The 5th Gezhi Forum for Young Scientist

School of Physics, Peking University

Fragrant Hill Hotel, April 20-22, 2012

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Excursion for Biyunsi

Noting:

Due to the limit schedule, we have no specific time for the poster show. We encourage all colleagues to visit the poster during the time of coffee break.

Application of Nonlinear Science in Systems Biology

Qi Ouyang[1,2]

[1] Center for Theoretical Biology, Peking University, Beijing, 100871 China, [2] The State Key Laboratory for Artificial Microstructures and Mesoscopic Physics, School of Physics, Peking University, Beijing, 100871

In recent decades, biological studies are quickly moving from qualitative science to quantitative science. One of the major fields of theoretical physics is using its concept and analytical tools in the systems biology. In this talk, we report some recent works in this area. Using the cell cycle control networks of budding yeast (*Saccharomyces cerevisiae*) and the p53 signal transduction pathway of mammalian cell as examples, we discuss the application of nonlinear dynamic analysis in the systems and computation biology. These works demonstrate that nonlinear science can make a good impact in biological studies, but some key mathematical methods should be developed.

e-mail: qi@pku.edu.cn

Exotic superfluidity in spin-orbit coupled Bose-Einstein condensates

Qizhong Zhu[1], Chuanwei Zhang[2], and Biao Wu[1]
[1]International Center for Quantum Materials, Peking University
[2]Department of Physics and Astronomy, Washington State University

We study the superfluidity of a spin-orbit coupled Bose-Einstein condensate (BEC) by computing its Bogoliubov excitations, which are found to consist of two branches: one is gapless and phonon-like at long wavelength; the other is typically gapped. These excitations imply a superfluidity that has a surprising new feature: due to the absence of the Galilean invariance, one can no longer define the critical velocity of superfluidity independent of the reference frame. This is illustrated in Fig.1, where it is shown that a superfluid moving inside a tube can no longer be regarded as equivalent to a superfluid in a moving tube.

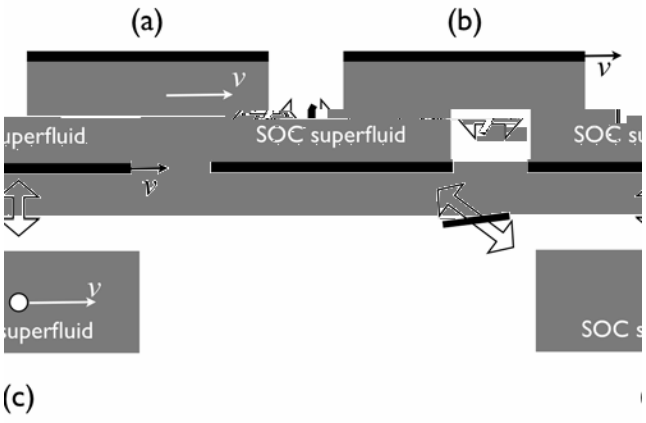


Fig.1 (a) A superfluid with spin orbit-coupling moves while the tube is at rest. (b) The superfluid is dragged by a tube moving at the speed of v. (c) An impurity moves at v in the SOC superfluid. The reference frame is the lab. The two-way arrow indicates the equivalence between different scenarios and the arrow with a bar indicates the non-equivalence.

Playing with surface electrons in InN

Xinqiang Wang
[1]State Key Laboratory of Artificial Microstructure and Mesoscopic Physics, School of Physics, Peking University, Beijing 100871, China
wangshi@pku.edu.cn

Recent progress in InN epitaxy has led to improved quality, low residual electron concentration, high electron mobility, and evidence of buried *p*-type conductivity, which made a great step forward the device fabrication. One of the key problems hindering the progress is the strong electron accumulation which exists on the surface and at the interface between InN and buffer layer as well. These layers not only hamper the direct measurement of true transport properties of bulk InN layer, but also prevent a direct electrical contact to the bulk layer in *p*-type InN. On the other hand, it is known that large conductance mismatch between ferromagnetic layer to semiconductor layer leads to poor injection efficiency and this surface electron accumulation may benefit for spin injection since the conduction match well. In addition, the surface accumulated electrons should be spin splitted in momentum space, and could also be further spin polarized with an external lateral electric field. In this work, we will report properties of surface electrons and then show the evidence of their spin splitting.

It is found in our experiment that the electron accumulation layers greatly affected the accurate determination of the electron concentrations and mobilities in InN bulk layer, especially at high temperatures. The room temperature electron densities in the electron accumulation layers are 3.26×10^{14} and 5.83×10^{13} cm^{-2} with mobilities of 149 and 429 cm2/Vs in N- and In-polarity InN, respectively. It should be noted that the above electron accumulation layers includes both the surface of InN and the interface between InN and GaN. On the other hand, the circular photogalvanic effect (CPGE) current along [0001] direction was detected in the a-plane InN films,, which should be contributed only by the surface electrons and thus shows direct evidence for the spin splitting of surface electrons in InN. Moreover, the surface-electron-induced CPGE current was successfully modulated by liquid gating

Plasmonic-Enhanced Molecular Fluorescence within Isolated Bowtie Nano-Apertures

Guowei Lu, Wenqiang Li, Tianyue Zhang, Song Yue, Jie Liu, Lei Hou, Zhi Li, and Qihuang Gong

Department of Physics, State Key Laboratory for Mesoscopic Physics, Peking University, Beijing 100871, China

Email: guowei.lu@pku.edu.cn

The molecule fluorescence behaviors within isolated BNAs are studied with numerical and experimental methods in detail. Firstly, we show that the scattering spectra of the BNAs present obvious plasmonic resonance and they are size dependence. The BNAs' characteristic resonances cover the excitation laser line and dye molecule emission, which allows not only a large plasmonic enhancement of the excitation field but also an enhanced fluorescence decay rate for brighter emission. Interestingly, the fluocar-10iter57tey, thcr57oenh-10Cii(il.)ti4(c)te eitinoc

Prompt Optical/UV Radiation and Dust Interaction in Gamma-ray Bursts

Xiaohong Cui[1] Zhuo Li[2]
[1]National Astronomical Observatories, Chinese Academy of Sciences
[2]Departments of Astronomy, School of Physics, Peking University

Observations imply that long gamma-ray bursts (GRBs) are originated from explosions of massive stars, therefore they may occur in the molecular clouds where their progenitors were born. We show here that the prompt optical-UV emission from GRBs may be delayed due to the dust extinction, which can well explain the observed optical delayed onset and fast rise in GRB 080319B. The density and the size of the molecular cloud around GRB 080319B are roughly constrained to be ~$10^3$$cm^{-3}$ and ~10pc, respectively. We also investigate the other GRBs with prompt optical-UV data, and find similar values of the densities and sizes of the local molecular clouds. The future observations of prompt optical-UV emission from GRBs in subsecond timescale, e.g., by UFFO-Pathfinder and SVOM-GWAC, will provide more evidence and probes of the local GRB environments.

Massive black hole(s) in the Galactic center and the origin of hypervelocity stars and S stars

Qingjuan Yu
Kavli Institute for Astronomy and Astrophysics, Peking University

The Milky way houses a massive black hole at its center, which provides one of the strongest evidence for the existence of a massive black hole in the universe. Hypervelocity stars, with velocities up to 1000km/s, were predicted to exist in the Galaxy as a consequence of dynamical interaction of stars with the central supermassive black hole. This prediction has been confirmed with the discovery of the first hypervelocity star in the Galactic halo in 2005. In this talk, I will review the dynamical mechanisms of ejecting hypervelocity stars and recent observations. I will talk about what hypervelocity stars can tell us about the Galactic center and halo. I will talk about how the spatial distribution of hypervelocity stars are related with their Galactic-center origin, and how they are connected with the young stellar disk stars and S stars moving around the central massive black hole.

Homogeneous crystal nucleation for globular proteins

Limei Xu[1] Sergey V. Buldyrev[2] H Eugene Stanley[3] Giancarlo Franzese[4]
[1]International Center for Quantum Materials, Peking University, China
[2]Department of Physics, Yeshiva University, USA
[3]Center for Polymer Studies and Department of Physics, Boston University, USA
[4]Departamento de F´ısica Fonamental, Universitat de Barcelona, Spain

Several theories have been proposed to describe protein crystallization and aggregation in solutions near a fluid-fluid metastable phase separation below the solubility line. For instance, based on computations, it was proposed that the fluid-fluid critical point enhances the crystallization rate by many orders of magnitude, while based on experiments, it was posposed that the fluid-fluid spinodal controls the crystalization rate. Using molecular dynamic simulations for a model of globular proteins with sticky interaction, we show here that the scenario is in general more complicated and no present theory describes well the mechanism of protein solution nucleation. We propose a generalization of the classical nucleation theory to account for our results.

Recent progress in coordinate-space Hartree-Fock-Bogoliubov approach for superfluid Fermi systems

Junchen Pei
Dept. of Technical Physics, School of Physics, Peking University

Properties of strongly interacting, two-component finite Fermi systems are discussed within the recently developed coordinate-space Hartree-Fock-Bogoliubov (HFB) approach. This approach is capable of treating the salient features of weakly bound and extremely deformed nuclei. I will talk about the nuclear quasi-particle continuum and resonances that can be precisely described by the L2 discretization in a large box. Meanwhile, the numerical efforts in solving the HFB equation on supercomputers are reviewed. HFB applications based on multi-wavelet techniques are especially introduced. I will also discuss the coordiante-space HFB approach to spin-polarized cold atomic gases, especially the Larkin-Ovchinnikov phase.

Feedback effect on high-energy magnetic fluctuations in a model high-Tc superconductor observed by electronic Raman scattering

Yuan Li[1,2], M. Le Tacon[1], M. Bakr[1], D. Terrade[1], D. Manske[1], R. Hackl[3], L. Ji[4], M. K. Chan[4], N. Barisic[4], X. Zhao[5], M. Greven[4], B. Keimer[1]

[1]Max Planck Institute for Solid State Research, Germany

[2]International Center for Quantum Materials, School of Physics, Peking University, China

[3]Walther Meissner Institute, Bavarian Academy of Sciences, Germany

[4]School of Physics and Astronomy, University of Minnesota, USA

[5]State Key Lab of Inorganic Synthesis and Preparative Chemistry, College of Chemistry, Jilin University, China

High-temperature superconductivity is one of the most fascinating macroscopic quantum phenomena in modern condensed-matter physics. Unlike in conventional superconductors (*e.g.*, certain elements and alloys) where it has been established that Cooper pairing is mediated by phonons, it is widely believed that a different "pairing glue" is responsible for the unconventional superconductivity in the high-T_c cuprate and in the Fe-pnictide superconductors. Since superconductivity in these materials is commonly found near an antiferromagnetic instability, a leading contender for its mechanism is that the Cooper pairing is mediated by antiferromagnetic fluctuations. This picture is able to explain the observed pairing symmetries and the absence of substantial isotope effect on T_c in these materials.

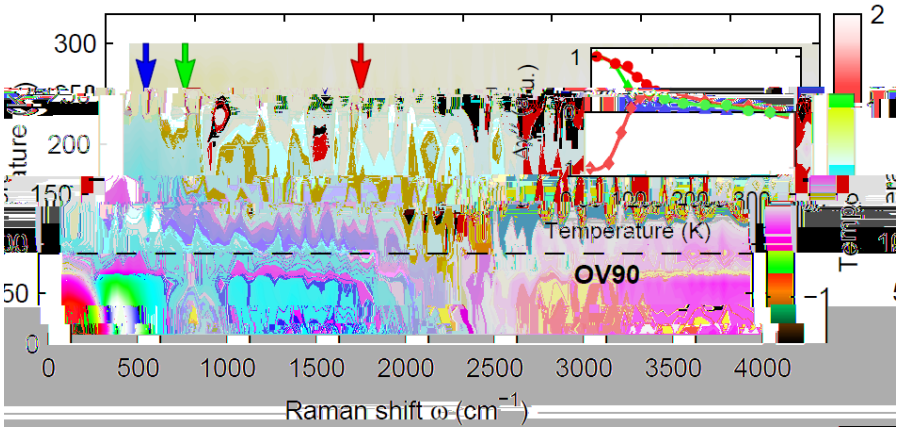


Fig.1 Variation of Raman susceptibility relative to 300 K in an overdoped sample (T_c = 90 K). The superconducting gap, the pair-breaking peak, and the two-magnon features are indicated

Unlike phonons in conventional superconductors, antiferromagnetic excitations are generated by the same electrons that form the Cooper pairs. If such excitations act as the pairing bosons, their spectrum is hence expected to be strongly modified in the superconducting state. Such a “feedback effect” has indeed been observed by inelastic neutron scattering experiments in the form of a resonant mode that develops below T_c in many unconventional superconductors. However, it has been argued that both the energy and the spectral weight of the resonant mode are insufficient for explaining the high values of T_c especially in the cuprates, and recently it has been realized that magnetic fluctuations at much higher energies are sufficiently strong, even close to optimal doping (with the highest T_c) where the systems no longer show static antiferromagnetic order. While this opens up the possibility that high-energy magnetic fluctuations are available as a possible resource for Cooper paring, it remains largely unknown whether this resource is actually utilized, as no feedback effect has yet been observed on this part of the spectrum.

In order to address this question, we have performed an accurate electronic Raman scattering study of the model single-layer cuprate system $HgBa_2CuO_{4+\delta}$ ($T_{c,max}$ = 97 K). Our results provide detailed information about the temperature evolution of the magnetic fluctuations that is difficult to obtain by inelastic neutron scattering and *X*-ray scattering due to the limited beam time resources. With decreasing temperature, we observe an amplitude enhancement and an energy shift of a “two-magnon” peak attributable to high-energy magnetic fluctuations, which is accompanied by the opening of a gap and the appearance of a pair-breaking peak above the gap. This effect occurs at T_c in an overdoped sample (Fig. 1), and can hence be understood as a high-energy feedback effect analogous to the resonant mode observed by inelastic neutron scattering, indicating a contribution of the high-energy magnetic fluctuations to the pairing interaction. In underdoped samples, we observe the same phenomena at temperatures well above T_c. This suggests that a related feedback mechanism is operative in the pseudogap regime.

Related publication: Yuan Li *et al.*, *Phys. Rev. Lett.* (accepted for publication), preprint available at arXiv:1112.2725.

Molecular Dynamics Driven by Strong Femtosecond Laser Pulses

Chengyin Wu
Institute of Modern Optics

Strong femtosecond laser pulses have become powerful tools to probe and control the behaviors of molecules. In this talk, we present our recent progresses in the field of laser-induced field-free alignment, tunneling ionization and Coulomb explosion imaging of molecules.

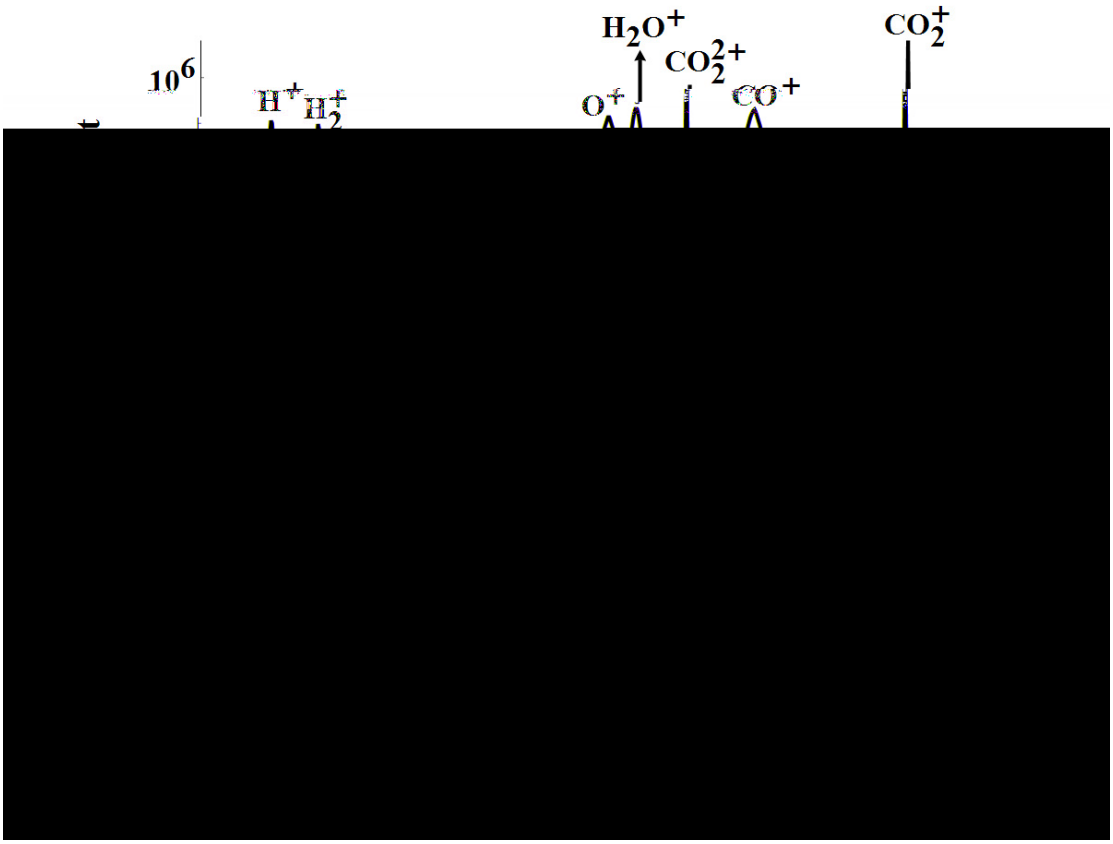


Fig. 1: Two-dimensional momentum distribution (bottom) and time-of-flight mass spectra (upper) of CO_2 irradiated by 8 fs laser pulses at an intensity of 1×10^{15} W/cm^2.

References:

[1] C. Wu, H. Jiang, Q. Gong, Advances in Multi-photon Process and Spectroscopy, Chapter 2, PP53-100 (2011).
[2] C. Wu, Y. Yang, Z. Wu, et al., Physc. Chem. Phys. Chem., 13, 19398 (2011).

Quantum nature of the hydrogen bond

Xin-Zheng Li, Brent Walker, and Angelos Michaelides

Hydrogen bonds are weak, generally intermolecular bonds, which hold much of soft matter together as well as the condensed phases of water, network liquids, and many ferroelectric crystals. The small mass of hydrogen means that they are inherently quantum mechanical in nature, and effects such as zero-point motion and tunneling must be considered, though all too often these effects are not considered. As a prominent example, a clear picture for the impact of quantum nuclear effects on the strength of hydrogen bonds and consequently the structure of hydrogen bonded systems is still absent. Here, we report ab initio path integral molecular dynamics studies on the quantum nature of the hydrogen bond. Through a systematic examination of a wide range of hydrogen bonded systems we show that quantum nuclear effects weaken weak hydrogen bonds but strengthen relatively strong ones. This simple correlation arises from a competition between anharmonic intermolecular bond bending and intramolecular bond stretching. A simple rule of thumb is provided that enables predictions to be made for hydrogen bonded materials in general with merely classical knowledge (such as hydrogen bond strength or hydrogen bond length). Our work rationalizes the influence of quantum nuclear effects, which can result in either weakening or strengthening of the hydrogen bonds, and the corresponding structures, across a broad range of hydrogen bonded materials. Furthermore, it highlights the need to allow flexible molecules when anharmonic potentials are used in force field-based studies of quantum nuclear effects. For more detail of this work, please see Proc. Natl. Acad. Sci. USA 108, 6369 (2011).

Dynamics of diatomic molecules in intense laser fields

Liang-You Peng,Wei-Chao Jiang , Xue-Feng Hou, and Qihuang Gong
Institute of Modern Optics, Department of Physics, Peking University
liangyou.peng@pku.edu.cn

In this talk, I will present two recent work about the ionization dynamics of the simplest diatomic molecule. The first one is about the low-energy spectra of H_2^+ under the joint interaction of an attosecond pulse and a few-cycle IR pulse. We will put the emphasis on the accurate numerical method we proposed. In the second work, we will discuss the static-field-induced states and their manifestation in tunneling ionization dynamics of an asymmetric model molecule in the presence of Guassian-shape static field.

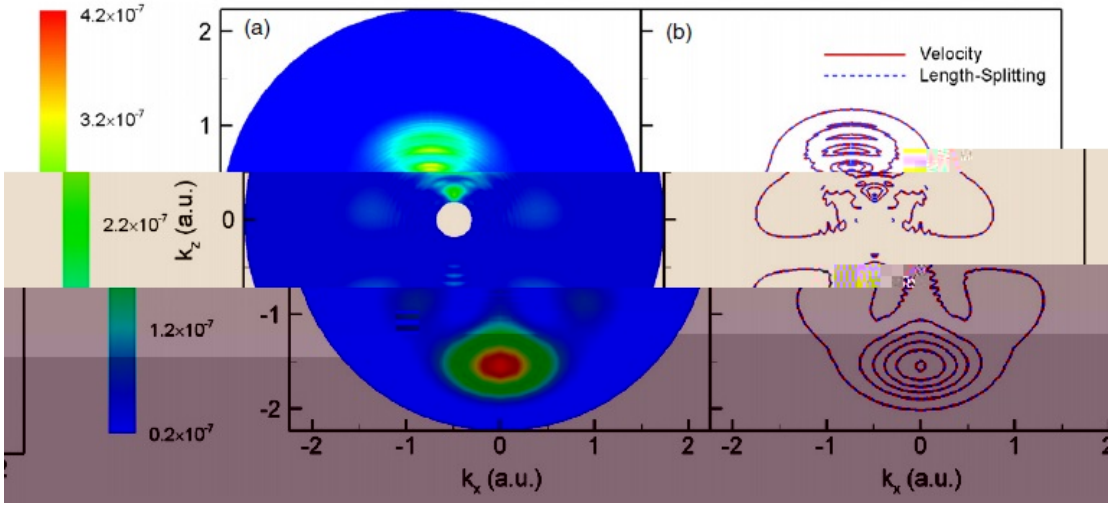


Fig.1 Comparison of streaking spectra of H_2^+ calculated from velocity-gauge non-splitting and from length-gauge splitting technique.

The accurate computation of the differential electron momentum of the two-center molecule in the presence of an intense IR field has long been a challenging problem. Previous attempts have been made mostly for reduced-dimensional and soft-Coulomb potential model molecules, which prevented direct comparisons with experimental measurements. Some attempts have also been made for the real H_2^+ in the spherical coordinates, which is very difficult in convergences at high laser intensities, especially at larger inter-nuclear distances. In the present work, we proposed a method to attack this problem for the real H_2^+ in the prolate spheroidal coordinates. Specifically, the

radial coordinate is discretized with the finite-element discrete variable representation (FE-DVR) for easy parallel computation and the angular coordinate with the usual DVR. A wavefunction splitting scheme is utilized to reduce the demanding requirement of the computational resource to solve the corresponding TDSE when an IR field is present.

It is well-known that there exists charge-resonance enhanced ionization for homonuclear diatomic molecules. It is mainly due to the existence of charge-resonance states in such a system. However, using a model asymmetric diatomic molecule, we identify a new resonant ionization of diatomic molecules. We investigate the phenomena using both the adiabatic theory and the numerical solution of time-dependent Schrödinger equation. It is shown that SFISs manifest themselves as peaks of the tunneling ionization rate both in static and time-dependent fields in the adiabatic regime. The peaks are located along the RTI ridges in the plane of internuclear distance R and the momentary value of electric field F. The RTI via SFISs appears to be one of the general ionization mechanisms of molecules.

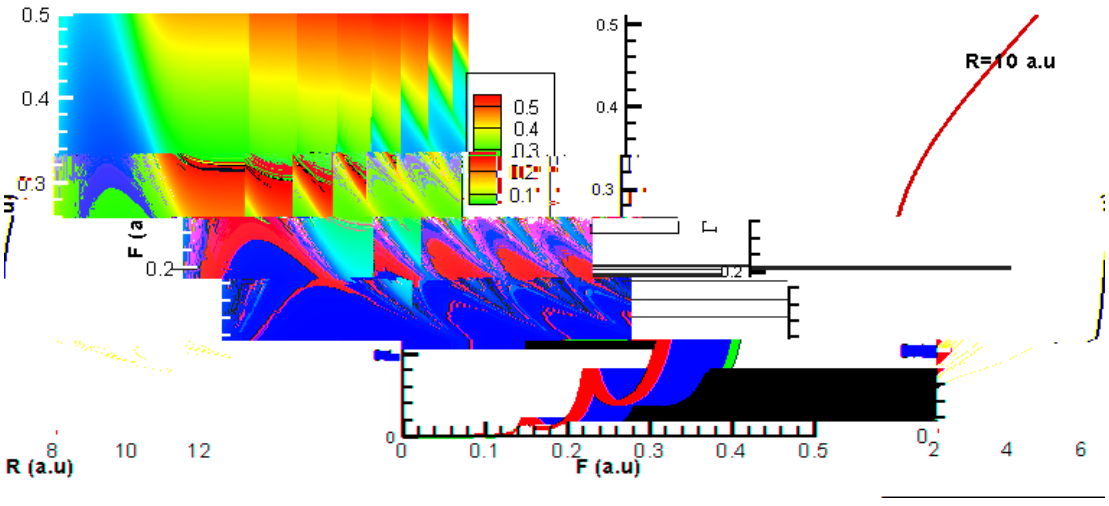


Fig.2 Left: Molecular ionization rate as a function of R and the field strength F. Right: a cut of the ionization rate in the left at R=10 a.u.

[1] M.-H. Xu, L.-Y. Peng, Z. Zhang, Q. Gong, X.-M. Tong, E.A. Pronin, and A.F. Starace, **Phys. Rev. Lett. 107**, 183001 (2011).

[2] X.-F. Hou, L.-Y. Peng, Q.-C. Ning, and Q.-H. Gong, **J. Phys. B**, **45**, 074019 (2012).

[3] W.-C. Jiang, O.I. Tolstikhin, L.-Y. Peng, and Q. Gong, **Phys. Rev. A 85**, 023404 (2012)

Kondo-Mediated Inelastic Electron Tunneling in a Single Molecule

Ying Jiang[1,2], W. Ji[3], Q. Huan[2,4], A. X. Yu[2]

Growth of uniform epitaxial graphene on 6H- and 4H-SiC

Rui Zhang[1] Xiaosong Wu[1] Dapeng Yu[1]
[1] Institutes of condensed matter physics

We grow EG on SiC using the CCS method. This method substantially increases the local Si pressure over the substrate. The growth consequently takes place at a slow rate in a condition close to thermodynamic equilibrium. Thus, we were able to grow uniform graphene islands. Particularly, the initial half-unit-cell high SiC steps are preserved underneath the graphene film and continuous at the boundary of the islands. Several features unveil two salient factors that affect the growth, e.g. carbon diffusion and stoichiometry. Furthermore, a "stepdown" growth has been identified and counter-intuitively, it is favored against the "climbover" growth in our growth condition. While the climbover growth tends to create step bunching, which roughens the surface, the stepdown growth keeps the regular SiC steps almost intact. Our results present reproducible and well-defined growth features that theoretical models can be compared with, which are relatively lacked so far. Furthermore, the stepdown process offers a method to realize uniform growth of large size graphene without degrading the initially flat morphology of the SiC surface.

Tilt Magnetic Field Dependence of the 12/5 Fractional Quantum Hall State

Chi Zhang[1,2], Chao Huan[3], J. S. Xia[3], N. S. Sullivan[3], W. Pan[2], K.W. Baldwin[1], K. W. West[1], L. N. Pfeiffer[1], and D. C. Tsui[1]

[1]Princeton University

[2]Sandia National Labs

[3]University of Florida and NHMFL

The 12/5 state has attracted growing interest due to its superior potential in performing universal topological quantum computation. Up to date, except for the observation of a well developed quantum Hall plateau at this filling, much less experimental work has been carried out and there is no experimental evidence to support this state being a paraferminoic or non-Abelian state.

Here, we present our tilt magnetic field dependence results in examining its spin-polarization. It was observed that the diagonal resistance R_{xx} non-monotonic dependence on tilt angle ( ). It first increases sharply with increasing , reaches a maximal value of ~ 60 around ~14^o, and then decreases with further increased. Correlated with this R_{xx} dependence, the 12/5 activation energy gap ($_{12/5}$) also shows a non-monotonic dependence. $_{12/5}$ first decreases. Around 14^o, R_{xx} becomes non-activated and a true activation energy gap is not obtainable. With further increasing , R_{xx} becomes activated again and $_{12/5}$ increases with . This tilt dependence in R_{xx} and $_{12/5}$ is similar to the com in the lowest Landau level, which was interpreted as a spin transition. Our results thus call for more investigations on the nature of the 12/5 ground state.

Photooxidation of Methanol on TiO_2(110) surfaces

Zefeng Ren
International Center for Quantum Materials, Peking University, Beijing 100871, P.R. China.

It is well known that pure TiO_2 is not photocatalytically active for water splitting to produce hydrogen while adding methanol to water can dramatically enhance hydrogen production, but the dynamical origin of this striking phenomenon has remained a mystery. We have recently investigated the photocatalysis of CH_3OH and its isotopic molecules on TiO_2(110) using a newly developed universal photocatalysis apparatus. Photocatalyzed products, CH_2O on five-coordinated Ti sites and H atoms on bridge-bonded oxygen sites, from CH_3OH have been clearly detected. Methyl formate (CH_3OCHO) products were also probed after long time light illumination. The experimental results show that dissociation and oxidation of CH_3OH on TiO_2(110) occurs in a stepwise manner in which the O-H dissociation proceeds first and is then followed by C-H dissociation, that is oxidation process. In this talk, I will try to give a clear picture of photooxidation of methanol on TiO_2(110) surfaces. Finally, an outlook of dynamics studies on this system with surface sum frequency generation method will be present.

Tailoring graphene properties by choosing appropriate substrates

Zonghai Hu

Tuning the properties of graphene is of great importance to both materials research and device applications. The electronic structures of graphene can be tailored by periodic potentials. Applying such potentials through fabricated nanoscale patterns remains challenging. Alternatively, forming graphene superlattices on appropriate substrates such as the graphene moiré patterns on metal surfaces has received much attention. Large area high quality monolayer graphene was prepared by chemical vapor deposition (CVD) method on copper foils and characterized by Raman spectroscopy, low energy electron diffraction (LEED), Auger electron spectroscopy (AES) and scanning tunneling microscopy (STM). Atomic resolution STM results revealed a significant periodic modulation by the substrate causing a graphene superstructure with large apparent corrugation. Three prevailing azimuthal arrangements between graphene and the surface were observed.

Measurements of quasi-particle tunneling in the ν= 5/2 fractional quantum Hall state

X. Lin, C. Dillard, M. A. Kastner, L. N. Pfeiffer, and K. W. West
Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA
International Center for Quantum Materials, Peking University, Beijing, P.R. China 100871
Department of Electrical Engineering, Princeton University, Princeton, New Jersey 08544, USA

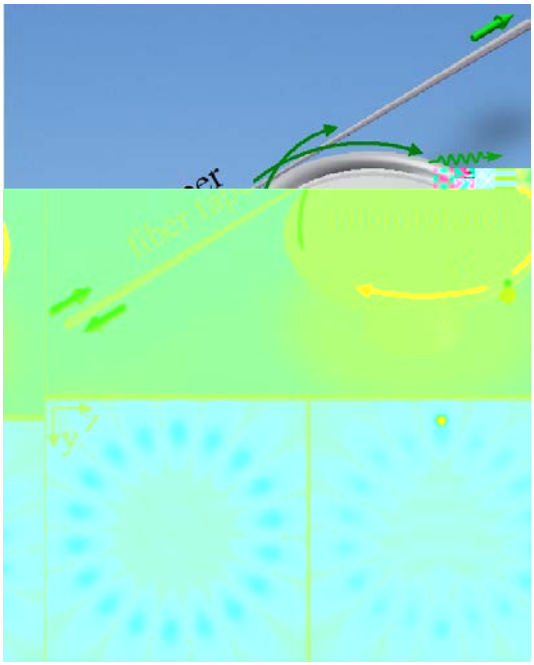
Some models of the 5/2 fractional quantum Hall state predict that the quasi-particles, which carry the charge, have non-Abelian statistics: exchange of two quasi-particles changes the wave function more dramatically than just the usual change of phase factor. Such non-Abelian statistics would make the system less sensitive to decoherence, making it a candidate for implementation of topological quantum computation. We measure quasi-particle tunneling as a function of temperature and DC bias between counter-propagating edge states. Fits to theory give e*, the quasi-particle effective charge, close to the expected value of e/4 and g, the strength of the interaction between quasi-particles, close to 3/8. Fits corresponding to the various proposed wave functions, along with qualitative features of the data, strongly favor the Abelian 331 state.

A hybrid photonic-plasmonic resonator: interface of strongly enhanced light-matter interaction

Yun-Feng Xiao
Institute of Modern Optics

Achieving strong light-matter interaction is of crucial importance for a broad field. Unfortunately, the light-matter interaction in single emitter level is typically very weak due to the size mismatch. To enhance the interaction, one way is to use a high finesse microcavity, in which the photons circulate and interact with the emitter for many times. However, the interaction is still limited due to the relatively large cavity mode volume. Plasmonic structures

Here we propose a hybrid photonic-plasmonic resonant structure which consists of a metal nanoparticle (MNP) and a whispering gallery mode (WGM) microcavity. It is found that the hybrid mode enables a strong interaction between the light and matter, and the single-atom cooperativity is enhanced by more than two orders of magnitude compared to that in a bare WGM microcavity. The novel system has significant advantages over a single microcavity or a single MNP, and holds great potential in quantum optics, nonlinear optics and highly sensitive biosening.



Supercontinuum generation using imaging taper

Kebin Shi

Institute of Modern Optics, School of Physics, Peking University, China 100871

Email: kebinshi@pku.edu.cn

Abstract: We investigate supercontinuum generation from a Schott imaging fiber taper. Supercontinua simultaneously generated from two fibers of an imaging taper were demonstrated.

1. Introduction

Supercontinuum generated in nonlinear fibers and its applications have drawn intensive interests recently [1-8]. ue(91) Tw 2.57ngi gin g .0.263(g)a2 0.00613(g)2.57id s -33uie0.01.0.26w2 Tdew46.006e2 0.obsS91ew4

Fig. 3. (a) Typical supercontinuum spectra of three different patterns. The spectra of the three patterns are quite different in the short wavelength part (500nm-700nm). They are all peaked around the pump wavelength near 800nm and extend to the visible and near infrared regimes. (b) and (c) show dependence of spectral broadening on pump power. The horizontal axis shows the average incoming laser power while the vertical axis represents the wavelength. The insets show the corresponding far field patterns.

We also measu the spectra of the suercontinuum generat with different incident average power. Fig. 3(b) and (c) show the spectra-power dependence for pattern 1 and 3. These measu spectral signat ac 0 T8 consistent with the spectral broadening observed with a self-phase modulation (SPM) dominated process.

A unique property of an imaging taper is that it consists of many closely packed individual fibers. Therefore it is possible to generate mtiple suercontinu Fig. 4 shows two suercontinuenerated simultaneously when two laser beams were coupled into two individual fibers of an imaging taper. In this experiment, a femtosecond laser beam (Spectra-Physics Tsunami) was first divided into two beams by a beamsplitter and then steec 0 T8d Ty mirroo a 60x objective lens (focal length 2.8 mm) at a separation angle of about 2º to ensure the two beams wec 0 T8 coupled into diffec 0 T8nt fibec 0 T8. The patters wec 0 T8 imaged onto a scc 0 T8en by another 60x objective lens. When both beams wer let through the two supercontinuum patterns can be observed simultaneously as illustrated in Fig. 4(a). The two supec 0 Tcontinuum pattec 0 Tns ac 0 T8 separated spatially 0 T8 generated in different fibers of the tapec]TJ 0.003 Tc -0.003 Tw 1.952 0 Td (.)Tj 0 Tc 0 Tw 0.807 0 Td (W)Tj 0.002 Tc -0.002 Tw 0.867 0 Td (e)Tj -0
bers availabl8 in an v. J 0.007 Tc 064.67232d [(c)-11(o1(uj"TJ /TA)2)-p(r)(o)114c 0 Tw 2.896 0 Td36.

Evolution of superconductivity and resistivity in MgB_2 films towards the ultrathin limit

Yue Wang, Chen Zhang, Da Wang, Yan Zhang, Qing Rong Feng, Zi Zhao Gan
State Key Laboratory for Mesoscopic Physics and School of Physics, Peking University

With the hybrid physical-chemical vapor deposition (HPCVD) method, a series of MgB_2 superconducting films with thickness varying from 100 nm to 7.5 nm have been epitaxially grown on (0001) Al_2O_3 or 6H-SiC substrates. The T_C of the films is found to decrease slightly as the film thickness decreases and for 7.5 nm thick films the T_C is still around 34 K, which follows the expectation of recent theoretical calculations but is much higher than the values reported for the same thick MgB_2 films fabricated by other methods such as co-evaporation and molecular beam epitaxy. This discrepancy in T_C is suggested to be related with the different residual resistivity ratios of the films prepared by different techniques. The upper critical fields of our films are also investigated. Above T_C, the normal sate resistivity has been measured and discussed under traditional transport scheme or two-band transport picture.

Dynamical manipulation of NaI predissociation using optimum laser pulses

Yunquan Liu
Institute of Modern Optics, School of Physics, Peking University

Abstract. We propose a dynamic pump-control scheme to manipulate the molecular predissociation process of NaI using two well-controlled ultrashort laser pulses. We excite NaI molecule by a pump pulse (648 nm, 35 fs) and employ another control laser pulse (7.53 , 50 fs) to modify the molecular potential energy surfaces (MPESs) of NaI in the coupling zone. The intersection of the two diabatic MPESs could move into two opposite directions due to the nonresonant dynamical stark effect (NRDSE) introduced by the control pulse. The final dissociation channels, i.e., ionic channel and covalent channel, can be well controlled by tuning the carrier-envelope phase (CEP) and the time delay of control pulse. We find that the percentage of covalent channel can reach ~91.3% when the CEP of control pulse is taken to be ~ ly before the adiabatic coupling zone. On the contrary, a minimum percentage of 18.3% can be obtained at CEP ~ ly after the adiabatic coupling zone.

Ultrafast tunable Fano resonance in nonlinear ferroelectric photonic crystals

Xiaoyong Hu, Yingbo Zhang, Hong Yang, Qihuang Gong
State Key Laboratory for Mesoscopic Physics & Department of Physics, Peking University, Beijing 100871 China

Fano resonance in photonic microstructure materials has attracted great attention because of its great potential applications in fields of nanophotonics and integrated photonic devices. Fano resonance originates from the interference between a discrete energy state and a continuum of states, taking on an asymmetric line shape and a drastic change in transmission or reflection spectra. Tunable Fano resonance, the central wavelength of which varying with external parameters, can find more flexible and important applications in practice.[1] However, up to now, little attention was paid to ultrafast tunable Fano resonance in photonic microstructures.

We adopted a one-dimensional photonic crystal structure made of polycrystal lithium niobate ($LiNbO_3$), which can provide a very large third-order nonlinear susceptibility due to strong quantum size effect of nanoscale crystal grains.[2] Fano resonance can be reached when probe light is incident in the direction perpendicular to the surface of the ferroelectric film, which is associated with the excitation of guide resonance in the one-dimensional photonic crystal structure. A large shift of 37 nm was reached for the Fano resonance wavelength under excitation of a pump laser with a intensity as low as 30 MW/cm^2. An ultrafast response time of 43 ps is achieved due to fast relaxation dynamics of bound electrons in polycrystal lithium niobate. [3,4]

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Thermal fluctuations and flux-tunable barrier in proximity Josephson junctions

Jian Wei ( )[1]
[1]ICQM ( )

The effect of thermal fluctuations in Josephson junctions is usually analyzed using the Ambegaokar-Halperin (AH) theory in the context of thermal activation. ``Enhanced'' fluctuations, demonstrated by broadening of current-voltage characteristics, have previously been found for proximity Josephson junctions. Here we report measurements of micron-scale normal metal loops contacted with thin superconducting electrodes, where the unconventional loop geometry enables tuning of the junction barrier with applied flux. We observe stronger ``enhanced'' fluctuations when the flux threading the normal metal loop is near an odd half-integer flux quantum, and for devices with thinner superconducting electrodes. These findings suggest that the activation barrier, which is the Josephson coupling energy of the proximity junction, is different from that for conventional macroscopic Josephson junctions.

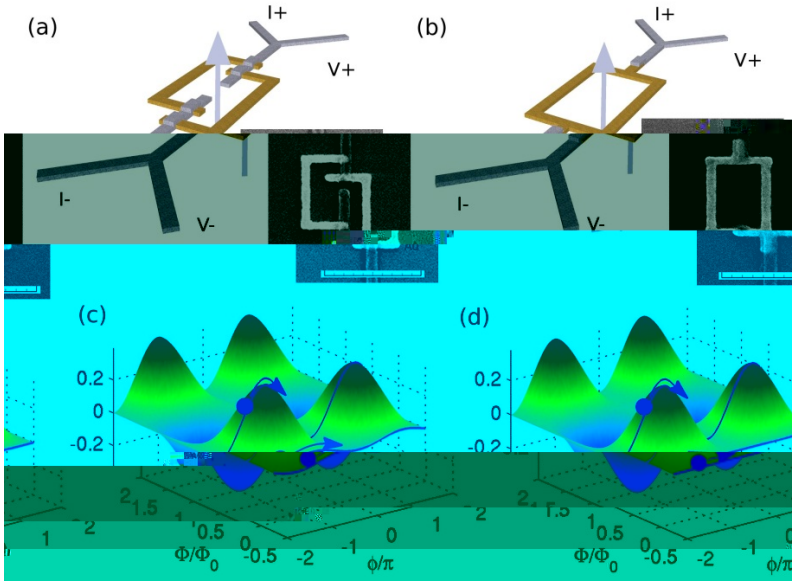

Fig.1 Schematic diagrams of two SNS quantum interference devices: asymmetric (a) and symmetric (b). The normal metal arms are shown in gold and the superconducting wires are shown in gray. The arrow in both figures corresponds to the direction of applied magnetic flux.

Insets: Scanning electron micrographs of the devices measured, the scale bars are 1 μm. The calculated energy profile of the asymmetric/symmetric device are shown in (c)/(d) as a function of the external magnetic flux Φ and the phase difference across the two superconductors ϕ, which is determined by the external current through the device.

Simple one dimensional quasiclassical theory is used to predict the interference effect due to the loop structure, but the exact magnitude of the coupling energy cannot be computed without taking into account the details of the sample dimensions. In this sense, the physics of nanoscale proximity junctions can be related to the thermally activated phase slips (TAPS) model for thin superconducting wires, and indeed our data can be better fitted with TAPS model than AH theory. Besides shedding light on thermal fluctuations in proximity junctions, the findings here also demonstrate a new type of superconducting interference device with two normal branches sharing the same SN interface on both sides of the device, which has technical advantages for making symmetrical interference devices.

Laser proton accelerator for cancer therapy

X. Q. Yan

Generation of high-energy ions by ultraintense laser pulses has been intensively studied due to its wide range of applications, such as cancer therapy and proton imagning. Radiation pressure acceleration (RPA) has been proposed as a promising route to obtain high-quality ion beams in a much more efficient way, compared to the target normal sheath acceleration (TNSA). In order to accelerate ions to a relativistic velocity in RPA regime, hole-boring effects and transverse instabilities should be restrained, which normally require extremely high laser intensity (> 10^21W/cm^2), sharp rising front, and high temporal laser contrast(> 10^10).

By 3D particle-in-cell (PIC) simulation and analysis, we propose a plasma lens to generate high intensity, high contrast laser pulse with a steep front. When an intense, short Gaussian laser pulse of circular polarization propagates in near-critical plasma, it drives strong currents of relativistic electrons which magnetize the plasma. This quasistatic magnetic field is strong enough to pinch the relativistic electrons into a small channel and affects the index of refraction. The laser pulse will be compressed and focused into the channel. Three pulse shaping effects are synchronously observed when the laser passes through the plasma lens. The laser intensity is increased by more than one order of magnitude while the initial Gaussian laser profile undergoes self-modulation longitudinally and develops a steep front. Meanwhile, a non-relativistic prepulse can be absorbed by the over-critical plasma lens, which can improve the laser contrast without affecting laser shaping of the main pulse. The plasma lens will be very promising for the laser proton accelerator.

The Predictability of a Squall Line in South China on 23 April 2007

Duochang Wu Zhiyong Meng Dachun Yan

Laboratory for Climate and Ocean-Atmosphere Studies, Department of Atmospheric and Oceanic Sciences, School of Physics, Peking University, Beijing, China

Abstract

This study explores the predictability of a squall line associated with a quasi-stationary front on 23 April 2007 in South China through deterministic and probabilistic forecasts. Result shows that the performance of squall line simulation is very sensitive to model error associated with resolution and uncertainties in the physical parameterization schemes. At least a 10-km grid size is necessary to decently capture the squall line in this event. Relative to microphysics and PBL schemes, the simulated squall line with a grid size of 4.5-km is most sensitive to long-wave radiation parameterization schemes. For a grid size from 20 km to 5 km, using cumulus parameterization scheme degrades the squall line simulation relative to turning it off with a more severe degradation to grid size smaller than 10 km than coarser resolutions.

The sensitivity of the squall line simulation to initial error is examined through probabilistic ensemble forecast. The performance of the ensemble simulation of the squall line is very sensitive to the initial error. About 15% of the ensemble members accurately capture the evolution of the squall line, 25% fail and 60% dislocate the squall line. Using different combinations of physical parameterization schemes for different members can apparently improve the probabilistic forecast. The lead time of this case is only a few hours. Error growth is clearly associated with moist convection development in terms of both time and space. A linear improvement in the performance of the squall line simulation is observed when the initial error is deceased gradually with the largest contribution from initial moisture field.

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Name		Affiliation	Email
	Zhiyong Meng		zymeng@pku.edu.cn
	Haijun Yang		hjyang@pku.edu.cn
	Xiaoyong Hu		xiaoyonghu@pku.edu.cn
	Yunquan Liu		Yunquan.liu@pku.edu.cn
	Chengyin Wu		cywu@pku.edu.cn
	Guowei Lu		guowei.lu@pku.edu.cn
	Yunfeng Xiao		yfxiao@pku.edu.cn
	Liangyou Peng		liangyou.peng@pku.edu.cn
	Kebin Shi		kebinshi@pku.edu.cn
	Junchen Pei		Peij@pku.edu.cn
	Tao Zheng		tzheng@pku.edu.cn
	Qingjuan Yu		yuqj@pku.edu.cn
	Jian Wei		Weijian6791@pku.edu.cn
	Xi Lin		XiLin@pku.edu.cn
	Yuan Li		yuan.li@pku.edu.cn
	Limei Xu		limei.xu@pku.edu.cn
	Zefeng Ren		zfren@pku.edu.cn
	Ying Jiang		yjiang@pku.edu.cn
	Biao Wu		wubiao@pku.edu.cn
	Chi Zhang		chizhang.riceu@gmail.com
	Xincheng Xie		xcxie@pku.edu.cn
	Zonghai Hu		zhhu@pku.edu.cn
	Xinqiang Wang		wangshi@pku.edu.cn
	Yue Wang		yue.wang@pku.edu.cn
	Xiaosong Wu		xswu@pku.edu.cn
	Ouyang Qi		qi@pku.edu.cn
	Xinzheng Li		xzli@pku.edu.cn
	Zhuo Li		Zhuo.li@pku.edu.cn
	Xueqing Yan		x.yan@pku.edu.cn
	Qing Pan		panq@pku.edu.cn
	Li Xiao		xiaoli613@pku.edu.cn