Nosarzewski, 2020 Electron phonon interactions are ubiquitous in materials and give rise to bipolarons charge density wave order and superconductivity The Holstein model is a toy model of electrons coupled to phonons and exhibits much of the same low energy physics observed in real materials We study the Holstein model in two dimensions in the limit of weak coupling through many body perturbation theory to compute and analyze the superconducting and charge density wave susceptibilities and various spectral properties These calculations are performed for systems both in and out of equilibrium and make connections with angle resolved photoemission and time resolved angle resolved photoemission spectroscopy For systems in equilibrium we discuss the enhancement of superconductivity driven by the renormalization of the phonon propagator and a surprising difference in two common definitions of the dimensionless electron phonon coupling strength Out of equilibrium we simulate a novel method of determining electron phonon coupling strength by analyzing electron relaxation dynamics and also characterize the Higgs excitation in a textit d wave superconductor In the intermediate coupling limit no perturbative approach or general analytic solution exists for the Holstein model To overcome this challenge we study the Holstein model using determinantal quantum Monte Carlo which provides a numerically exact and unbiased method to explore the superconducting and charge density wave tendencies across a wide range of the phase diagram We find that superconductivity is optimized at intermediate electron densities and intermediate coupling strength and the strength of the superconducting tendency monotonically increases with phonon frequency

The Physics of Superconductors Karl-Heinz Bennemann, John B. Ketterson, 2012-12-06 Superconductivity has undergone tremendous advances in recent years Most notable of course was the discovery of high temperature superconductivity in the cuprates This discovery resulted in an enormous influx of new workers to the field representing a host of experimental and theoretical disciplines When we combine this with the discovery of superconductivity in other materials such as heavy fermion metals MgB2 various organics fullerenes field effect devices magnetic metals under pressure and presumably non s symmetry triplet Cooper pairing in ruthenates e g Sr_2RuO_4 we have an enrichment of the

phenomena superconductivity This resulted in an explosion of interest in the field Many of the new superconductors are being called unconventional either with respect to the pairing mechanism or the symmetry of the underlying order parameter Yet in spite of these new materials and directions continuing studies of conventional electron phonon based superconductivity remain interesting With the aid of historical hindsight we expect the field to continue to advance in unexpected directions Nonetheless it is our view that a state of the art treatise on superconductivity is justified at this time not only to summarize the present understanding but also to introduce newcomers to the field as was the case with the two justly famous 1968 bibles of superconductivity by our former colleague R D Parks for an earlier generation Hopefully the present books might help to point the way for future workers research and discoveries

Effects of Electron-Phonon Interaction in Metals Xiaodong Yang, 2010 Phonons and electrons are two types of excitations which are responsible for many properties of condensed matter materials The interaction between them plays an important role in condensed matter physics In this thesis we present some theoretical investigations of the effects due to the interactions between phonons and electrons interactions We show evidence that a structural martensitic transition is related to significant changes in the electronic structure as revealed in thermodynamic measurements made in high magnetic fields The effect of the magnetic field is considered unusual as many influential investigations of martensitic transitions have emphasized that the structural transitions are primarily lattice dynamical and are driven by the entropy due to the phonons We provide a theoretical framework which can be used to describe the effect of a magnetic field on the lattice dynamics in which the field dependence originates from the dielectric constant The temperature dependence of the phonon spectrum of alpha uranium has recently been measured by Manley et al using inelastic neutron scattering and x ray scattering techniques Although there is scant evidence of anharmonic interactions the phonons were reported to show some softening of the optic modes at the zone boundary The same group of authors later reported that an extra vibrational mode was observed to form at a temperature above 450 K The existence of the proposed new mode is inconsistent with the usual theory of harmonic phonons as applied to a structure composed of a monoclinic Bravais lattice with a two atom basis We investigate the effect that the f electron phonon interaction has on the phonon spectrum and its role on the possible formation of a breathing mode of mixed electronic and phonon character We examine the model by using Green's function techniques to obtain the phonon spectral density Some materials undergo phase transitions from a high temperature state with periodic translational invariance to a state in which the electronic charge density is modulated periodically The wave vector of the modulation may be either commensurate or incommensurate with the reciprocal lattice vectors of the high temperature structure In the case of an incommensurate charge density wave the system supports phason excitation For an incommensurate state the new ground state has a lower symmetry than the high temperature state since the charge density does not have long ranged periodic translational order If the metal is ideal with no impurities a charge density wave should be able to slide throughout the

crystal without resistance resulting in current flow similar to that of a superconductor The phason is an excitation of the charge density wave which is related to the collective motion of electrons We estimate the phason density of states and the phason contribution to the specific heat Angle resolved photoemission experiments have been performed on USb₂ and very narrow quasiparticle peaks have been observed in a band which local spin density approximation LSDA predicts to osculate the Fermi energy The observed band is found to be depressed by 17 meV below the Fermi energy The experimentally observed quasiparticle dispersion relation for this band exhibits a kink at an energy of about 23 meV below the Fermi energy The kink is not found in LSDA calculations and therefore is attributable to a change in the quasiparticle mass renormalization by a factor of approximately 2 The existence of a kink in the quasiparticle dispersion relation of a band which does not cross the Fermi energy is unprecedented The kink in the quasiparticle dispersion relation is attributed to the effect of the interband self energy involving transitions from the osculating band into a band that does cross the Fermi energy

Whispering the Techniques of Language: An Mental Quest through **Manifestations Of The Electronphonon Interaction 2nd Cinvestav Superconductivity Sym**

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