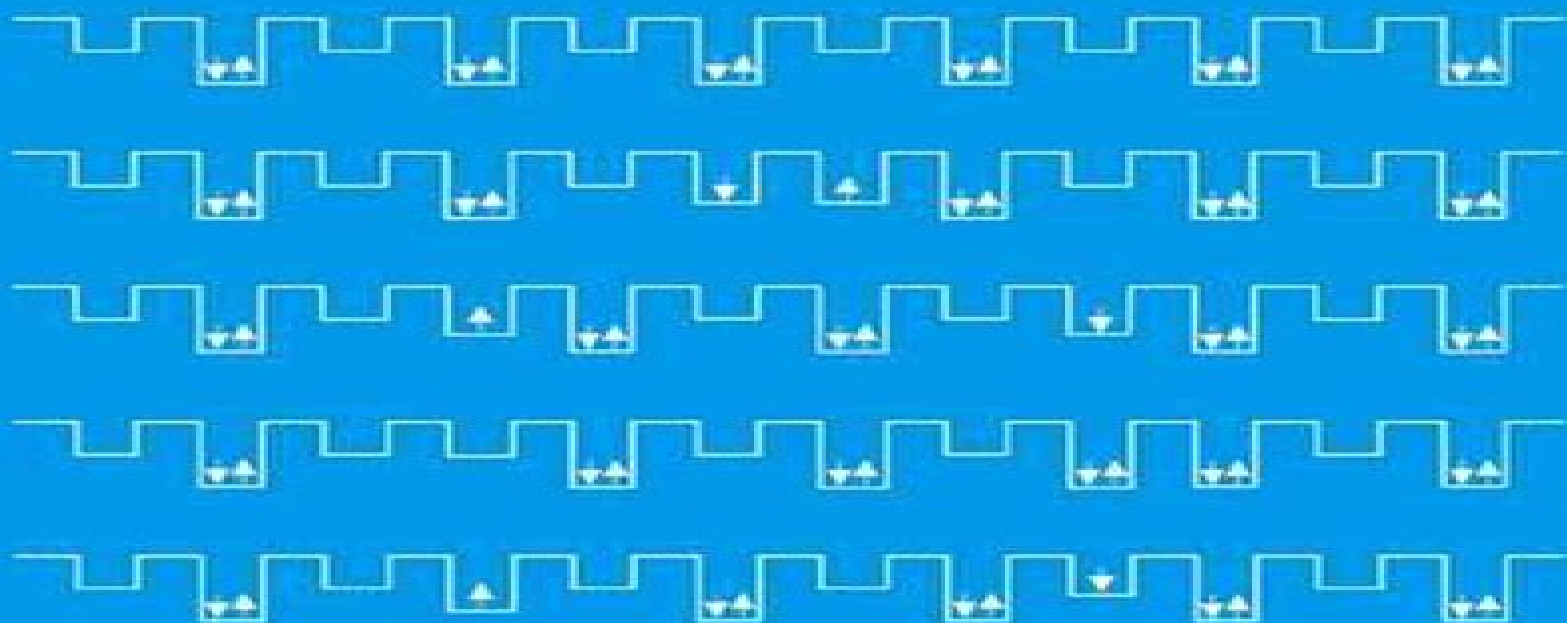


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K. NASU
editor

Photoinduced Phase Transitions

Kunal Tiwari



Photoinduced Phase Transitions:

Photoinduced Phase Transitions Keiichir? Nasu, 2004 A new class of insulating solids was recently discovered When irradiated by a few visible photons these solids give rise to a macroscopic excited domain that has new structural and electronic orders quite different from the starting ground state This occurrence is called photoinduced phase transition and this multi authored book reviews recent theoretical and experimental studies of this new phenomenon Why and how do photoexcited few electrons finally result in an excited domain with a macroscopic size How is the resultant photoinduced phase different from the ordinary thermal induced phase This review volume answers those essential questions This book has been selected for coverage in CC Physical Chemical Earth Sciences Index to Scientific Book Contents ISBC **Emergent States in Photoinduced Charge-Density-Wave Transitions** Alfred Zong, 2021-09-17 This book advances understanding of light induced phase transitions and nonequilibrium orders that occur in a broken symmetry system Upon excitation with an intense laser pulse materials can undergo a nonthermal transition through pathways different from those in equilibrium The mechanism underlying these photoinduced phase transitions has long been researched but many details in this ultrafast non adiabatic regime still remain to be clarified The work in this book reveals new insights into this phenomena via investigation of photoinduced melting and recovery of charge density waves CDWs Using several time resolved diffraction and spectroscopic techniques the author shows that the light induced melting of a CDW is characterized by dynamical slowing down while the restoration of the symmetry breaking order features two distinct timescales A fast recovery of the CDW amplitude is followed by a slower re establishment of phase coherence the latter of which is dictated by the presence of topological defects in the CDW Furthermore after the suppression of the original CDW by photoexcitation a different competing CDW transiently emerges illustrating how a hidden order in equilibrium can be unleashed by a laser pulse Photoinduced Phase Transitions and Irreversible Dynamics Studied with Single-shot Spectroscopy Samuel Welch Teitelbaum, 2016 Single shot femtosecond spectroscopy was developed to study irreversible processes and materials far from equilibrium It was then applied to investigate photoinduced phase transitions in semimetals and manganites The dual echelon single shot instrument was developed and noise sources experimental artifacts and the fundamental limits of the single shot technique were explored In this thesis advances in the single shot technique that allow for more detailed investigation of material processes and characterization of far from equilibrium dynamics in a wider range of systems are discussed Experiments and modeling of photoinduced phase transitions in two classes of systems semimetals and manganites are presented Both systems show collective structural change under photoexcitation that ultimately results in a low symmetry to high symmetry phase transition In semimetals the high symmetry phase relaxes after a few picoseconds and in manganites the higher symmetry

phase persists essentially indefinitely A photoinduced structural phase transition in bismuth is discussed in terms of the removal of a Peierls distortion by electronic excitation When more than 2% of the valence electrons are excited the Peierls distortion is inverted and the bismuth crystal is collectively driven into a symmetric crystalline phase An extended two temperature model is used to interpret and identify a photoinduced symmetric phase that exists above the damage threshold at low temperature and high excitation density Analogous experiments and analysis on antimony and tellurium are discussed demonstrating the generality of this method to exploring phase transitions in Peierls distorted systems A recently discovered photoinduced insulator to metal phase transition in epitaxially strained $\text{La}_{2-x}\text{Ca}_x\text{MnO}_3$ on an NdGaO_3 001 substrate at low temperature is characterized by frequency domain and time domain spectroscopy The ground state and metastable photoinduced phase in LCMO are characterized by their steady state behavior Conventional pump probe and single shot experiments are interpreted in terms of an effective medium model that describes the density of charge transfer excitations in the material An extended two parameter Ginzburg Landau model with biquadratic coupling describes the ground state of the manganite phase diagram and the stability of the photoinduced metallic phase

Photoinduced Phase Transitions K. Nasu, 2004 A new class of insulating solids was recently discovered When irradiated by a few visible photons these solids give rise to a macroscopic excited domain that has new structural and electronic orders quite different from the starting ground state This occurrence is called photoinduced phase transition and this multi authored book reviews recent theoretical and experimental studies of this new phenomenon

Theory of Photoinduced Phase Transitions in Itinerant Electron Systems Kenji Yonemitsu, 2008

Relaxations of Excited States and Photo-Induced Phase Transitions Keiichiro Nasu, 2012-12-06 Message from The Taniguchi Foundation Dr Kanamori Distinguished Guests and Friends The Taniguchi Foundation wishes to welcome the participants of the nine tenth International Symposium on the Theory of Condensed Matter who have come from within this country and from different parts of the world The concept of the symposium is unique in that participants both Japanese and from abroad are limited in number to small discussion groups and live together although for a short period as a close knit community We feel that this kind of environment will assist towards the strengthening of understanding and the fostering of friendship among the attendees It is easy to talk about but difficult to realize the ideal of international friendship and understanding in a world which is steadily growing smaller So far the Foundation has invited a total of 149 participants in this division from 24 foreign countries and 299 participants from Japan And we are all friends We hope and trust that even after they have reached the heights of academic fame during the coming decades the participants will continue to join forces and help to forge closer bonds of friendship and cooperation that will make major contributions not only to academia but also towards world peace and the welfare of mankind We hope that all the participants will return home with warm memories of both this symposium and the pleasant times that we have shared Thank you

Photoinduced Phase Transitions Studied by Femtosecond Single-shot Spectroscopy Taeho Shin, 2010 Single

shot femtosecond spectroscopy has been developed and employed for the study of phase transitions of solid state materials. Using two crossed echelons a two dimensional spatial delay gradient was generated across a single probe pulse profile. This novel scheme enables us to monitor irreversible change in solids by acquiring many time resolved data points with a single laser pulse. With the integration with a non collinear optical parametric amplifier (NOPA) and a conventional pump probe instrument, ultrafast dynamics of coherent lattice vibrations and photo induced phase transitions were examined in two different systems. Ultrafast dynamics such as coherent lattice vibrations and bond softening were investigated for Bi thin films and bulk single crystals. Depending on the thickness, transient reflectivity was changed significantly. The variations are ascribed to different electronic structures possibly originating from quantum confinement. Bond softening exhibits a strong thickness dependence due to hot carrier dynamics as well as to the different electronic structures. At high pump fluences, no phonon oscillations were observed, suggesting a phase transition to liquid or to a higher symmetry crystalline phase, reverse Peierls distortion. Together with thermal modeling, double pump measurements reveal nonthermal melting occurring in bulk and thin Bi films. A higher threshold fluence for nonthermal melting is observed in bulk bismuth as compared to thin films, suggesting ultrafast carrier dynamics such as ballistic transport. In addition to nonthermal effects, thermal effects such as inelastic electron phonon scattering and nonradiative recombination play a crucial role in melting and cooling at later times after nonthermal melting takes place. A quasi one dimensional platinum iodide complex showed strong oscillations in reflectivity which are attributed to oscillatory motions of wave packets on a self-trapped exciton (STE) potential surface. As optical excitation increased, electron transfer from Pt 2 to an adjacent Pt4 occurred over a wider range of lattice sites and weakened the oscillations. Above a certain pump fluence, oscillations disappeared completely, indicating that the mixed valence charge density wave state changed to monovalent Mott Hubbard phase. The reverse phase transition, i.e. from the Mott-Hubbard phase to the charge density wave state, began within 3 ps of the optical pump.

The Photoinduced Phase Transitions of Vanadium Dioxide Kunal Tiwari, 2015. The insulator to metal transition of vanadium dioxide has attracted the interest of condensed matter physicists for over half a century. In its high temperature phase, VO₂ is metallic with tetragonal rutile crystallography. In its low temperature phase, it has correlated semiconducting electronic character and a charge density wave like paired monoclinic lattice structure. Determining the relative roles of electron-electron and electron-phonon interactions in the electronic structure of the low temperature phase has been the source of the physics community's interest in VO₂. Over the past two decades, it has been shown that the insulator to metal transition may be photoinduced with ultrafast laser pulses. In this thesis, we present ultrafast electron diffraction and ultrafast time-resolved terahertz spectroscopy measurements of this photoinduced phase transition. Our ultrafast electron diffraction results reveal that at low fluences, a novel metastable phase exists. This phase has the crystallography of the insulating state but a dramatically collapsed band gap. A reorganization of valence charge density accompanies this modulated spectroscopic activity. These results have twofold

significance They show that the insulating behavior of the low temperature phase is affected primarily by electron-electron correlations not by lattice structure Importantly they also show that ultrafast electron diffraction may be used to probe both electronic and lattice structure dynamics it is sensitive to valence charge density reorganizations Our time resolved terahertz spectroscopy results complement these ultrafast electron diffraction data We show that in the novel metastable monoclinic phase the band gap does not collapse below 50 meV We also show that dynamics in the time resolved terahertz conductivity through the full photoinduced phase transition occur on two timescales one fast 240 femtosecond timescale characteristic of the coherent athermal photoinduced phase transition and one slow picosecond timescale characteristic of the structural transition to the metastable monoclinic phase In conjunction with our ultrafast electron diffraction measurements these results suggest that the slow dynamics of the structural phase transition and the structural phase transition may be affected by the same underlying mechanism

Ultrafast Dynamics of Photoinduced Phase Transitions in Correlated Electron Materials Steffen Eich, 2016

Photoinduced Phase Transitions in 1/4 Filled Organic Materials Matthieu Chollet, 2006 Le contrôle par la lumière des propriétés physiques de matériaux est associé à l'émergence d'une nouvelle physique des états hors équilibre Dans des solides les processus coopératifs entre molécules sont portés à l'extrême et peuvent induire une commutation vers un nouvel état macroscopique avec des propriétés physiques différentes optiques magnétiques structurales Des réversibles transitions de phase peuvent ainsi être gouvernées par la lumière Ces transitions photoinduites ont été étudiées dans des conducteurs organiques commutant entre différentes phases sur des échelles de temps allant de la picoseconde à quelques heures La complémentarité des études optiques et structurales permet de mieux comprendre la nature et les mécanismes de ces transitions de phase hors équilibre Des techniques novatrices résolues en temps de diffraction X et de spectroscopie ultra-rapides ont été utilisées pour étudier ces états transitoires

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