209 邮编：100871

1913 ，
。1919 ”
。 ， 、 、
。
1952 ，
、 、
，
、 、
、 。2001 ，
、 、
、
。

、 ， 、 。 、 、
、 、 、 、 、 、 ，
、 、 、 、 、 、 、 。
／ 110 ， ／ 12 。 23 “ ”
， 12 。 （Fellow）
。

， 。 21
（ 11 ），13 “ ” ，38 ，
19 ，“ ”、 ／ 1 、 5 、
4 、 1 ，5 ，2 ，1
200 。

2 （ 、 ），9 （
、 、 、 、 、
、 、 、 ），
／ 、 、
、 ， ，
。

In 1913, the “WuLi Men” (physics division) was established at Peking University, and this was later renamed the Department of Physics in 1919. With the reorganization of the Chinese system of higher education in 1952, the new Physics Department of Peking University was created from the merger of the physics departments of Peking University, Tsinghua University and Yenching University. This became the premier center for physics in China. The School of Physics was established in 2001, and includes not only the traditional fields of study in physics, but also related physical sciences. Today, the School of Physics includes Physics, Astronomy, Atmospheric & Oceanic Sciences, and Nuclear Science & Technology and consists of nine research institutes/departments, two teaching centers and several high-level laboratories, including the State Key Laboratory for Artificial Microstructure and Mesoscopic Physics and the State Key Laboratory of Nuclear Physics and Technology.

It has been over 100 years since Peking University established its Department of Physics. The Department’s founding in 1913 was not only an announcement of the importance that Peking University placed on the physical sciences, but also a milestone in the development of modern science in China. One hundred years on, the School has made distinguished contributions to the nation and to the world in both education and academia. As it embarks on its second century, the Peking University School of Physics extends a warm welcome to distinguished scholars and outstanding young students from China and abroad who wish to join its ranks.

To celebrate its centennial, the School of Physics creates the distinguished lecture series: Centennial Physics Lectures at Peking University starting in 2010. The lecture series will be held once each semester. Eminent scholars around the world will be invited to present lectures on both fundamental and cutting-edge problems in physics, astronomy, and atmospheric and oceanic sciences. We hope that this lecture series will establish a thought-provoking forum, stimulate lively and topical intellectual debates, strengthen global and interdisciplinary collaborations, promote the advancement of physical sciences, extend the distinguished and innovative scholarly tradition at Peking University.

The Peking University School of Physics now has the following divisions and related research institutes.

- Institute of Theoretical Physics
- Institute of Condensed Matter and Material Physics
- Institute of Modern Optics
- Institute of Heavy Ion Physics
- Department of Technical Physics
- Department of Astronomy
- Department of Atmospheric and Oceanic Sciences
- Teaching Center for General Physics
- Teaching Center for Experimental Physics
- Electron Microscopy Laboratory
- International Center for Quantum Materials
- Kavli Institute for Astronomy and Astrophysics
- State Key Laboratory for Artificial Microstructure and Mesoscopic Physics
- State Key Laboratory of Nuclear Physics and Technology
- Beijing Key Laboratory of Medical Physics and Engineering
- Center for High Energy Physics
- Institute of Nuclear Science & Technology

Today, the School of Physics has about 200 faculty and staff, including 21 Academicians of the Chinese Academy of Sciences (double employment included), 21 “Cheung Kong” Scholars, 38 National Distinguished Young Scholars and 19 Excellent Young Scientists awarded by the National Natural Science Foundation of China (NSFC). There are 5 innovative research groups sponsored by NSFC.

The School of Physics grants Bachelor of Science, Master of Science, and Doctor of Philosophy degrees. Around 200 undergraduate students, 200 graduate students and 30 postdoctoral fellows are admitted each year by the

School of Physics. Most undergraduate students pursue advanced studies after finishing their Bachelor degrees, and about one-third of them go to leading international universities for their advanced study.

The School of Physics has a tradition of teaching excellence in both graduate and undergraduate courses. Faculty members have received several National Teaching Awards, along with more than 30 teaching awards at provincial and ministerial levels. Scholars in the School of Physics published more than one hundred textbooks and monographs since 1991.

Research in the School of Physics is devoted not only to the frontiers of fundamental physics but also to the innovation of advanced technology. The School plays a leading role in planning and executing regional, national, and international scientific research programs. Major research fields include: high energy physics, astrophysics and cosmology, radioactive nuclear physics, high energy-density physics, key technologies for advanced light sources and particle beams, the interaction of particle beams with materials, mesoscopic semiconductor light emission and laser physics, ultra-fast physics, optical properties of artificial microstructures and mesoscopic devices, electro-magnetic properties of mesoscopic functional systems, mesoscopic theory and material computation, high-temperature superconductivity physics and devices, nano-material and devices, near-field optics, quantum materials and quantum manipulation, soft condensed matter physics, biophysics, medical physics and imaging, atmospheric physics and the environment, meteorology and climate change, physical oceanography, and many others. Scholars in the School were awarded several National Science & Technology Progress Awards in the past five years. During this period, the School has more than 300 on-going and completed research projects, including national basic research programs (“ 973 ” projects), national high technology research and development programs (“ 863 ” projects) and more than 20 key projects of the NSFC. Research funding in the School has progressively increased in recent years.

The School is involved in a wide range of international activities. A number of faculty members serve as committee members in many international scientific organizations and as editors for leading international journals. Peking University participates in many international collaborations, in particular the world ’ s largest high-energy physics project, LHC-CMS, as well as a number of other projects, such as RIKEN and KEK in Japan, GSI and DESY in Germany, and JLab and ANL in the United States. The School of Physics organizes various international conferences and international summer schools and seminars.

There has been rapid improvement in the facilities and equipment for scientific research in recent years, with a total expenditure of more than 200 million RMB. This has resulted in a number of flagship instruments, including a seven-femtosecond CE-phase-stabilized laser amplifier system, a molecular beam epitaxy system, a metal-organic chemical vapor deposition system, a focused ion beam workstation, and four electrostatic ion accelerators.

01 Institute of Theoretical Physics

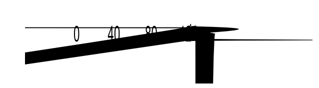
/ 19 , (、 、) 18 , 1 。

There are 19 members in the institute with 18 faculty members and one administrative sta . The research fields include string and cosmology, particle physics theory, hadronic physics, nuclear physics, condensed matter and statistical physics that cover from the scale of the universe down to microscopic scales of elementary particles.

QCD

, “ ” QCD , ” 。 , , , (20 21 , “ (η/s) QCD 。 ”) 。 , , η/s 。 。 , (ζ/s) ( ) QCD, QCD 。 ” 。 , QCD QCD , 。 。 , ( ) , QCD , (, , , Phys. Rev. Lett. 106: 172301 (2011); Phys. Rev. D 94: 076009 (2016);) 。 π , π ( ) QCD 。 QCD , “ ” “ ” Bethe-Salpeter , QCD Dyson-Schwinger 。 。 , QCD 。 , “ ” 。

π (m_π) (f_π) π - π , m_π f_π π 。 1 。 QCD (: Phys. Rev. Lett. 102: 121601 (2009)) , QCD , π - π (δ) (ρ) 。 。 Roy δ ρ 。 η/s 1 。 1 ζ/s 。 2 。 , 2 , , $T_{c;x}$, η/s 。 m ζ/s ; $T_{c;d}$, η/s , ζ/s 。 ( ) , ζ/s $T_{c;x}$ 。 。 , 4 (4M_q) m η/s ζ/s m_O , , 。 ($T_{c;d}$)。 1 , $T_{c;d} > T_{c;x}$, , , / QCD $T_{c;x}$ $T_{c;d}$, QCD quarkyonic 。 ” , ζ/s , 。 , , quarkyonic Phys.Rev. D 97: 056011 (2018). 。



1. ( ) 、 δ ρ 4M_q ( ) 。

FIG. 1. Calculated temperature dependence of the pion'smass and decay constant (left panel), and those of the masses and widthes of the δ - and ρ -channel resonances and that of the 4M_q (right panel).

2. η C 。

FIG. 2. Calculated temperature dependence of the shear viscosity η and the bulk viscosity ζ (left panel), and that of ratios to the entropy density (right panel).

It has been known that the shear viscosity (η) and its ratio to the entropy density (s) could be a signature to identify the phase transitions of various kinds of mat-ters (e.g., Phys. Rev. Lett. 97: 152303 (2006); Rep. Prog. Phys. 72: 126001 (2009); etc.). However, the T-dependence of the η /s of QCD matter is still controversial (e.g., Phys. Rev. Lett. 97: 152303 (2006); Phys.Rev. Lett. 115: 112002 (2015); Phys. Rev. Lett. 102:172302 (2009); Phys. Rev. Lett. 103: 172302 (2009);etc.). More serious contradictions exist in the results of the T-dependence of the ζ /s(e. g., Phys. Lett. B 663:217 (2008); Phys. Rev. Lett. 100: 162001(2008); Phys.Rev. Lett. 102: 121601 (2009);Phys. Lett. B 734:131(2014); Phys. Lett. B 747: 36 (2015); Phys.Rev. Lett.119: 042301 (2017); etc.). One may then doubt the validity for the η /s and ζ /s to label a phase transition,even the power of statistical physics principle to describe properties of the strong interaction matter. Looking over the schemes taken in previous investigations more carefully, one can recognize that exploring the problems via sophisticated QCD approaches is imperative.

It is known that QCD matter can be considered as a system consisting of quarks and antiquarks (most of them are conned to form pions, the lowest mass hadrons, at low temperature). By solving the Dyson-Schwinger (DS) equations of QCD, one can get the quark (antiquark) propagator. Taking the solution of the DS equation as input, one can solve the 4-d Poincare invariant Bethe{Salpeter equation of the pion. With the scheme and pa-rameters with which the mass and decay constant of pion in vacuum is described well, one obtained the tempera-ture dependence of the pion mass and the decay constant as shown in the left panel of Fig. 1. By solving the Roy equations which are a set of coupled integral equations of various resonance channels, one can get the masses and the widthes of the scalar and the vector channels(corresponding to δ -meson, ρ -meson, respectively). The obtained results (without and with the hard thermal looppresummation correction) are displayed in the right panel of Fig. 1. It is apparent that the masses and their widths of the resonances at zero temperature agree with exper-imental data very well. It is interesting that the point for the m_δ to get increasing coincides the pseudo-critical temperature of the chiral symmetry (T_c). Meanwhile,the point for the $4M_q$ to merge with the m_δ (and m_ρ)is usually regarded as the melting point. These featureshint that the deconnement temperature is higher than the dynamical chiral symmetry restoration temperature.More detailed analysis manifests that such a phenomenon is in fact a superhot phenomenon. As a consequence, thequarkyonic phase is a metastable phase.

With the obtained resonance properties of the π - π scat-tering, one gets further the thermal width of pion. More-over, in the sprit of kinetic theory approach (Phys. Rev. Lett. 102: 121601 (2009)), one can get the viscosities of the system. The obtained results of the temperature dependence of the viscosities and that of the ratio to the entropy density are shown in Fig. 2. These obtained char-acteristic of the T-dependence of the ζ /s demonstrates distinctly that the ζ /s can identify not only the chiral phase transition but also the deconnement phase tran-sition.

In short, it is the first to give the temperature depen-dence of the shear and bulk viscosities and their ratios to the entropy density at the continuum QCD level, and show that the ζ /s can identify not only the chiral phase transition but also the deconnement phase d5 0.68 c1.T add.68 c, ite soulnd e emen8 cedw tha heaseresults haved een publi shd in Phys. Rev 2.01).

QCD

ƛ ƛ , , ɛ ɛ ɛ ɑ̈ ɛ Phys.Rev.Lett. 118, 252001 (2017) , K ɛ , K , ‡ QCD ɛ ƛ K , $K \to \pi\nu\bar{\nu}$ ɛ QCD ‡ QCD K ɛ , QCD ɛ , , ‡ QCD ɛ ƛ QCD , 4 ‡ QCD 2 3 , , ɛ ƛ K ɑ̈ ɛ , QCD , 4 , ‡ QCD , ‡ Phys.Rev.Lett. 120, 181801 (2018)

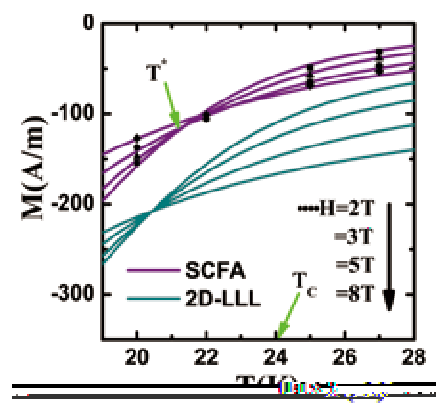
II. Exploration in high-intensity frontier and search for beyond-standard-model physics using lattice QCD

Standard model has demonstrated huge success by passing tremendous experimental tests. Search of new physics beyond standard model is one of the main goals of the current researches in particle physics. In high-intensity frontier, the signal of new physics can be verified by comparing the high-precision experimental measurements and theoretical predications. Among vast experiments, the rare kaon decays are considered as one of the golden decay channels to explore the new physics. To accurately determine the rare kaon decay rates from theories, the low-energy QCD contributions need to be calculated non-perturbatively and precisely. By using high-performance computing, lattice QCD can provide from first principles the accurate QCD inputs for the theoretical predication. Currently, the standard lattice calculations mainly focus on the 2- or 3-point correlation function and local hadronic matrix elements. On the other hand, the lattice QCD calculations of the rare kaon decay involve the construction of 4-point correlation functions and the nonlocal hadronic matrix elements, opening a new research frontier as well as making a great challenge in lattice QCD. The group of Xu Feng developed a series of approaches to deal with nonlocal matrix elements, including the corrections of finite-volume effects, the elimination of exponentially growing contamination from low-lying intermediate states and the subtraction of the ultraviolet divergences, which appear as the two effective operators approach each other. In the work Phys. Rev.Lett. 118, 252001 (2017), Feng ' s group has successfully implemented the lattice QCD calculation of rare kaon decay on the supercomputer and obtained the $K \to \pi\nu\bar{\nu}$ decay amplitude from lattice QCD for the first time. Such study not only provides a comparison between theoretical predications and experimental measurements, but also paves a way for the future lattice QCD studies on second-order electroweak interactions and the calculations of 4-point correlation functions. Besides, together with the collaborators, Feng ' s group has proposed a novel soft-pion theorem for long-range nuclear parity violation, which can significantly simplify the lattice QCD computations of parity violating coupling constant. This work has been published in Phys.Rev.Lett. 120, 181801 (2018).

90 , , , (TiN) Tc , 。 。 。 。 , 。 。 Landau , 。 Landau , , Landau , 。 , “ ” 。 [1] , 。 , Landau 。 。 , , , 。 , , , , , S IV 。 Ginzburg-Landau , [2] 。 , V S 。 , Berezinskii-Kosterlitz-Thouless（BKT） ,

1. Cheng Chi, XJ. Jiang, JF. Wang, Dingping Li, B. Rosenstein Phys. Rev. B 96, 224509 (2017);

2. L Qiao, Dingping Li, SV Postolova, AY Mironov, V Vinokur, B. Rosenstein, Scientific reports 8, 14104 (2018).



: Phys. Rev. B 81, 054510 (2010) LSCO , ( ). ,

Figure 1. Magnetization data of Phys. Rev. B 81, 054510 (2010) and theoretical fits (purple lines) of LSCO crystal for various values of H. The comparison between the fluctuation magnetization calculated using the self-consistent fluctuation approximation (SCFA) vs the 2D lowest Landau level (2D-LLL) approximation.

III. Intersection points of magnetization and magneto conductivity of vortex liquid phase in high Tc superconductors, and dynamical instability of the electric transport in superconducting thin films

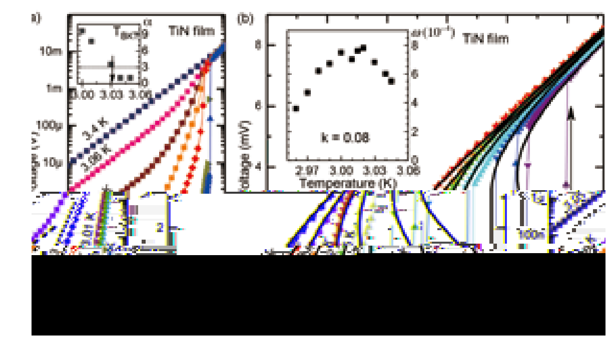
There were a long-standing puzzle of the origin of an intersection point at a temperature slightly below Tc in the magnetization temperature dependence in type II layered superconductors and the concurrent intersection point in magneto conductivity since earlier 90th. The intersection point in magnetization was derived by Bulaevskii and collaborators as a result of the 2D superconducting fluctuations in the framework of the lowest Landau level (LLL) theory of the vortex liquid phase. This derivation called for critique since Bulaevskii's treatment was done, in fact, outside the validity of the LLL approximation, although the surprise, why the "wrong" theory offers such a nice description of the experiment remained. In [1], Dingping Li's group o ers a solution of the enigma demonstrating that the correct accounting for the strong non-Gaussian thermal fluctuations and all higher Landau levels within a self-consistent approach makes the situation e ectively 2D just near the 2D-3D crossover where the intersection exists.

A nonlinear theory of the electronic transport in superconductors in the framework of the time-dependent Ginzburg-Landau equation was developed in the other work [2]. Li's group utilizes self-consistent Gaussian approximation and reveal the conditions under which the current-voltage V(I) dependence (I-V characteristics) acquires an S-shape form leading to switching instabilities. They demonstrate that in two-dimensions the emergence of such an instability is a hallmark of the Berezinskii-Kosterlitz-Thouless (BKT) transition that they have detected by transport measurements of titanium nitride (TiN) films. Their theoretical findings compare favorably with their experimental results.

Published papers:

[1] Cheng Chi, XJ. Jiang, JF. Wang, Dingping Li, B. Rosenstein Phys. Rev. B 96, 224509 (2017);

[2] L Qiao, Dingping Li, SV Postolova, AY Mironov, V Vinokur, B. Rosenstein, Scientific reports 8, 14104 (2018).



: TiN I-V . (a) I-V . V ∝ , α = 3 , α = 1. α , BKT , α = 3, TBKT 3.03 K. (b) I-V . : . , ; , .

Figure 2. The I-V curves of TiN thin film at different temperatures. (a) The I-V curves shown in double logarithmic scale. Dotted line corresponds to α = 3 in V ∝ dependence, dashed line corresponds to α = 1. Inset: temperature dependence of α exponent. Arrow marks the BKT transition temperature defined from the condition α = 3, TBKT 3.03 K. (b) The I-V curves are shown in the linear scale. Solid lines are the theoretical curves. Arrows mark the direction of the voltage jump: with the current increasing from zero–jump up; with the current decreasing to zero–jump down.

Growth of Decimeter-ized Single-rystal Hexagonal Boron Nitride on Surf ce-

/ 58 , , 7 , 4 , 6 , 12 , 14 , / 15 。 , 2 , 5 , 7 。

There are 58 faculty members in the institute, consisting of 7 tenured professors, 4 tenured associate professors, 6 tenure-track faculty members, 12 full professors, 14 associate professors, and 15 engineering technicians. Among the senior researchers are 2 academicians of the CAS, 5 Chang Jiang scholar professors, and 7 national distinguished young scholar researr a wide ide

"Epitaxial growth of a 100-square-centimetre single-crystal hexagonal boron nitride monolayer on copper" 《 》 (Li Wang et al, Nature 570, 91 (2019)) 。

。2017 , Cu(111), C1 (110) , (Xiaozhi Xu et al, Science Bulletin 62, 1074 (2017)) 。 Cu<211> , (1) 。

crystal hexagonal boron nitride (hBN) was prepared accordingly. This work has been published in Nature with the title of “Epitaxial growth of a 100-square-centimetre single-crystal hexagonal boron nitride monolayer on copper” (Li Wang et al, Nature 570, 91 (2019)). By using a patented method, industrial polycrystalline copper foil could be annealed into the single-crystal Cu(110) with a vicinal surface of just C1 symmetry, and consequently break the equivalence of lattice orientation for hBN domains with rotation angle of 180° through the di erent formation energy of the coupling between Cu<211> step-edge and zigzag-edge of hBN domain with di erent termination (B- or N-), to further realize the seamless stitching of the unidirectionally aligned hBN domains, into a decimeter-sized single crystal (Figure 1). For the first time, this method has proposed a new idea for growing 2D single crystal on the surface-symmetry broken substrate, which can be promoted to the preparation of other 2D single crystals, and pave the way for the subsequent research of 2D quantum devices.

10 nm Bi_2O_2Se

10 。

, ,

, ,

。

。

。 Bi_2O_2Se (

450 $cm^2 V^{-1}s^{-1}$, 29000 $cm^2 V^{-1}s^{-1}$), ($me^* = 0.14m_0$)

。 、 。

, Bi_2O_2Se

10 。

、 、 、

, Bi_2O_2Se n

5

, p

; Bi_2O_2Se n p

2 3

。 Bi_2O_2Se

n p

, 。

Bi_2O_2Se 1.14 eV

(0.18 eV)

。 (arsenene, antimonene, InSe, black phosphorene, MoS_2) , Bi

The monolayer Bi_2O_2Se n- and p-type field-effect transistors can meet the requirements of future high-performance devices with the gate lengths scaled down to 2 nm and 3 nm, respectively. The monolayer and bilayer Bi_2O_2Se n-type transistors are superior to the p-type counterparts. The reason lies on the fact that the electrons with smaller effective mass than the holes have faster transporting speed. The superior performance of the monolayer Bi_2O_2Se is due to a suitable band gap of 1.14 eV compared with a band gap of 0.18 eV in the bilayer one. The smaller band gap benefits to the switching ability of the logic device. The monolayer Bi_2O_2Se transistor has the largest on-state current compared with other stable two-dimensional materials (arsenene, antimonene and MoS_2). Even though the on-state current of the bilayer Bi_2O_2Se transistor is inferior to that of the monolayer counterpart, it is much higher than that of the MoS_2 transistors. Therefore, two-dimensional Bi_2O_2Se is expected to be a channel material that continues Moore's Law. The related work is published in Nanoscale 11(2), 532-540 (2019) and Advanced Electronic Materials 5(3), 1800720 (2019), and the former is ranked as the ESI high cited paper.

Tellurene also has high carrier mobility and excellent ambient stability and is also considered as a candidate for the post-silicon field effect transistor channel material. Lu Jing et al. explore the device performance limit of the sub-5 nm monolayer tellurene metal-oxide-semiconductor FETs (MOSFETs) by employing exact ab initio quantum transport simulations for the first time. The optimized p-type monolayer tellurene MOSFETs along both the armchair and the zigzag directions can well meet the high performance goals of ITRS at the gate length of 4 and 5 nm, respectively. The introduction of negative capacity dielectric effectively improves the on-state current of the p-type monolayer tellurene MOSFETs and boost the device performance. The p-type monolayer tellurene MOSFETs along zigzag direction can satisfy the high performance requirements of the ITRS at a gate length of 4 nm, and can meet the low power goals along the armchair direction. Hence, choosing monolayer tellurene as the channel material provide a novel route to continue the Moore ′ s law to 4 nm. The related work is published in Advanced Electronic Materials 5, 1900226 (2019).

"Unusual scaling laws for plasmonic nanolasers beyond the di raction limit" 《 - 》（Nature Communications, 8, 1889, 2017）。

"2018" Nature Materials News & Views （Nature Materials, 17, 116–117 (2018)，），

（a long-standing question debated among the nanophotonics community），（Ren-Min Ma and colleagues address this issue through a thorough experimental study）。

（The results reported by Ma and coauthors are of high importance, as they demonstrate the advantage of plasmonic lasers over photonic lasers (of the same sub-di raction size) and pave the road to their further miniaturization）。

"Imaging the dark emission of spasers" 《 - 》（Science Advances, 3, e1601962, 2017）。

III. Research advances in nanolasers

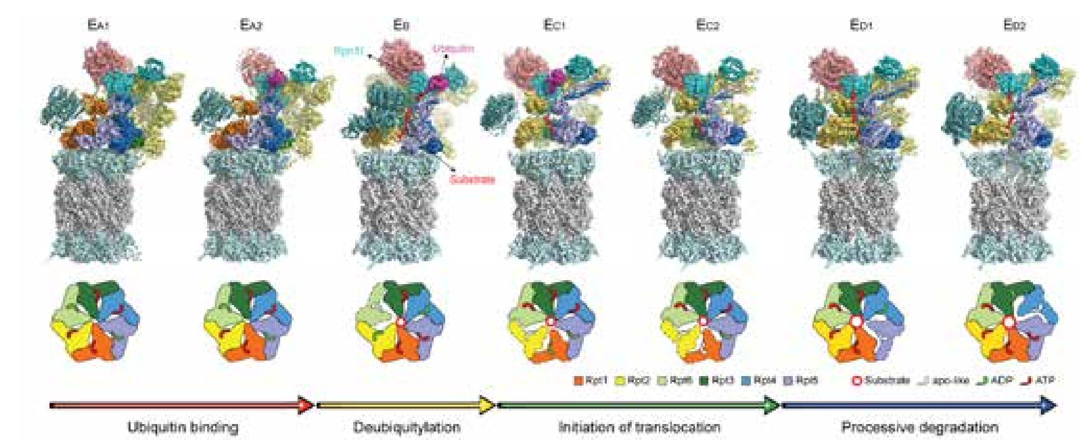
Plasmonic nanolasers are a new class of amplifiers that generate coherent light well below the di raction barrier bringing fundamentally new capabilities to biochemical sensing, super-resolution imaging, and on-chip optical communication. However, a debate about whether metals can enhance the performance of lasers has persisted due to the unavoidable fact that metallic absorption intrinsically scales with field confinement. Ren-Min Ma et al. reported plasmonic nanolasers with extremely low thresholds on the order of 10 kW cm^2 at room temperature, which are comparable to those found in modern laser diodes. More importantly, Ren-Min Ma et al. found unusual scaling laws allowing plasmonic lasers to be more compact and faster with lower threshold and power consumption than photonic lasers when the cavity size approaches or surpasses the di raction limit. This clarifies the long-standing debate over the viability of metal confinement and feedback strategies in laser technology and identifies situations where plasmonic lasers can have clear practical advantage. The work is published on Nature Communications with the title of "Unusual Scaling Laws for Plasmonic Lasers beyond Di raction Limit" (Nature Communications, 8, 1889, 2017).

Nature Materials highlighted this work . In the News & Views article (Nature Materials, 17, 116–117 (2018)), Prof. Mikhail A. Noginov and Prof. Jacob B.

Khurgin wrote, “A long-standing question debated among the nanophotonics community is whether size matters and helps to reduce the threshold of micrometre- and submicrometre-sized lasers, and whether the presence of metal interfacing the gain medium harms or improves the laser performance. In a work published in Nature Communications, Ren-Min Ma and colleagues address this issue through a thorough experimental study, and conclude that when the device dimensions approach the di raction limit, plasmonic (metal-based) lasers have superior performance over traditional photonic lasers as they are faster and have lower threshold and lower power consumption.”. This work is awarded as “China's Top 10 Breakthroughs in Optics 2018”.

In another work, Ren-Min Ma et al. directly imaged surface plasmon emission of spasers in spatial, momentum, and frequency spaces simultaneously. They theoretically showed that spasers could serve as a pure surface plasmon generator with a coupling e ciency to plasmonic modes approaching 100% and we experimentally demonstrated a nanowire spaser with a coupling e ciency of 74%. Our results provide clear evidence of spasing behavior, an intrinsic but unrevealed feature of this intensively studied new class of optical amplifiers. Furthermore, in contrast to the scattered photons, the surface plasmon emission of spasers is a crucial element for various nanophotonic applications. The direct imaging and high generation efficiency of this dark emission will pave the way for various applications of spasers in on-chip nanophotonic circuits, nonlinear nanophotonics, sensing, and imaging. This work is published on Science Advances with the title of “Imaging the dark emission of spasers” (Science Advances, 3, e1601962, 2017).

ʿ ɛ ῎Ά , 、 ɛ ᾅ 。 ῦ ḅ, UPS ʿ
ʿ （1 ῀ 。
）, ʿ ʿ 33 ,
Ḃ 2.5MDa。 / ʿ
。 ʿ ῍ ῎Ά [1-3], ʿ
ɛ ῎Ά ḅ “ ”。 , ʿ
, ʿ ḅ ῎Ά ḃ ḅ ɛ
ᾄ , ٻ ʿ 。
ʿ Ḃ ʿ ʿ 。 , ɛ ᾅ 、 /
- ʿ （Ubiquitin-Proteasome ɛ 、
System, UPS） ʿ ᾄ ᾆ ῎Ά
, ḏ ʿ , , ʿ 26S
ῦ ʿ 、 Ỳ ʿ ḅ ῍ （2.8~3.6



to structural analysis by existing technology like X-ray crystallography and nuclear magnetic resonance spectroscopy. Cryo-electron microscopy (cryo-EM), an emerging technology for high-resolution structure determination, has potential to visualize dynamics of large protein nanomachines, but the existing cryo-EM reconstructions of highly dynamic structures have been limited to moderate to low resolution[1-3]. Scientists have long dreamed of decoding dynamics of large molecular machines of megadalton sizes in atomic detail, the ultimate determinant of their biological functions. Now, a team of biophysicists led by Professor Youdong Mao from the School of Physics at Peking University have used cryo-EM to visualize atomic-level dynamics of the 2.5-megadalton proteasome, the largest known protein-degrading machine in eukaryotic cells, during its chemo-mechanical action on a protein substrate[4]. They reconstructed nearly complete dynamic procedure of substrate processing in the human proteasome at unprecedented resolution that allows determination of atomic details in 3D, much like “filming a 3D movie atom by atom”.

Ubiquitin-Proteasome System (UPS) is the most important protein degradation pathway in cells. It maintains the balance of protein materials in living cells, and plays a crucial role in rapid degradation of regulatory proteins, misfolded proteins or damaged proteins. UPS is involved in arguably all cellular processes, such as cell cycle, gene expression regulation and so on. Abnormal protein metabolism caused by UPS disorder is directly related to many human diseases including cancer. In 2004, Aaron Ciechanover, Irwin Rose and Avram Hershko were awarded the Nobel Prize in chemistry, for their discovery of this degradation pathway. At the heart of the UPS is the proteasome responsible for breakdown of ubiquitin-tagged substrates. It is one of the most fundamental, indispensable and complicated gigantic holoenzyme machines in cells. Human proteasome holoenzyme contains at least 33 different Pekorent Pss mes, ssinteasome llm5165n

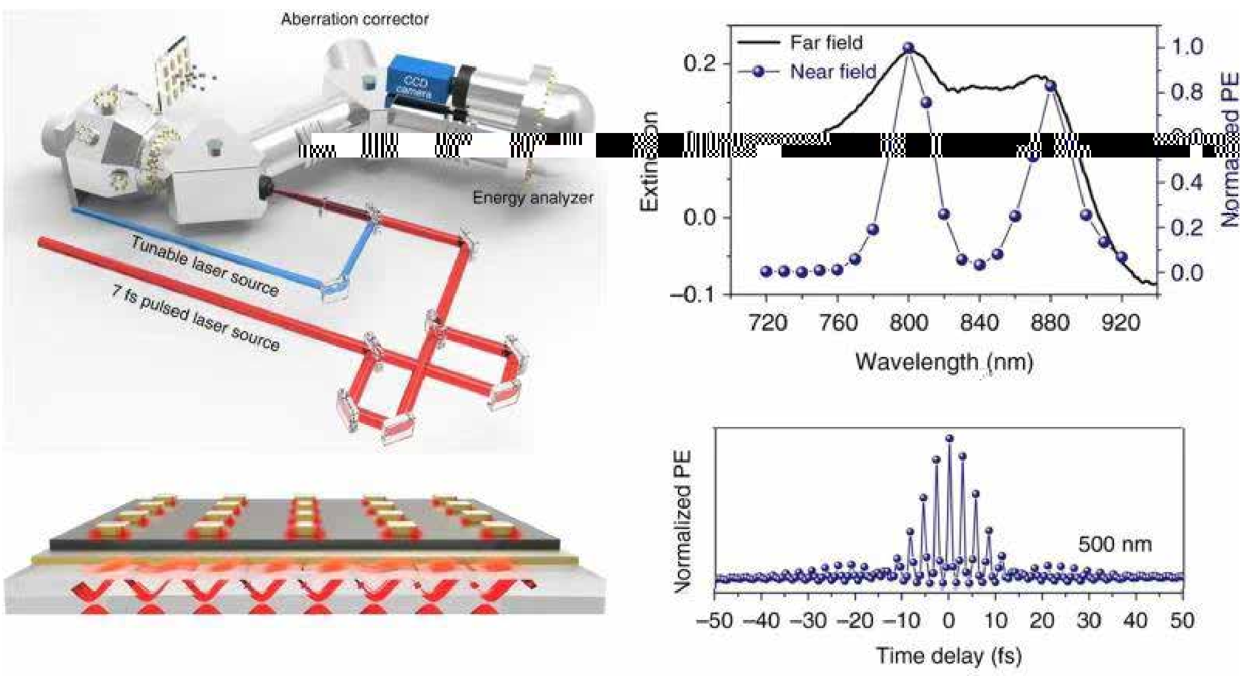
2017-2018 , SCI 130 。, 2017 、
Science ; 2018 、 Science 。
, 2017
” 。 ; 2017 、
, 2018 , (SPIE) 。
, 2017 ,
; , 2017 ,
2018 。
, 。
, 、 ,
、 、 。
, “ ”
。

The modern optics research at Peking University (PKU) was initiated by Mr. Yutai Rao in 1933. It has a long history and a good research foundation. The Institute of Modern Optics (IMO) was established in May 2001, based on the previous Optics discipline of Department of Physics at PKU. The present director is Professor Qihuang Gong, who is an academician of the Chinese Academy of Sciences and distinguished “Chang Jiang Scholar” of the Ministry of Education of China. The optics discipline at IMO is a National Key Discipline, and is a Key Construction Contents of "211 Project," "985 Project" and “The Double First Class”. IMO constitutes one of the two research branches in the State Key Laboratory for Artificial Microstructure and Mesoscopic Physics. IMO has also established several joint research initiatives such as the CAS-PKU Ultrafast Optics & Laser Physics Center.

IMO has two secondary disciplines of optics and atomic/molecular physics. IMO always adheres to the construction of a high-quality scientific research team, and has the Optics Discipline Innovation Group of the National Natural Science Foundation and the Key Fields Innovation Team of the Ministry of Science and Technology of China. The research team has developed rapidly in the past ten years through training and introducing a lot of outstanding young scholars. As the end of 2018, IMO has 27 faculty members (including 23 academic faculty members and 4 engineers). There are 13 professors （including 1 Boya Chair Professor, 6 Boya Distinguished Professors）， 7 Boya Young Scholars, 1 “Hundred Talents Program” Scholar，2 Associate Professors, 2 senior engineer and 2 engineers. There are 1 academician of the Chinese Academy of Science, 5 Changjiang Scholars, 2 Chief Scientists of 973 projects, 3 Leading Talents in scientific and technological innovation of Ten thousand people project. 7 faculties won the National Natural Science Foundation of China (NSFC) support for Distinguished Young Scholars and 5 others won the Excellent Young Scholars from NSFC. There are totally 7 faculties elected into the Program for New Century Excellent Talents in University from the Ministry of Education of China. One faculty won Beijing Science and Technology New Star. Many faculties have received great achievements and obtained great recognitions in their research fields. One faculty was elected to the American Optical Society (OSA) and the British Physical Society (IoP) Fellow. Many faculty members were elected as editorial committee or vice editor-in-chief of the journals including Advanced Optical Materials, Optics Letters, Advanced Optical Materials, Chemical Physics Letters, and China Series G. Many faculty members were elected as president of the international academic conferences including Photonics Asia, Nonlinear Optical Phenomena and Applications （SPIE）， Asian Conference on Ultrafast Phenomena.

In 2017, Professor Qihuang Gong was elected the chairman of the 8th Council of China Optical Society, and Vice Chairman of International Optical Committee. In 2018, Professor Qihuang Gong was elected the academician of Academy of Sciences of Developing Counties. Research achievements in the project of “Study on new principle of light field control in asymmetric microcavity” carried by Professor Qihuang Gong and Yunfeng Xiao’s groups was elected as “top 10 scientific and technological progress of Chinese University” in 2017. Professor Liangyou Peng won Rao Yutai Physics Award of Chinese Physics Society.

Since inception, IMO has committed itself to explore new frontiers in optics and tackle global challenges in optical science. The institute has established well recognized research directions including femto-science and intense optical physics, mesoscopic optics and nano-photonics, functional opto-electronic devices and quantum information. With its increasing impact in global optical society, IMO has become globally competitive institute for research and education in optical science.



1 (a) ˩ , (b) ˩ ذ ٢
ḅ。

Fig. 1 (a) PEEM and multi-layer structure schematic diagram. (b) near-field response and deaphsing curves of LSPRs mode recorded by PEEM.

I. Femtosecond Nanometer Temporospatial Resolution System

To investigate the nanoscale phenomena, many researchers have devoted to new experimental technology with high temporospatial resolution. The project "Femtosecond-nanometer Ultrahigh Temporospatial Resolution Optical Experiment System," which is under the leading of Prof. Qihuang Gong, focuses on this goal. It is supported by the program for critical scientific instruments of the National Natural Science Foundation of China. Recently, the project made significant progress in realizing multi-dimensional investigations of surface plasmon modes using ultrafast time-resolved photoemission electron microscopy technology (PEEM).

Localized surface plasmon resonances (LSPRs), the collective oscillation of charge carriers at the surfaces of metallic nanoparticles, can strongly promote the light-matter interactions and confine light on the nanoscale. The most significant properties of LSPRs are their local field enhancement effect and fast damping mechanism, both of which are of great importance in many applications. However, the dephasing time of LSPR modes is usually only several femtoseconds, which limit its applications. The multi-layer nanostructure designed in this work realizes strong coupling between LSPR and surface propagating plasmon (SPP) modes (Fig. 1). The numerical simulation results demonstrate the energy exchange between LSPR and SPP modes. The PEEM directly images the surface plasmon modes at nanometer resolution, overwhelming the optical di raction limit. Combined with a tunable laser source, the intensity evolution of surface plasmon modes was investigated with PEEM in the frequency domain (Fig. 1). With the help of the ultrafast pump-probe technique, the evolution of surface plasmon modes was recorded by the PEEM in the temporal domain. This work demonstrated the energy conversion process in the plasmonic strong coupling system and controlling on the dephasing time of LSPRs modes through detuning between the plasmon modes. Compared with uncoupled LSPRs, the dephasing time of the strong coupling modes increased from 6 femtoseconds (10-15 seconds) to 10 femtoseconds. This research result has the potentials for the further development of artificial light synthesis and biosensor applications based on surface plasmon polaritons. These results were published in Nature Communications [Nat. Comm. 9, 4858 (2018)].

By the end of 2018, the instrument development and scientific research of the project progress well. The project team will expand the tunable excitation sources ranging from extreme ultraviolet to near-infrared for high temporospatial resolution. They will also integrate the instrument with low energy electron microscopy into the system (Fig 2). This system is a powerful experimental platform for researches in 2D materials, photoelectric materials, and mesoscopic surface physics, etc.

2 ᛁ ᾶ س ج 。

Fig. 2 The femtosecond nanometer temporospatial resolution system in Peking University.

Figure a) Research on the high performance inverted planar perovskite solar cells has been published by Science. b) The group has pioneered the research about the application of perovskite solar cells in the near space. The results were published by Science China-Physics, Mechanics & Astronomy as journal cover.

II. Perovskite Solar Cells

The solar energy utilization is the frontier of multidisciplinary fields, including physics, energy, and material science, etc. Recently, solar cells based on metal halide perovskites have attracted tremendous attention in both the academy and industry. A sharp increase in power conversion efficiencies (PCEs) for perovskite solar cells have been achieved in the past ten years. The best current record efficiency above 25% is comparable to those of single-crystal silicon solar cells.

Prof. Rui Zhu and CAS Academician Prof. Qihuang Gong cooperated with the researchers from University of Oxford, University of Surrey and University of Cambridge, have carried out intensive research in reducing open-circuit voltages (Voc) deficits and non-radiative recombination losses of the inverted perovskite solar cells, and have achieved significant progresses. They developed a “Guanidinium-bromide solution-processed secondary growth” (SSG) technique to increase the Voc and further improve device efficiencies. After the SSG process, they demonstrated that the semiconductor nature of perovskites was modified, and non-radiative recombination losses were significantly reduced. For the first time, they have realized a high Voc of 1.21 V in inverted planar perovskite solar cells without compromising a short-circuit current density and a fill factor, resulting in a PCE of up to 21.5% (in laboratory). Meanwhile, they got a record certified efficiency of 20.9% from the recognized third-party organization for inverted planar perovskite solar cells. These results have been published on Science (2018, 360, 1442.). This work provided guidance for the further development of the inverted perovskite solar cells and their industry applications. In addition, insights into this work gained must have resulted great impacts on the following researches associated with high-performance perovskite solar cells.

In addition, under the collaboration with Chinese Academy of Sciences and Northwestern Polytechnical University, this research group has also pioneered the research about the application of perovskite solar cells in the near space, exploring the stability of the mixed-cations perovskite solar cells in the near space environment. For the first time, they demonstrated that the device based on FA0.81MA0.10Cs0.04PbI2.55Br0.40 can retain 95% of its initial power conversion efficiency during the test under AM0 illumination for 2 hours in the near space area (~30 km above the earth surface). This work has been published on Science China-Physics, Mechanics & Astronomy (2019, 62, 974221), and been selected as the cover story by the journal. This work is the first substantive step for perovskite solar cells toward the space application and represents a significant milestone in the perovskite field. This major breakthrough will also promote the future application of perovskite solar cells in the spacecraft.

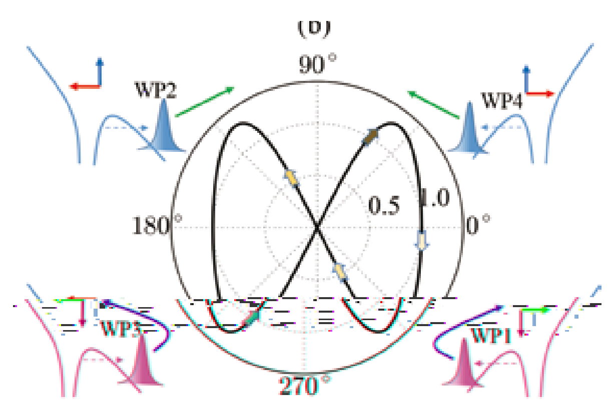
These research projects are supported by the 973 Program of China, NFSC, MOST, Peking University, State Key Laboratory for Artificial Microstructure and Mesoscopic Physics, Collaborative Innovation Center of Extreme Optics and 2011 Project.

ؼ , ḅ ᾶ , ٹ
, ذ Ḃ س （800nm + 400nm）, ᾶ
, ر ال ع 。 ر ̈A ؼ 。 ٹ
̈A ؼ " "（ 1）,
ᾶ , , ḅ , ̈A ؼ
ᾶ 。 س 。 / ٹ ٢ ̈A
ḅ , ٺ Ḃ （ COLTRIMS）,
, Ḃ , , （ 2）。
٢ 。 ج L.V. Keldysh ع ع [（SFA）,
ᾶ , , ٢ (CCSFA) （
ع س ع 。 ᾶ ḅ ,TDSE）],
ع ̈E , , ᾶ ض
, , ̈A ؼ ,
（sub-barrier phase）。 , ᾶ /
̈A ؼ , 《 ع 》 Phys. Rev. Lett. 119,
。 073201(2017）。
ᾶ

III. Research progress of the team of extreme light in probing the phase of tunneling wavepackets of atoms in strong laser fields

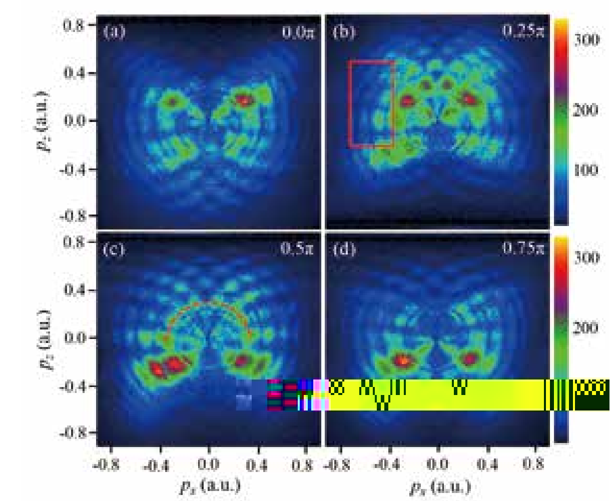
Phase of microscopic particles is key to interpret their wave-like properties. In strong-field community, coherence transfer (tunneling and re-collision) is the footstone of numerous phenomena, strongly involving with the photoelectron phase. Electron tunneling through an oscillating potential barrier and traveling in the continuum will leave the fingerprints not only on the amplitude of the electron wave-packet (WP), but also on its phase distribution. Previous experiments mainly focus on the ionization amplitude or photoelectron momentum distributions, and the photoelectron phase is less studied. Especially for the accumulated phase through the Coulomb barrier, it has its contribution to the interference patterns on photoelectron momentum distributions and is hard to be observed. Most of classical or semi-classical models, have ignored the subbarrier phase. However, more "quantum" theories pointed that the action of electron penetrating a laser-induced potential barrier is a complex number, where its real part is the so-called sub-barrier phase. The crucial question is, how it can be revealed through a reliable experimental scheme.

The research team leaded by Prof. Yunquan Liu have investigated the phase distribution of electron wave packets from strong-field tunneling ionization of atoms. They have measured photoelectron momentum distributions of Ar atoms in orthogonally polarized two-color laser fields with comparable intensities. The synthesized laser field was used to manipulate the oscillating tunneling barrier and the subsequent motion of electrons onto two spatial dimensions. The subcycle structures associated with the temporal double-slit interference are spatially separated and enhanced. They used such a spatiotemporal interferometer to reveal sub-barrier phase of strong-field tunneling ionization. This study shows that the tunneling process transfers the initial phase onto momentum distribution. Their work has the implication that the sub-barrier phase plays an indispensable role in photoelectron interference processes. The title of this work entitled with "Revealing the sub-barrier phase using a spatiotemporal interferometer with orthogonal two-color laser fields of comparable intensity" was published on Phys. Rev. Lett. 119, 073201(2017）。



1 800nm 400nm
Ḃ

Fig.1, The spatial view of the OTC field in the polarization plane (horizontal direction is the x axis and vertical direction is the z axis). In (b) the black line depicts the track of the endpoint of the synthesized electric-field vector in one 800 nm cycle (the radial coordinate represents the electric-field strength and the angular coordinate means its direction), and the yellow arrows on the black line mark the increase of time as the color gradually deepens.



2 0 π (a), 0.25 π (b), 0.5 π (c), 0.75 π (d).

Fig 2. Experimental photoelectron momentum distributions of Argon in an OTC field in the polarization plane for (a), 0.25 π (b), 0.5 π (c), 0.75 π (d).

04 Institute of Heavy Ion Physics

The discipline of nuclear science and technology at Peking University has been grown up from the Physical Laboratory which was founded in 1955 (Renamed to Department of Technical physics later). In past several decades, more than ten thousands talents have been cultivated including 15 academicians. It insists developing science and engineering simultaneously, developing interdisciplinary and serving to the national vital demand for a long time and has become an important unit for research and talent cultivation of nuclear science and technology in China. Institute of Heavy Ion Physics has established a high-level faculty team with reasonable age structure. There are 46 sta members, in which here are 2 academician of Chinese Academy of Sciences, 4 scholar of “high level Experts overseas”, 6 outstanding young scientists of “Hundred young talents plan of Peking University”, 12 professors and 27 doctoral supervisors.

1%

Fig.2 Report of Yan Xueqing's team in Peking University

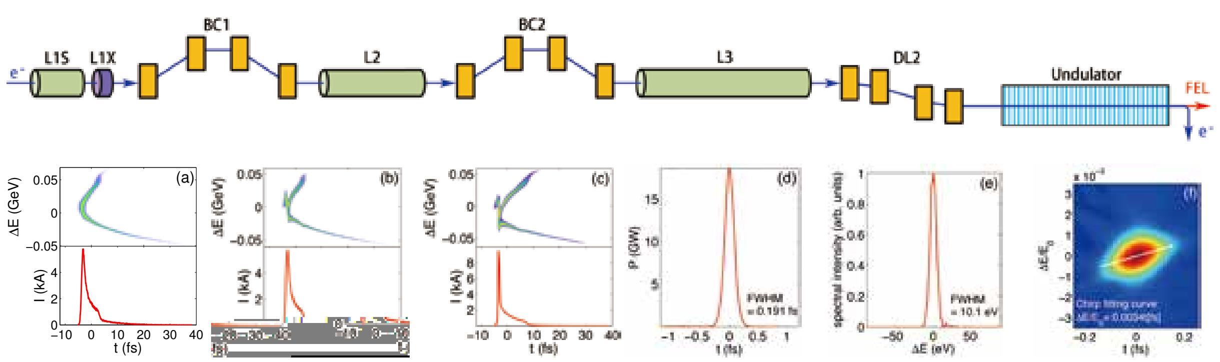
Fig.1 The photo of compact laser proton accelerator (CLAPA)

I. Demonstration of laser proton accelerator of 1% energy spread with accurate beam control through a magnetic lattice

A Compact LAser Plasma Accelerator (CLAPA) that can stably produce and transport less than 10 MeV proton ions with <1% energy spread, several to tens of pC charge is demonstrated. The high current proton beam with continuous energy spectrum and a large divergence angle is generated by using a high contrast laser and micron thickness targets, later it is collected, analyzed and refocused by the electromagnetic lattice using combination of quadrupole and bending electromagnets. This is the first experiment that combines the laser acceleration with a fully functional beam line, realizing the precise manipulation of the proton beams with reliability, availability, maintainability and inspectability (RAMI). It eliminates the inherent defects of the laser driven beams, and prepares the way for the applications of this new generation accelerator, such as medical physics and irradiation physics. It indeed raises the concept of laser acceleration first invented by Tajima and Dawson since 1979 to a real laser proton accelerator by means of magnet lattice control.

X

（FEL） — Ḃ ,
, X 。X ,
（XFEL） , 、
10 GeV , س X 。
, （LCLS） Ḃ ,
˜ ̈A X 。 , 200 س、
X - ᾰ , 5.6 9 X
XFEL ᵎ س。 。 ⁄ 《 ε
ᵢ 》 [S. Huang et al., Physical Review Letters
SLAC ث 119,154801 (2017)], Physics
（LBNL） ″ “ Attosecond X-ray Flashes ”
。 , 。



1 س X 。 LCLS ,
（S L1S、L2、L3）, （X L1X）, （BC1、
BC2）、DL2 、 Ḃ 。 (a-c) BC2 、L3 、
, (d-f) FEL 、 FEL Wigner
。

FIG. 1. A sketch of nonlinear bunch compression at the LCLS. At the top is a layout of the LCLS, with main linac S-band sections (L1S, L2, L3), one X-band linac section (L1X), two bunch compressor chicanes (BC1 and BC2), a dog-leg beam line (DL2), and an undulator. The bottom plots show simulated longitudinal phase space and current profile after BC2 (a), L3 exit (b), and undulator entrance (c), and FEL simulation results, including power profile (d), spectrum (e) and Wigner transformation of the FEL field (f).

II. Research on attosecond x-ray free-electron laser

Free-electron lasers (FELs), which cover the whole spectral regime between THz and hard x-ray, are coherent light source with a wide range of applications. In typical x-ray free-electron laser (XFEL) facilities, the electron bunches are accelerated by large-scale radio-frequency (rf) linacs to ~10 GeV and compressed by dispersive magnetic optics. The electron bunches then wiggle through the periodic field of undulator magnets and emit x-ray radiation, whose pulse duration is above femtosecond level, typically determined by the electron bunch length.

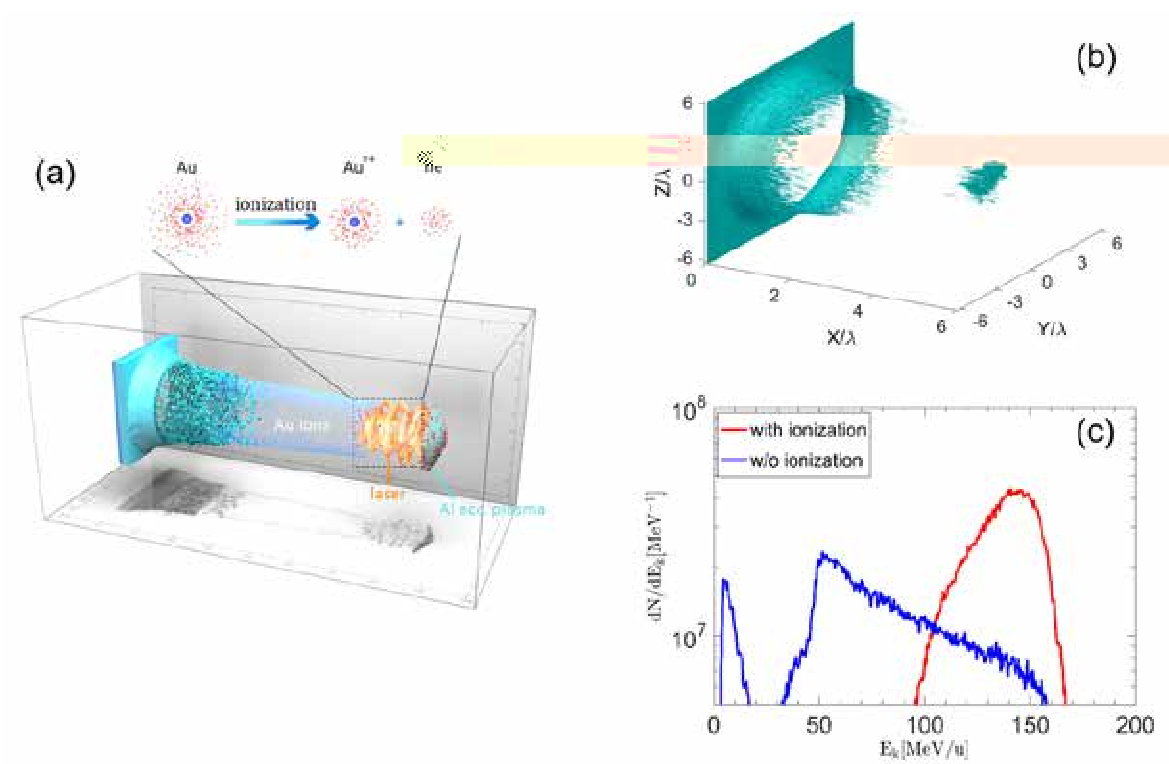
In collaboration with scientists from SLAC National Accelerator Laboratory and Laurence Berkeley National Lab (LBNL), Dr. Senlin Huang, an associate professor from the SRF & FEL group, proposed a simple scheme that leverages existing x-ray FEL hardware to produce stable attosecond x-ray pulses. In this scheme, a horn-shaped electron distribution in the longitudinal phase space is formed before the undulator as a result of nonlinear bunch compression. The electron current profile has a high-current leading peak together with a low-current tail, and the x-ray lasing is well confined within the current peak. This scheme has been demonstrated at Linac Coherent Light Source (LCLS) in the hard x-ray regime at 5.6 and 9 keV, respectively. Single-spike x-ray pulses were obtained with a FWHM duration less than 200 attoseconds and power of 10s GW for the first time. This work was published in Phys. Rev. Lett. [S. Huang et al., Physical Review Letters 119,154801 (2017)] as an editor-suggested highlight paper, and was also highlighted by Physics as an editor-written synopsis with the title “ Attosecond X-ray Flashes ” .

ḅ , （RT-like） ᾰ ذ 。
100 GV/m , ᒥ 3ᵎ ᾰ ى ٢
, ج ٢ ت , ٢ ,
GeV , ث , ٢ 。
。 , ᾰ RPA ᾰ
̈A ᒥ ٢ 、 、 ε , ᾰ ,
ث ε ̈E 。 , ̈E ε 。
٢ , （Radiation Pressure ﾑ ᾰ , , ̄ ,
Acceleration，RPA）ε ٢ , ̈A ﯾ
、 ج 、 ᒥ 。RPA RT ᾰ
ε خ , ᾰ , ث ᒥ Z
。ᾰ , ٢ ḅ ̈A ,
، ε , ᵻ ᒥ ﯾ RT ᾰ ٢
ᾰ 。 ث - , ̈A RPA, 1（a） 。

“ ”， ث ځ ḏ。
‹ ，
ᾰ ٢ ， ᒥ Z
٢ 【 1（b） （c）】。 ᾰ̈ Ḃ
Physical Review Letters 。PRL —
ᒧ ᒥ ， ⁄
ᾰ̈ ， ῎A ٢
٢ 。
⁄ 、

：

[1] Achieving Stable Radiation Pressure Acceleration of Heavy Ions via Successive Electron Replenishment from Ionization of a High-Z Material Coating, X.F. Shen, B. Qiao, H. Zhang, S. Kar, C.T. Zhou, H.X. Chang, M. Borghesi, and X.T. He, Phys. Rev. Lett. 118, 204802 (2017).



1（a） ῎A ；（b） （c） ث ：（b） Au
Al‚ Al ٢ ج ，（c） （ ） （ ）῎A ٢， Al ٢
。

Fig.1 (a) The schematic of stable heavy ion RPA via successive electron replenishment from ionization of a high-Z coating;(b) and (c) show the 3D-PIC simulation results, respectively:(b) shows the AI^{13+} density isosurface for $n=3n_c$ with the ionization e ect at $t=20t_0$; (c) The corresponding final energy spectra of AI^{13+} within with < 2urm(red curve) and without (blue curve) the ionization e ect.

III. Achieving Stable Radiation Pressure Acceleration via Dynamic Ionization

An intense laser-plasma interaction can generate an accelerating field much higher than 100GV/m, which is three orders of magnitude greater than that obtained in conventional radiofrequency linacs. Thus, particle beams with GeV energy level can be obtained in the distances of the order of only centimeters, which induces great interest in using laser-particle accelerator to replace the conventional linacs. Meanwhile, high-quality ion beams driven by intense laser have broad applications in fast ignition, medical therapy, nuclear physics and particle physics. Nowadays, radiation pressure acceleration (RPA) promises high-quality ion beams with smaller energy spread, larger beam current and higher energy convention efficiency, compared with other mechanisms. Though the results of RPA from theory and one-dimensional simulations is very attractive, they are not as good as expected from the present experimental results. Except the imperfect parameters of laser and target used in experiments, the key reason is due to the seriously developing of instabilities in high-dimensional cases, especially for the negative effects induced by Rayleigh-Taylor-like instability. The increase of instabilities eventually leads to serious electron heating and significant amounts of electron losses, which results in Coulomb explosion of the accelerating slab and prematurely termination of ion acceleration. Finally, the obtained ion beams are always characterized with low energy and bad beam quality. Thus, how to suppress the destructive e ects induced by instabilities is one of the most challenging problems in the present research of RPA. Though many methods have been proposed, the experimental e ects are not satisfied.

After several years of research, Prof. Qiao's group proposed a novel method considering how to dynamically repair and offset the destructive effects induced by instabilities during acceleration, rather than suppressing the instabilities. Stable RPA is achieved via successive electron replenishment from dynamic ionization of a high-Z material coating, as shown in Fig. 1(a). This method is very robust. Three-dimensional particle-in-cell simulations show that ion stable RPA can be realized even with the real experimental parameters of laser and target, as shown in Fig. 1(b) and (c). More importantly, this mechanism is also suitable for the acceleration of heavy ions. This work was published in Physical Review Letters.

This work was supported by NSAF (Grant No. U1630246); the National Natural Science Foundation of China (Grants No. 11575298 and 11575011); the Science Challenging Project (Grant No. TZ2016005);

Reference:

[1] Achieving Stable Radiation Pressure Acceleration of Heavy Ions via Successive Electron Replenishment from Ionization of a High-Z Material Coating, X. F. Shen, B. Qiao, H. Zhang, S. Kar, C. T. Zhou, H. X. Chang, M. Borghesi, and X. T. He, Phys. Rev. Lett. 118, 204802 (2017).

05 Department of Technical Physics

ε / 28 , : 8 (3), / ḅ 1 , 7 ,

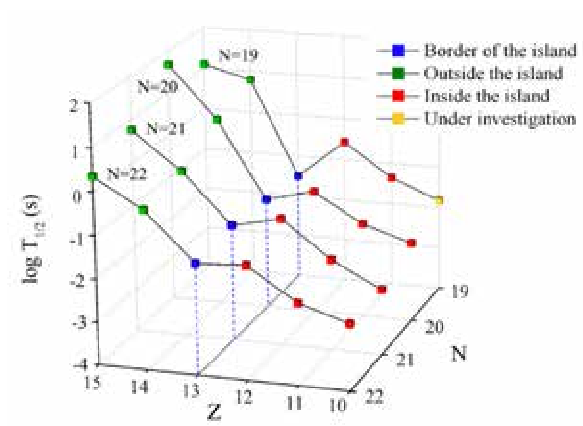
2 (1 , , , : (, ,((

significance at about 3.0 standard deviations for both VBS processes [Fig.1]. They also provided the most stringent constraints on anomalous quartic gauge coupling [PLB 770(2017)380；JHEP06(2017)106].

These works are jointly supported by the Ministry of Science and Technology and National Foundation of Science and Technology.

ε ε ᾰ̈
。 ٢ β ᾰ̈
ᾰ̈ ̈E ᾰ̈ خ̇ ,
。 ,
ε ٹ β Z ~ 10
-12，N ~ 20" " N ~ 8 "
" ᾰ̈ 。
" " β
ε ᾰ̈ RIBLL1 。
HIRFL ^{40}Ar ^{9}Be ˛
, ⅄ RIBLL1 ٢ 、
, Z ~ 12，N ~ 20
。 ڌ / , ٹ
ص
β ٹ
, γ
β - γ β -n 。 ⅄
" " ↑ - ,
- , ᾰ̈ " " N =
19 ~ 22 ڌ -
(1）, - Z = 13
" ˆ " Al ج ,
ĩ " " 。
N ~ 8
ε ᾰ̈ 。ٹ
11Be(d, p)^{12}Be , ᾰ̈

^{12}Be s d Ḃ 。 ص（ 2）,
^{11}Be s-wave , ^{12}Be
d-wave 。 ^{11},^{12}Be
, ᾰ̈ ض ꜛ N=8
。
ᾰ̈ 2 Physics Letters B
, ᾰ̈ 973
。



1: " " N = 19 22
ڌ -

Figure 1： Experimental half-lives of four isotonic chains from N=19 to 22 in and around the "island of inversion".

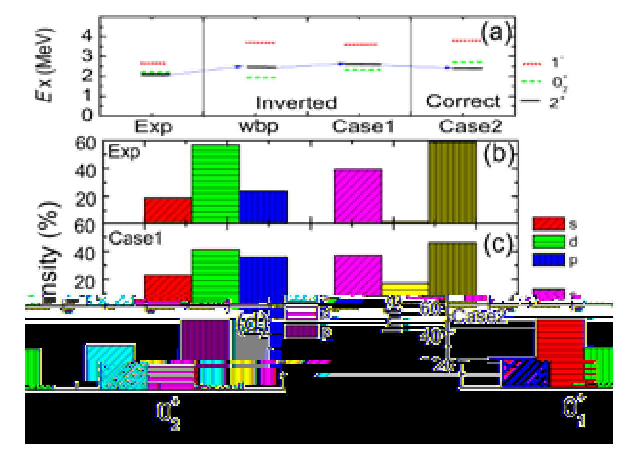
II. Shell evolution in light neutron-rich region

Nuclear studies have been moved forward to the drip line with the development of the modern radioactive ion beam facilities. The research on exotic neutron-rich nuclei far away from the β-stability line has been attractive for nuclear scientists all the time. There are many new interesting phenomena in the neutron-rich region and the "shell breaking" is one of the hottest topics. Recently，the experimental nuclear physics group at PKU has carried out β-decay and transfer reaction experiments to study shell evolution in light neutron-rich region with.

The experiment was carried out at the radioactive ion beam line in Lanzhou (RIBLL). The primary beam 40Ar, which was provided by the heavy ion research facility in Lanzhou (HIRFL), was impinged on a 9Be target to produce the neutron-rich radioactive species around the Z ~ 12, N ~ 20 region. The experiment was performed in the continuous beam mode. By correlating the implantation nuclei with their subsequent β-decays within the same pixel or adjacent pixels of a double-sided silicon detector (DSSD), the β decay properties of implanted nuclei can be measured with much less disturbance from other unstable nuclei and the random background. More than 10 nuclei in and around the "island of inversion" have been investigated and the half-lives of them with higher accuracies have been obtained. With a systematic investigation of half-lives for the isotonic chains from N = 19 to 22 (see Fig. 1), conspicuous kinks observed at Z=13 provide a clear signature of a boundary on the northern (high-Z) side of the island.

The 11Be(d, p)12Be transfer reaction experiment was carried out at the EN-course beam line, RCNP (Research Center for Nuclear Physics), Osaka University. The s-wave spectroscopic factors were extracted for the first 0+ and second 0+ states, respectively, in 12Be. Using the ratio of these spectroscopic factors, together with the previously reported results for the p-wave components, the single-particle component intensities in the bound 0+ states of 12Be were deduced. It is evidenced (see Fig. 2) that the ground-state configuration of 12Be is dominated by the d-wave intruder, exhibiting a dramatic evolution of the intruding mechanism from 11Be to 12Be, with a persistence of the N = 8 magic number broken.

The results were published recently in Journals such as Physics Letters B. This work has been supported by the 973 program and the NSFC projects.



2:（a） 12Be ,
（wbp YSOX ） 。
（b） 12Be 01+ 02+ , s-,
p-, d- 。(c) ٹ YSOX ,
s-, p-, d- (case1)。（d）
（c）, YSOX , d- 0.5
MeV（case2）。

Figure 2: (a) Comparison of the level schemes of the low-lying states in 12Be between the experimental data and the shell model calculations with traditional wbp or YSOX Hamiltonian. (b) The individual s-, p-and d-wave intensities for the 0+1and 0+2states deduced from experiments. (c) Shell model calculations with YSOX interaction (Case 1). (d) Same as (c) but with a decrease of 0.5 MeV for the d-orbit (Case 2).

Gamow ( ) , 24O (1) , ^{25}O ^{26}O Phys. Lett. B 769 (2017) 227.

Gamow , ^{22}C (2) , ^{22}C ,

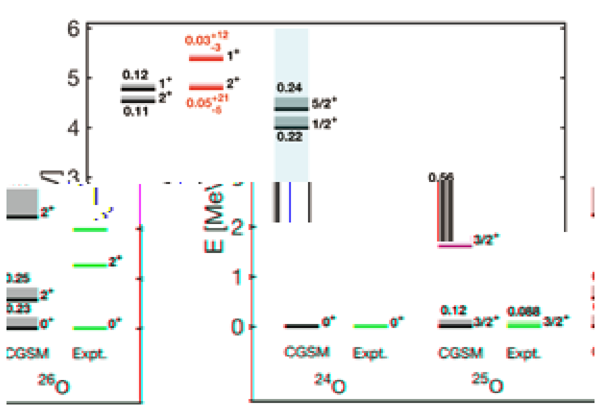
Berggren , Gamow

i) Gamow ii) Gamow

N2LO , Berggren . CD Bonn ,

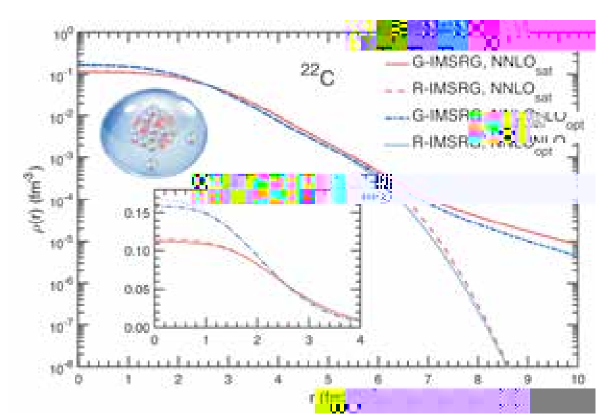
1.Z.H. Sun, Q. Wu, Z.H. Zhao, B.S. Hu, S.J. Dai, F.R. Xu*, Phys. Lett. B 769 (2017) 227: Resonance and continuum Gamow shell model with realistic nuclear forces.

2.Q. Wu, B. S. Hu, F. R. Xu*, Y. Z. Ma, S. J. Dai, Z. H. Sun, and G. R. Jansen, Chiral NNLOsat descriptions of nuclear multipole resonances within the random-phase approximation, Phys. Rev. C 97, 054306 (2018).



1. CD-Bonn Gamow

Fig.1. Calculated resonant excitation spectra for ^{24}, ^{25}, ^{26}O, using the Gamow shell model with the CD Bonn potential.



2. Gamow ^{22}C

Fig.2. ^{22}C density distribution calculated with EFT Gamow IM-SRG, giving a halo structure.

III. Ab initio calculations of nuclear structures of dripline nuclei

Nuclei in dripline regions are a frontier of current nuclear physics research. The nuclei have weakly bound or unbound properties. They are di cult to be synthesized and measured experimentally. They are also difficult to be calculated theoretically. Models should contain continuum e ects. Since experimental data in dripline region are still very lacking, the usual phenomenological model calculations that need to fit experimental data are often not ideal. With the developments of basic theories and calculation methods of nuclear physics, the first-principles calculations (or called ab initio calculations) of nuclear physics has been greatly developed in the past decade. Starting from the e ective field theory (EFT), F. R. Xu's team has developed the first-principles calculations of atomic nuclei and applied to dripline regions.

To include the continuum effect, the first-principles calculation was performed in the complex-momentum Berggren basis, called the Gamow first-principles calculation. It is not a easy task to perform first-principles calculations in the complex-momentum space, which involves complicated mathematical and numerical calculation problems. Nevertheless, Xu's team has successfully developed two types of the first-principles calculations: i) the Gamow shell model based on realistic nuclear forces and ii) the Gamow in-medium similarity renormalization group (Gamow IM-SRG).

Three-body force is another important frontier hot issue. Three-body forces often play an important role in describing the nuclei of dripline regions. They have developed the EFT three-body forces at the level of next-to-next-to-leading order (N2LO), and extended to the complex-momentum Berggren space. Starting from the CD Bonn potential, they have calculated the properties of oxygen isotopes (including excitation energy spectra) using the Gamow shell model. The calculations reproduce well the weakly bound or unbound resonance characteristics of the dripline nucleus ^{24}O (see Figure 1), predicting the resonances of ^{25}O and ^{26}O beyond the dripline. The work has been published in Phys. Lett. B 769 (2017) 227.

With N2LO$_{opt}$ and N2LO$_{sat}$ in which three-nucleon forces are included, they used the Gamow IM-SRG to calculate the properties of carbon isotopes near the neutron dripline, giving the halo property of the dripline nucleus ^{22}C (see Figure 2). It is found that the continuum plays a key role in describing the weakly bound halo structure of ^{22}C. The properties of ^{22}C low-lying states are predicted, which should be useful for relevant experiments that are currently being focused on.

06 Department of Astronomy

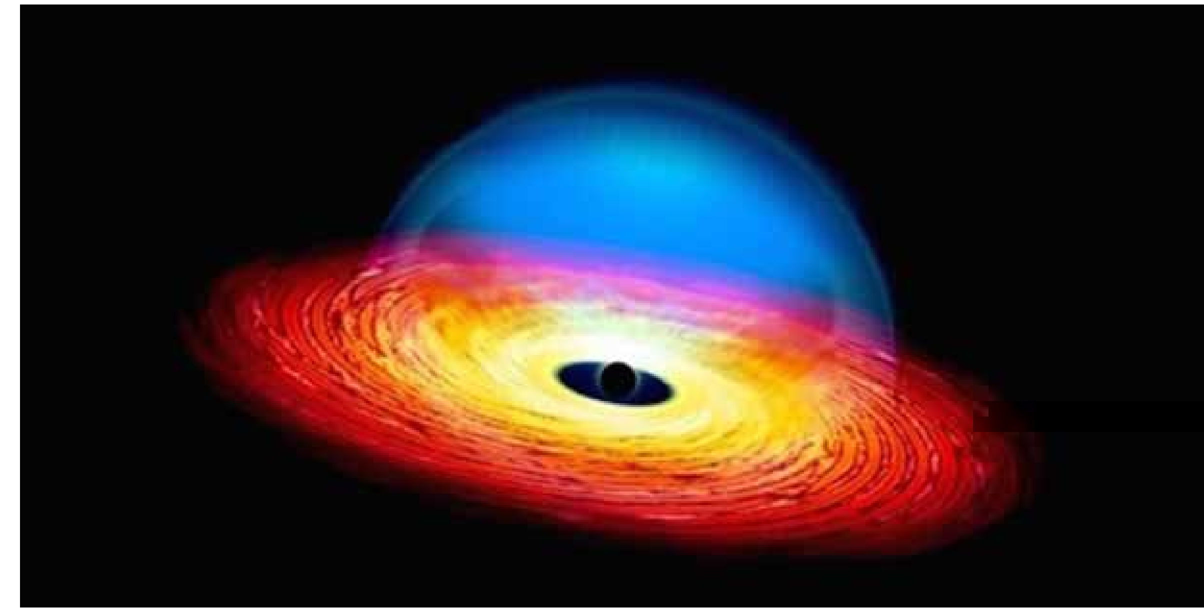
2000 , 1960 , 2001 2001 , 10 , 5 , 4 , 1 .

1 ， 3 ， 2 ， 10 。 6 ， 73 ， 111 ， 2 。 、 、 、 ， 。

The Department of Astronomy of PKU was founded in 2000, based on the Astronomy Division in the Department of Geophysics established in 1960. It became a family member of the School of Physics when the later was created in 2001. PKU Astronomy was given the status of National Key Discipline by Ministry of Education in 2001. The Department of Astronomy has 10 full-time faculty members consisting of 5 professors , 4 associate professors and 1 assistant professor. Among them, there are 1 Changjiang Scholar chair professor and 3 NSFC "Distinguished Youth Award" winners; besides, Department of Astronomy has over 10 joint faculty members including 2 academicians. Department of Astronomy has 6 post-doctors, 73 post-graduate students, 113 undergraduates and 2 secretaries. The main research fields include Cosmology and Galaxy Formation, High Energy Astrophysics, Interstellar Medium, Stellar and Planet System, and Astroparticle Physics, involving astronomical phenomena and astrophysical processes at all scales and various astrophysical environments.

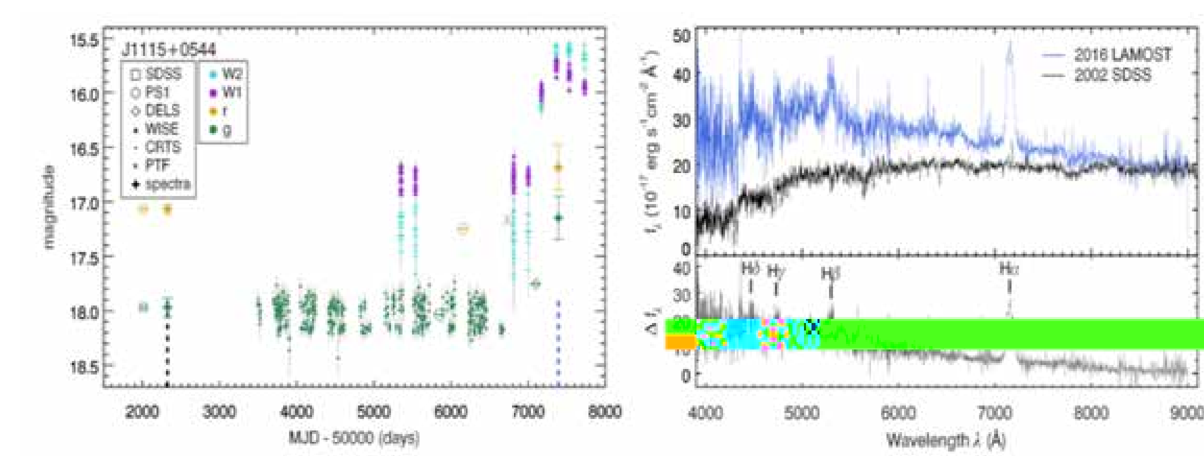
20

， 。 ， 。 。 ， - ， I II 。 。 ， ， ， 21 0.08 0.58 ， 。 10 / "（LAMOST） ， 6 "（changing-look） 。 2.16 20 ， ， 5 。（SDSS） 。 ，I II ， ， 。 2018 。 8 1 《 》 " "（Astrophysical Journal） ， ， 。 。 21



1: " " 。 （ Michael Helfenbein）

Figure 1: The artist's rendering shows the changing look quasar at full brightness (Credit: Michael Helfenbein/ Yale University)



2 : J1115+0544 ， 。 : 。 （SDSS） ， （LAMOST） 。 （ ）。

Figure 2: Left: The optical and mid-infrared light curves of a newly discovered changing-look quasar J1115+0544. Right: The spectra change over 14 years. The black and blue curves are SDSS and LAMOST spectra respectively. The lower part shows the di erence between two spectra (Figure taken from Yang et al. (2018))

1 13 , ,

。 Ά“ ”（ “ ” 。

ش” ） , . Ά ξ ξ Ά

（ ）。 10 。 ,

（

） 3σ 。 , ” ,

, “ “ ” ξ ξ 。

” , “ ”。 ： http://iopscience.iop.org/article/

Ά Ά 10.3847/1538-4357/aaca3a

I. New Discoveries Double the Number of Changing-look AGNs

Quasars are the most luminous active galactic nuclei (AGN), and are thus very important to probe the distant Universe. Their huge luminosities come from the gravitational energy of accreting matters around the supermassive black holes. According to their spectral properties, AGN can be usually divided into two classes, Type 1 AGN with both broad and narrow emission lines and Type 2 AGN with only narrow emission lines.

Recently, in the spectra of some AGN, the broad emission lines are found to disappear in a few years, and may even re-appear in later years. These rare objects with obvious changes in the spectra within a few years are called “changing-look AGN”. Although only about 20 changing-look AGN have been found, they present serious challenges to the widely accepted unification scheme of AGN, which attributes the di erence of Type 1 and Type 2 AGN to the di erent orientations to the dust torus. According

Xian Chen, an assistant professor at the Department of Astronomy, proposed with his collaborators a model for the formation and evolution of a new type of gravitational wave source. Unlike other known sources, this new object emits gravitational waves in both the milli-Hertz and the hundred-Hertz bands, and hence can be simultaneously detected by ground- and space-based detectors.

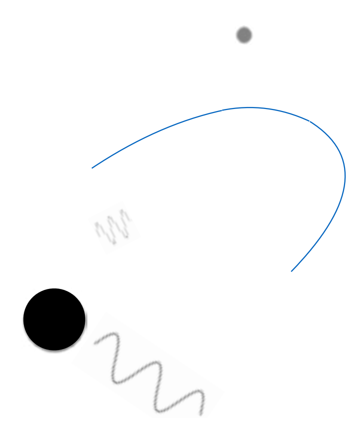
Gravitational wave is an important prediction of Einstein ’ s General Relativity. The first detection of gravitational waves was made in 14 September 2019 by the Laser Interferometer Gravitational-wave Observatory (LIGO), where the first signal was from two merging black holes. Since then, astronomy has entered the gravitational wave era. Astrophysical theories also predict that a supermassive black hole of millions of solar masses could occasionally capture a stellar-mass black hole of about ten solar masses, and form a two-body system called “ extreme-mass-ratio inspiral ” (EMRI). Such a system emits gravitational waves in the milli-Hertz band. It is among the major targets of the future space-based detectors, such as the Laser Interferometer Space Antenna of the European Space Agency, or China ’ s Taiji and Tianqin projects.

Xian Chen and his collaborators studied the formation mechanism of EMRI and discovered that the “ small guy ” in it, in fact, could be a binary composed of two stellar-mass black holes. They call such a triple system “ binary extreme-mass-ratio inspral ” (b-EMRI, see Figure 1). They also described in detail how a small black hole binary could be tidally captured by a supermassive one (see process i in Figure 2), spiral inward to tens of Scharzschild radii of the supermassive black hole, and finally be detected by a space-borne low-frequency gravitational wave detector (process ii in Figure 2).

The authors used state-of-the-art numerical three-body simulations to follow the dynamical evolution of the small binary around the big black hole. They found that the binary has a large probability to coalesce, and hence also emit high-frequency gravitational waves which can be detected as well by a ground-based detector (see process iii in Figure 2).

Because a b-EMRI emits both low- and high-frequency gravitational waves, it is similar to having two instruments performing a duet. The future joint observation of such an object by the ground and space detectors could help us further understand the generation and propagation of gravitational waves, as well as the non-linear dynamical processes in the regime of strong gravity.

This work is published in the journal of Communications Physics (Nature Publishing). Full article link: https://www.nature.com/articles/s42005-018-0053-0



III. Two distant hypervelocity stars discovered by using LAMOST data

A group of Chinese astronomers led by Yang Huang, Xiaowei Liu, Huawei Zhang has detected two new unbound hypervelocity stars located over 70,000 light years away. The discovery could help scientists better understand the nature of these rare, peculiar stars.

Hypervelocity stars (HVSs) are rare objects with velocities so great that they exceed the escape velocity of the galaxy. Astronomers believe that they originate near the center of the Milky Way galaxy by dynamical interactions between binary stars and the central massive black hole. While ordinary stars have velocities around 100 km/s, the velocities of HVSs can reach even 1,000 km/s.

Although scientists estimate that approximately 1,000 HVSs exist in the Milky Way, only about 20 such stars have been identified so far. Given that these objects travel large distances across our galaxy, they could serve as powerful tracers to probe the mass distribution in the Milky Way, providing crucial information about the shape of the galactic dark matter halo. Therefore, finding new HVSs could help us build a valuable database of such tracers.

With this aim in mind, Huang's team have analyzed the available data provided by the LAMOST spectroscopic surveys. The surveys, utilizing the Large Sky Area Multi-Object Fibre Spectroscopic Telescope (LAMOST) in China, investigate the structure and evolution of our galaxy, and have already located one hypervelocity star.

Now, the Chinese astronomers report the finding of two new HVSs in the latest data release from the LAMOST surveys. The researchers found two new unbound hypervelocity stars, designated LAMOST-HVS2 and LAMOST-HVS3.

Published paper:

Huang, Y., Liu, X.W., Zhang, H.W. et al., (2017), ApJL, 847, 9

News:

https://www.universetoday.com/137100/chinese-astronomers-spot-two-new-hypervelocity-stars/

https://phys.org/news/2017-09-distant-hypervelocity-stars-chinese-astronomers.html

07 Department of Atmospheric and Oceanic Sciences

The Department of Atmospheric and Oceanic Sciences (AOS) at Peking University originated from a meteorological program established in 1929, and has a long and prestigious history of academic excellence. Over the past 90 years, many prominent scholars have taught or studied at AOS. Immersed in an environment of academic freedom, rigor and innovation, AOS scholars have made extraordinary contributions to education, fundamental research, and applications of atmospheric and oceanic sciences to the betterment of society.

AOS has the only first-tier focal discipline in atmospheric sciences in China. It has two second-tier focal disciplines (meteorology, atmospheric physics and atmospheric environment), and two more second-tier disciplines (climatology and physical oceanography). In 1993, AOS was selected in the first group of "National Natural Science Basic Scientific Research and Teaching Training Base – Atmospheric Science Base". In 2008, AOS established jointly with other Earth Science disciplines at PKU the national-level "Earth Science Teaching and Experiment Center – Atmospheric Science Laboratory". In 2010, AOS added the Physical Oceanography program, and established the "Laboratory for Climate and Ocean-Atmosphere Studies".

AOS employs a total of 28 full-time faculty members, including 3 National Outstanding Early-Career Scientists, 1 National Outstanding Early-Career Scientist, 1 Qing Nian Ba Jian Scholar, Research fields within AOS cover meteorology, climatology, atmospheric physics, atmospheric chemistry, environmental science, physical oceanography, and planetary atmospheres. AOS actively pursues fundamental and cutting-edge research, promotes multidisciplinary collaborations on the basis of independent research, and strives to become a world-leading institution in atmospheric and oceanic sciences. In each of recent years, each faculty member received about 900,000 RMB research funds and published 3.5 SCI papers (including 2.3 papers with Peking University as the first a liation).

$PM_{2.5}$

2011 PM2.5 ， 、
α̈ ， α̈ ㇓ 、 ， ï

㇓ ， α̈ Ḃ PNAS（ 。 ḅ，
Cozzarelli ）、Nature Geoscience 。 $PM_{2.5}$
2017 3 30 ， Nature （ 1）。 α̈ ㇓
“Transboundary health impacts of transported ㇓ Ḃ 。
global air pollution and international trade” ， ； ，
α̈ ，
$PM_{2.5}$ ㇓ 。 ， ε。
α̈ ， α̈
、 、 Ḃ 、 ，
， 2007 $PM_{2.5}$ 、 ㇓ 、 ㇓
㇓ ㇓ 。 Steven Davis
， ， α̈ Ḃ
$PM_{2.5}$ ㇓ 、 α̈。 α̈ /
， Ḃ 76 ， α̈ （973
$PM_{2.5}$ Ḃ 22%。 ） ḏ。
、 、α̃ 、α̃

I. $PM_{2.5}$ related premature deaths associated with international trade and atmospheric transport

According to the estimate of the World Health Organization, ambient fine particle pollution ($PM_{2.5}$) leads to more than 3 million premature deaths worldwide. $PM_{2.5}$ is produced from emissions out of economic activities producing goods and services to supply consumption. PM pollution is thought to mostly affect local air quality, with some fractions being transported in the atmosphere to long distances. The current economic globalization means that production of goods and associated emissions is transferred from regions consuming to regions producing those goods. This results in significant redistribution of emissions and pollution worldwide, with important consequences on air quality and human health. Yet there remains little quantitative understanding on the extent to which such transboundary pollution would led to premature mortality.

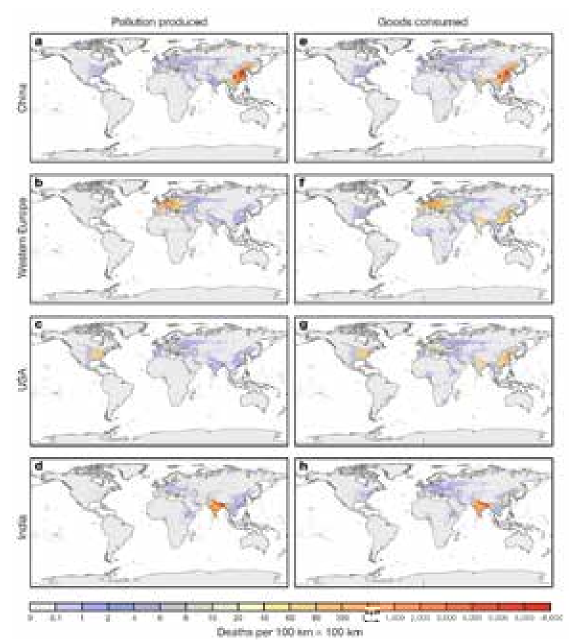
Starting from 2011, Professor Jintai Lin's group in the Department of Atmospheric and Oceanic Sciences, School of Physics, Peking University and collaborators at Tsinghua University have co-led an international collaborative team to analyze the atmospheric environmental problems related to consumption and trade, particularly on how trade activities are coupled with atmospheric transport processes to lead to globalizing air pollution and resulting environmental and climate impacts. To date, the team has published a series of papers on this topic in PNAS (Cozzarelli Prize winner), Nature Geoscience and other journals.

On March 30th, 2017, the team published another paper entitled "Transboundary health impacts of transported global air pollution and international trade" in Nature, which revealed for the first time the global premature deaths from ambient $PM_{2.5}$ pollution as a result of economic trade and atmospheric transport. This work reveals that $PM_{2.5}$ pollution associated with the coupled effect of global trade and atmospheric transport is associated with about 760,000 mortalities worldwide in 2007, contributing 22% of all $PM_{2.5}$ related deaths. Trade-related pollution transfer is more effective than atmospheric transport in causing redistribution of premature deaths. China, India and other developing countries are net exporters of goods, and the developed countries are net importers. As a result, trade means increased pollution and deaths in the developing countries and reduced deaths in the developed countries. Atmospheric transport means that both production and consumption by a particular region leads to PM pollution and mortalities worldwide (Fig. 1). This study reveals the link between production, consumption, trade, pollution transfer and public health, and it calls for fastened emission reduction in the developing countries as well as improved global collaboration to reduce pollution by accounting for the role of consumption and trade in redistributing pollution.

Professor Jintai Lin is a co-corresponding author of the paper, together with Professors Qiang Zhang and Hebin He at Tsinghua University and Professor Steven Davis at the University of California, Irvine. Qiang Zhang and his team members Xujia Jiang and Dan Tong are the joint first authors. Ruijing Ni and Yingying Yan in Jintai Lin's group also participate in the study. The study was funded by NSFC and the 973 Project.

Paper:

Zhang, Q. #*, Jiang, X. #, Tong, D. #, Davis, S. J. *, Zhao, H., Geng, G., Feng, T., Zheng, B., Lu, Z., Streets, D. G., Ni, R.-J., Brauer, M., van Donkelaar, A., Martin, R. V., Huo, H., Liu, Z., Pan, D., Kan, H., Yan, Y.-Y., Lin, J.-T. * , He, K. *, and Guan, D.: Transboundary health impacts of transported global air pollution and international trade, Nature, 543, 705-709, doi:10.1038/nature21712, 2017, http://www.nature.com/nature/journal/v543/n7647/full/nature21712.html



1： 、 、 、 （ ） （ ） - - PM2.5 。 ：Zhang et al., 2017, Nature。

Figure 1. Global distribution of premature deaths due to ambient PM2.5 pollution as a result of production (left) and consumption (right) of goods and services in China, Western Europe, the United States and India. Source: Zhang et al., 2017, Nature.

Related papers:

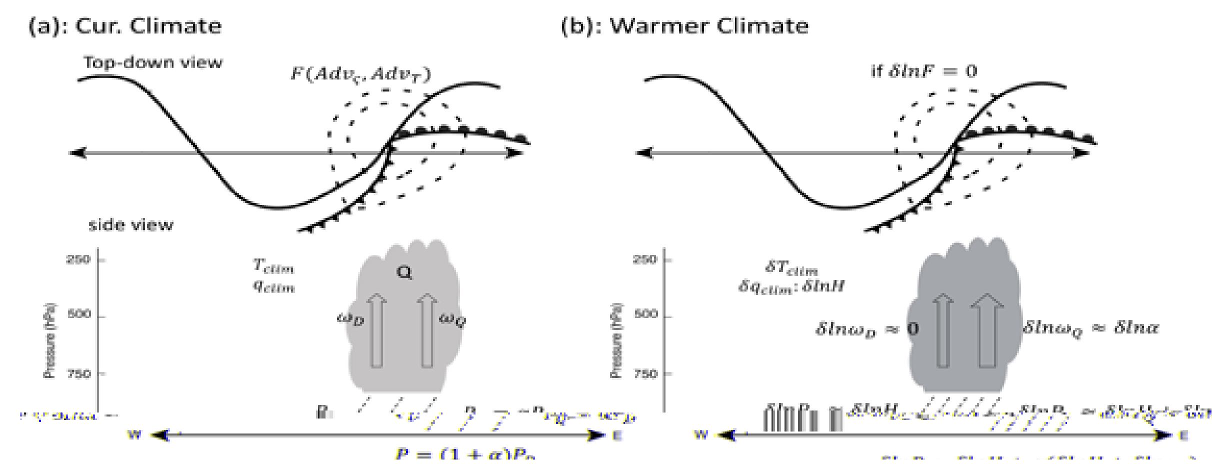
(1)Lin, J.-T. #*, Pan, D. # , Davis, S. J., Zhang, Q. *, He, K. *, Wang, C., Streets, D. G., Wuebbles, D. J., and Guan, D.: China ' s international trade and air pollution in the United States, Proceedings of the National Academy of Sciences of the United States of America, 111, 1736-1741, doi:10.1073/pnas.1312860111, 2014, http://www.pnas.org/content/111/5/1736.short

(2)Guan, D.-B., Lin, J.-T. *, Davis, S. J., Pan, D., He, K.-B., Wang, C., Wuebbles, D. J., Streets, D. G., and Zhang, Q.: Reply to Lopez et al.: Consumption-based accounting helps mitigate global air pollution, Proceedings of the National Academy of Sciences of the United States of America, 111, E2631, doi:10.1073/pnas.1407383111, 2014, http://www.pnas.org/content/111/26/E2631.full

(3)Lin, J.-T. #*, Tong, D. #, Davis, S., Ni, R.-J., Tan, X., Pan, D., Zhao, H., Lu, Z., Streets, D., Feng, T., Zhang, Q. *, Yan, Y.-Y., Hu, Y., Li, J., Liu, Z., Jiang, X., Geng, G., He, K., Huang, Y. *, and Guan, D.: Global climate forcing of aerosols embodied in international trade, Nature Geoscience, 9, 790-794, doi:10.1038/NGEO2798, 2016 , http://www.nature.com/ngeo/journal/v9/n10/abs/ngeo2798.html

Nie, J.*, A. H. Sobel, D. A. Shaevitz, and S. Wang, 2018: Dynamic Amplification of Extreme Precipitation Sensitivity, Proc. Natl. Acad. Sci., 115, 9467-9472.

http://www.pnas.org/content/early/2018/08/28/1800357115



1： ḅ（a） （b） 。

Fig. A schematic of the scaling of precipitation extremes with temperature in a CQG system. (a) is under the current climate, and (b) is in a warmer climate.

II. Climate responses of extreme precipitation

Extreme precipitation often leads to major disasters such as floods and landslides, which have great impacts on the social economy and the environment. Under global warming, in most regions the frequency and intensity of extreme precipitation have increased significantly in recent years. As the atmosphere warms, the amount of water vapor in the air increases, resulting in an increase in precipitation amount when rainfall occurs. With this thermodynamical consideration only, the increase in extreme precipitation intensity with temperature should be about 7% per degree of warming. However, the e ects of atmospheric motion in rainfall are also critical. However, due to its complexity, studies in this area are very limited

Dr. Ji Nie and his collaborators use a novel simplified model to address the dynamic effects of extreme precipitation and its response to climate change. They use this model simulated an extreme rainfall event occurred in the United States in May 2015, with focus on the coupling between motion and small-scale convection. They further modeled extreme rainfall with similar synoptic conditions but under climate scenarios before industrial warming (1.5 degrees lower than current temperature) and at the end of the century (4.5 degrees higher than the current temperature increase). The numerical results show that in the warmer climate, due to the increase of atmospheric water vapor (7% per degree), the latent heat released by condensation will increase, leading to a stronger atmospheric uplift. As a result, the extreme rainfall may increase by about twice the e ect of simple water vapor increase (~14% per degree). The study deepens the understanding of the extreme precipitation, and provide insights into the regional responses of extreme precipitation to climate change.

。 ， ذ خ
ذ ḏ Ḃ 。 ˏ
。 ب， （ ذ 60% ↄ ，
500℃）、 （ ذ -60℃）， 10% 。 ，
， ذ ， خ
。 خ ， ḯ 。
（ 、 ˇ ， ， ，
） Ḃ ， ， ḯ 。
。 ，
ɛ ， ḅ 、 。 ᾶ
，
。 ， 。
， ש Ḃ ɛ ⁄ Andrew Ingersoll
， 。 ɛ Nature Geoscience 。
ᾶ ： ， ᾶ ض:
。 ᾶ ض， ，
， ，
， ï ذ 。Nature
ḯ 100℃ ， ， ， ， ᾶ ，
。 ，
， 、 ，
， 。

III. Abrupt Climate Transition of Icy Worlds from snowball to moist or runaway greenhouse

Ongoing and future space missions aim to identify potentially habitable planets in our Solar System and beyond. Planetary habitability is determined not only by a planet ′ s current stellar insolation and atmospheric properties, but also by the evolutionary history of its climate. It has been suggested that icy planets and moons become habitable after their initial ice shield melts as their host stars brighten. Here Jun Yang's team shows from global climate model simulations that a habitable state is not achieved in the climatic evolution of those icy planets and moons that possess an inactive carbonate–silicate cycle and low concentrations of greenhouse gases. Examples for such planetary bodies are the icy moons Europa and Enceladus, and certain icy exoplanets orbiting G and F stars. Yang finds that the stellar fluxes that are

Abrupt transition from a snowball state to an extremely hot climate state

required to overcome a planet ′ s initial snowball state are so large that they lead to significant water loss and preclude a habitable planet. Specifically, they exceed the moist greenhouse limit, at which water vapour accumulates at high altitudes where it can readily escape, or the runaway greenhouse limit, at which the strength of the greenhouse increases until the oceans boil away. We suggest that some icy planetary bodies may transition directly to a moist or runaway greenhouse without passing through a habitable Earth-like state.

Icy worlds are common in the Solar System (such as Europa, Enceladus, Ganymede and early Earth) and plausibly also in extrasolar systems. A fundamental question is: would such icy planets and moons become habitable once their ice cover melts? There are two ways for the icy worlds to escape the globally ice-covered snowball states. One is that continuous atmospheric accumulation of CO2 from volcanic outgassing during the snowball phase triggers the melting; this is plausible for planets having an active carbon cycle (for example, Earth), and they become habitable for life after the ice melts. The other is that the stars brighten with time and the ice melts once the stellar flux exceeds a critical value; this is the case for planets and moons lacking an active carbon– silicate cycle and having low concentrations of greenhouse gases (for example, Europa). Here, Yang's team investigates the second case using a series of three-dimensional (3D) climate model experiments. In contrast to previous studies that suggest the existence of a habitable world after the snowball deglaciation, they show that the increased stellar insolation will force the planet into an uninhabitable moist or even runaway greenhouse state.

For details, please see the paper online: https://www.nature.com/articles/ngeo2994

08 Teaching Center for General Physics

The Teaching Center for General Physics is a branch of School of Physics at Peking University. Previously, it was called the Teaching and Research Section of the Physics Department. The main task of the Center is to supervise all the teaching programs of general physics courses, such as mechanics, electrodynamics, thermodynamics and optics, for the sciences major undergraduate students of Peking University. It is also responsible for organizing seminars and arranging foreign exchange activities, which are closely related to teaching and learning. All the members of the Teaching Center have full teaching load each semester. They are heavily involved in making and managing the entire teaching schedule at School of Physics, too. The Teaching Center has one laboratory for demonstration and 10 teaching groups. Each of them is led by a moderator and is dedicated to teaching a specific subject. Their duties cover the whole Physics 01-05 series. Each year, more than 2,000 undergraduate students take these courses. It is equivalent to a working load of 222,000 teaching units (number of students times class hours) per year.

Since its establishment, the Center has set very high standards for each course and made great e ort to achieve teaching excellence, as the Teaching and Research Section of the Physics Department did traditionally in the old days. As far as the teaching faculties are concerned, except several full-time members, many professors from other departments of School of Physics participate also in teaching general physics. Since these lecturers are experienced researchers, they make their classes more interesting and illuminating to the students. On the other hand, the Center invites also some retired teachers to be senior advisors. Therefore, each teaching group has an ideal structure with respect to the distributions of faculty ages, specialties, professional ranks and teaching experiences. These teams perform at very high professional levels which are compatible with the academic stature of School of Physics at Peking University. The Teaching Center for General Physics is dedicated to sustain such high teaching standards in future.

2018

I. The course on electromagnetism awarded as one of the 2018 National Quality MOOCs by the National Ministry of Education

For generations, the teachers of this course have been focusing on the curriculum construction. Now, the course is fully developed, emphasizing on rigorous reasoning, using simple cases for examples and demonstrating complicate theories with clear physical vision. Several textbooks have been published based on the lecture notes of these teachers and were welcome by many thousands of undergraduate students. In addition, the course was also awarded as one of the National High-quality Courses in 2003 and the National High-quality Resource Sharing Courses in 2013 by the National Ministry of Education.

MOOC is a new way of education developed in recent years. In order to promote the teaching of the general physics at Peking University and give more students opportunity to share resources, the teachers of electromagnetism made the MOOC version of this course in 2014 and put it on Coursera web. Then, in 2016, it was transferred to Chinesemooc and was eventually opened to public on the Icourses web in 2018.

Since most of the students of this course are junior undergraduates or high school teachers, the MOOC version of electromagnetism course is designed to be a self-study system. Therefore, great e orts have been made to preserve the same teaching quality at Peking University and, in the meantime, give also plenty of teaching resources. For student's convenience, several modules with exercises are provided. As a result, students can arrange their own learning process and have no need to follow the web schedule. The course is of great use to both kinds of students who want either learning the course by themselves or using it as a complementary resource. As a matter of fact, since the opening of this course, it has been welcome by students and teachers of the colleges with less teaching resources. Especially, the course was taken by many excellent high school students as advanced preparations for college.

The course team is led by Professor Jiajun Wang and the team members are Liangzhu Mu, Ce Meng and Xiaolin Chen. Up to now, two teaching sessions have been completed, and the third session is carrying on. Haijun Zhang is in charge of the maintenances of this course.

18 48

2017 、 ，2-6，5， 13，5 1-3，5-9，8， 8 18 。

48) Chinese team for the 48th International Physics Olympiad(From left to right, Liangzhu Mu, Qiantan Hong, Haoyang Gao, Pinyuan Wang, Zhun Wang, Xiquan Zheng, Jing Yang, Xiaolin Chen)

18) Chinese te Olympiad(From left to r Qiwei Yu, Qiuyuan Wan Hongyi Wang, Zhirui Wang, Liangzhu Mu)

II. Chinese teams have achieved excellent results in the 18th Asian Physics Olympiad and the 48th International Physics Olympiad

The training and selection of the 2017 International and Asian Physical Olympiad teams was undertaken by the School of Physics of Peking University, and the Teaching Center for General Physics was responsible for the theoretical courses. 13 students were selected, the top 5 formed the Chinese team for the 48th International Physics Olympiad, and the last 8 formed the team for the 18th Asian Physics Olympiad. The 18th International Physics Olympiad was held in Yogyakarta, Indonesia. The Chinese team members ranked 2-6 on the ranking list and won 5 gold medals. They won the Best The Award, too. The 18th held in Yakutsk, Russia ranked 1-3, 5-9 on the medals. They also wo Experiment Award, the Male Player, the Best S Award. The Chinese te results in these two com

09 Teaching Center for Experimental Physics

The Teaching Center for Experimental Physics at Peking University is a national demonstration center of experiment teaching. It is mainly engaged in teaching of "General Physics Experiment" and "Modern Physics Experiment", which are of high-quality nationwide and belong to "National Outstanding Courses". Besides, the center gives research courses called "Comprehensive Physics Experiment" and "Frontier Physics Experiment" to students who are willing to investigate some experimental problems. Now there are 16 faculty members in the center, in which are 3 professors, 6 associate professors, 1 senior engineer, 6 engineers.

I. Progress in the construction of Comprehensive General Physics Experiment

In order to combine the advantages of traditional teaching and innovative teaching, a new course "Comprehensive General Physics Experiment", has been constructed under the leading of Professor Zhang Zhaohui at our center. This course is purposed for interested students with the most excellent performance in "General Physics Experiment I" as the alternate course of "General Physics Experiment II".

The new course emphasizes on students' independent exploration. Students have a fixed time in the laboratory one afternoon a week, while the teacher is not on-site guiding. Students need to read the handout provided by the teacher before class and do experiments independently in class. Laboratory technicians are responsible for laboratory management and instrument maintenance. Teachers guide and assess each student through the one-on-one discussion after the lab class. Besides the fixed time, students can schedule extra time to work in the lab. Each student has a set of experimental equipment. Students are required to complete 1 topic in two weeks and accomplish 6 topics in one semester. All the experiments are carried out in cycle in one large laboratory space to encourage students to communicate with each other freely.

The course emphasizes comprehensiveness and openness. The current 6 topics are, optical imaging and optical information processing, Michelson-interference and optics correlation measurement, Frank-Hertz experiment based on virtual instrument

. Progress and achievement in research

The Teaching Center for Experimental Physics has promoted the team building and course construction with the idea of "leading experiment teaching by scientific research". We encouraged teachers to apply for research projects, and gave necessary supporting funds. We also encouraged teachers to introduce research progresses to basic physics-experiment teaching and to construct research-based teaching platforms. Thus, we could train excellent undergraduate students to develop the ability of scientific research and innovation. These efforts have achieved very good results. In the past two years, under the direction of our teachers, undergraduates as first authors have published research papers in several important international academic journals. For example, the research paper on multi-channel and binary-phase all-optical control with on-chip integrated subwavelength plasmonic waveguides was published in ACS Photonics [5, 1575–1582 (2018)], with undergraduate Wang Yuhan as the first author. The research paper on universal linear-optical logic gate with maximal intensity contrast ratios was published in ACS Photonics [5, 1137–1143 (2018)]. Undergraduates Peng Changnan and Li Jiayu contributed equally as first authors to the work. The research paper on spin-encoded subwavelength all-optical logic gates based on single-element optical slot nanoantennas was published in Nanoscale [10, 4523–4527 (2018)]. Undergraduates Yang Zichen and Fu Yang contributed equally as first authors to the work. Our works made outstanding contributions to the cultivation of scientific research ability of undergraduates. Meanwhile, our teachers also acquired a development. For instance, the young teachers Li Zhi and Liao Huimin were promoted to professor and associate professor in 2017 in the fierce competition of title promotion.

10 Electron Microscopy Laboratory of Peking University

1964 ， （ ）。1990 。 " " "211" "985" ， 12 ， 6 ， 3 ， 3 ， 40 22 。2015

Bi-annual Report

（Flexoelectric e ect，

1.5 （ 0.6 nm）

~16 μC/cm^2（

17%），

Pb O B。

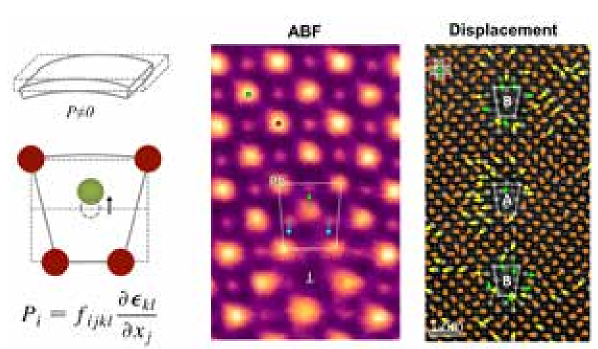
（0.6 nm），

（ABF），$SrTiO_3$ / 。

Nature Communications

（ 0.8nm）， 8, 15549 (2017)。

30 μCcm^{-2}。



。$SrTiO_3$ （ ） （ ）

（Electrical activities）。

Phys.Rev.Lett. 120, 26760 (2018)。

dislocation cores in STO. The polarization charges can interact with the nonstoichiometric dislocation cores and thus impact the electrical activities.

In this paper, they identify that a localized stable polarized zone exists at the dislocation cores in a 10 ° STO grain boundary. The point defects, strain field and strain gradient, and nonstoichiometry account for the stable electric dipoles. Their results suggest that the localized polarized zone plays an important role in determining the electrical activities of dislocations and low-angle grain boundaries, as flexoelectric polarization induced bound charge must be screened via a redistribution of free carriers or charged defects. The new insights provided by the localized polarized dislocations can help us to explain some of the past studies, such as the high ionic diffusion barrier along the dislocation cores, and also add more information about the double Schottky barrier model for the low-angle grain boundary in electroceramic STO. Their findings can help us to understand the properties of dislocations in perovskite, providing new insights into the design of new devices via defect engineering such as bi-crystal fabrication and thin film growth. The paper was published at Phys.Rev.Lett. 120, 26760 (2018).

Except to the electromechanical effects around dislocation cores, the effects of interface and surface also become more pronounced when the film becomes thinner. The depolarizing field, which is caused by the incomplete compensation of polarization bound charges at interfaces, mainly account for the size effect and therefore the value of critical size should be much smaller than previous thought (at a few nanometres or tens of nanometres). The depolarizing field increases as the film thickness decreases, leading to the instability of ferroelectricity in the ultrathin films and fine particles.

In Peng Gao group ′ s study (Figure 2), when the thickness is < 3-unit cells, the similar behavior of suppressed polarization for both of the ultrathin PZT films on insulating substrate and metallic bottom electrode indicates that the compensation of polarization may be governed by the internal screening.

They find that the residual polarization is ~16 $\mu C cm^{-2}$ (~ 17%) at 1.5-unit cells (~ 0.6 nm) thick film on bare SrTiO3. The residual polarization in these ultrathin films is mainly attributed to the robust covalent Pb–O bond. This atomic study provides new insights into mechanistic understanding of nanoscale ferroelectricity and the size effects. This paper was publ paper wastur term stability, which hinders the commercialization of this technology. It is generally believed that the structural degradation, which is caused by the ion migration driven by the external field in the actual working process of these devices, is the direct reason for the performance fading and the shortening of the life for these devices. Therefore, it is of great significance to study the structural instability and phase transition caused by ion migration in perovskite materials.

Electron microscope is widely used to characterize these organic-inorganic hybrid perovskite materials. Since these materials are sensitive to electron beam, electron diffraction mode with relatively low electron-beam dose rates is usually applied to identify the perovskite phase and check the crystallinity. However, there are slight differences between the electron diffraction patterns reported in many literatures from the simulated electron diffraction ones. For example, some theoretical di raction spots disappear or the intensity becomes weaker, and some reflections that should not appear. These subtle di erences are usually simply ignored, and most of the literature still inaccurately identify these mismatched electron diffractions as organic-inorganic hybrid perovskites.

Peng Gao, a researcher in the Electron microscope Laboratory of Peking University, probed the stability of $MAPbI_3$ single crystal films by controlling the electron beam dose rate, and found the instability of the material at low electron beam dose, determined the threshold condition to avoid damage under electron beam irradiation, and proposed the corresponding decomposition pathway. These findings impose important question on the interpretation of experimental data based on electron di raction, correct the wrong identifications of lead iodide as $MAPbI_3$ in the field of electron microscopy, and highlight the need to circumvent material decomposition in future electron microscopy studies. The structural evolution during decomposition process also sheds light on the structure instability of organic-inorganic hybrid perovskites in solar cell applications. The work was published in Nature Communications 2018, 9807.

11 International Center for Quantum Materials

The International Center for Quantum Materials (ICQM) was established in 2010 as a major initiative of Peking University, aiming to create a new type of platform for research and education. ICQM has since been committed to perform cutting-edge research at the frontiers of condensed matter physics and quantum materials, to create an innovative academic environment, and to establish a world-class plateform for physics research and education.

As an innovative plateform for science and technology, ICQM has been devoting a great effort to recruit internationally-renowned scientists as well as excellent young researchers, and to provide first-class infrastructure and dynamical scientific environment for basic research. Located in Beijing and amid the fast socioeconomic transformation of China, ICQM endeavors to implement a new academic structure that is based on two major components: independent principle investigator system and tenure appraisal system. As of December 2018, the ICQM faculty members consist of 4 Chair Professors, 8 tenured Full Professors, 6 tenured Associated Professors, and 8 tenure-track Associate/Assistant Professors. Among the senior researchers there are 1 Nobel Laureate, 2 Member of Chinese Academy of Sciences, and 5 Fellows of American Physical Society.

ICQM provides solid training and great research opportunities for young scientists, including postdoctoral researchers and graduate students from both domestic and foreign institutions. In the past a few years, ICQM has hosted 8 postdocs with several of them making important achievements in their research fields. 154 students are currently enrolled in the ICQM graduate program. The ICQM graduate students are typically graduates from top Chinese universities with exceptional academic performances. The students at ICQM are provided with an active scientific environment to explore a wide-range of frontier research topics through a rich array of academic activities, such as seminars, lectures and summer schools.

The research at ICQM is organized into 6 divisions according to research interest and expertise, namely

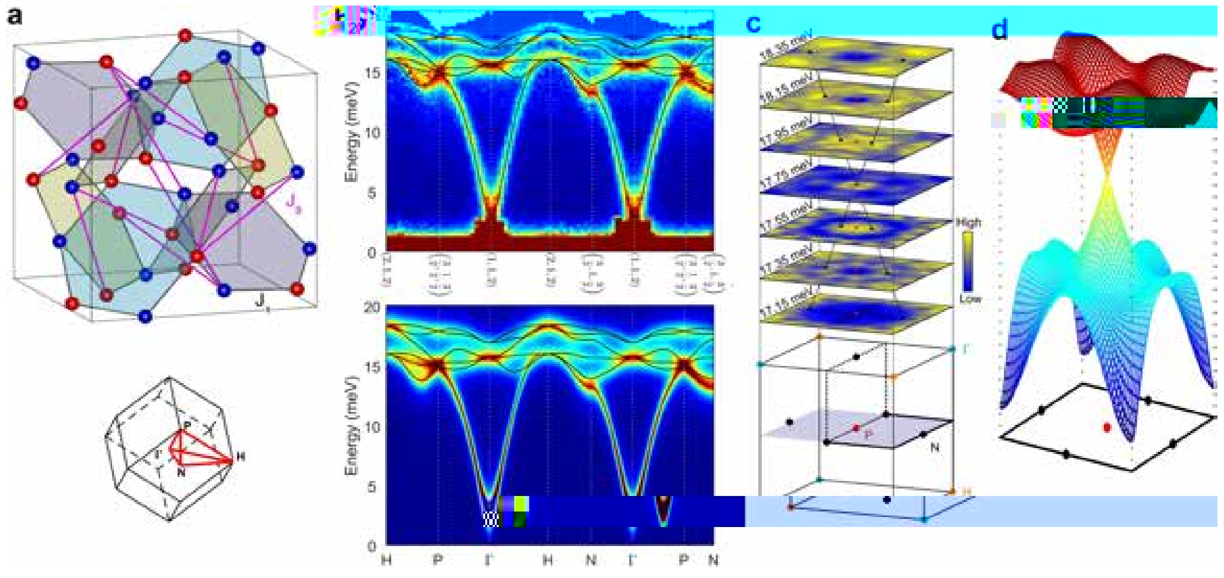
- Low temperature and quantum transport experiments;
- Spintronics and low-dimensional magnetism experiments;
- High-resolution Spectroscopy experiments;
- AMO experiment and precision measurement;
- Theoretical condensed matter physics;
- Computational physics.

Topics of current research activities include quantum transport, strongly-correlated electron systems, low-dimensional quantum systems, topological effects in condensed matter physics, mesoscopic superconducting systems, spintronics, advanced scanning tunneling microscopy, ultra-fast spectroscopy, neutron spectroscopy, ultra-cold atoms, computational simulations for quantum materials, surface dynamics, water behaviors under confinement, and soft matters materials, etc. ICQM consists of 16 experimental laboratories, a public supporting laboratory for physical property measurement, a shared nanofab facility, and a helium center. The PKU Daniel Chee Tsui laboratory is a liated to ICQM, which works on extremely low temperature physics.

By December 2018 since the establishment of the center in 2010, ICQM has published nearly 800 SCI papers, many of which were published in the most influential scientific journals in the world, such as Science, Nature series journals, Physical Review Letters, etc. The research funding received by ICQM faculty members from Chinese research funding agencies has almost reached 350 million RMB. ICQM members have garnered many national and international awards, such as the ACCMS Award, Ho Leung Ho Lee prize, OCPA AAA-Poe Prize, State Natural Science Award, etc.

In order to promote international academic exchanges and collaborations, collaboration agreements have been reached between ICQM and world-renowned institutions, such as the Rice University, University of Texas at Austin, and Pennsylvania State University. Incoming graduate students may take the advantage of such collaboration programs to work at di erent places and obtain Dual Degree Ph.D. in Physics. In addition, ICQM has been visited by more than 100 scientists annually through various capacities.

Cu_3TeO_6, [1]。 U(1) [2]。



: a, Cu_3TeO_6 Cu2+ b, c, P d,

Figure: a, The sub-lattice of magnetic Cu2+ ions of Cu_3TeO_6 (upper panel), where the up and down spins are represented by blue and red spheres. The lower panel displays the bcc Brillouin zone. b, Magnetic neutron scattering signals along high-symmetry lines of the Brillouin zone (upper panel) in comparison with calculations. Black lines show the calculated dispersions. c, The intensity patterns near the Brillouin-zone P-point indicate local Dirac-point-like dispersions, which evidences the existence of topological band crossing. d, Calculated dispersions near the same region as in c (the vertical axis is energy).

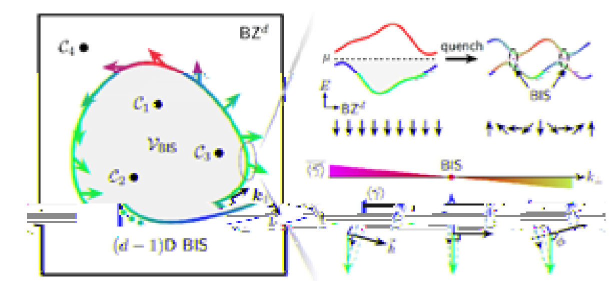
I. Topological magnons in three-dimensional antiferromagnets

The recent discovery of topological semimetals, which possess electron-band crossing with nontrivial topology, has stimulated intense research interest. By extending the notion of symmetry-protected band crossing into one of the simplest magnetic groups, namely by including the symmetry of time-reversal followed by space-inversion, Yuan Li's team predicts the existence of topological magnon-band crossing in a large class of three-dimensional antiferromagnets. The crossing takes on the forms of Dirac points and nodal lines, in the presence and absence, respectively, of the conservation of the total spin along the ordered moments (i.e., spin-rotation U(1) symmetry). In a concrete example of a Heisenberg spin model for a "spin-web" compound, Cu_3TeO_6, Li's team shows the presence of Dirac magnons over a wide parameter range using linear spin-wave theory and calculate the corresponding topological surface states [1]. Inelastic neutron scattering experiments have been carried out to detect the bulk magnon-band crossing in single crystals. The highly interconnected nature of the spin lattice suppresses quantum fluctuations and facilitates their experimental observation, leading to remarkably clean experimental data with very good agreement with their spin-wave calculations. The predicted topological band crossing is confirmed [2].

Related publication and preprint:

[1] K. Li, C. Li, J. Hu, Y. Li and C. Fang, Phys. Rev. Lett. 119, 247202 (2017).
[2] W. Yao et al., arXiv:1711.00632.

(d-1) ... (Science Bull. 63, 1385 (2018); Science Adv. 4, eaao4748 (2018); PRL 121, 250403 (2018); Nat. Phys. 15, 911 (2019)) ... d ... nodal line ... (PRL 121, 250403(2018); Science Adv. 4, eaao4748 (2018); PRL 123, 190603 (2019); Nat. Phys. 15, 911 (2019))



1: d-

Fig. 1 Universal dynamical characterization of the d-dimensional topological quantum phases with integer topological invariants.

II. Characterization of equilibrium topological phases by non-equilibrium quantum dynamics

How to characterize a topological phase is a most fundamental issue in the field of topological quantum physics. Conventionally, a topological phase is characterized by a topological invariant defined for a many-particle ground state in equilibrium. A generic question arises, is there a non-equilibrium characterization of a topological phase defined in equilibrium? This non-trivial question was recently proposed and studied through a series of papers by Xiong-Jun Liu's group at Peking University, who established a non-equilibrium classification theory of equilibrium free-fermion topological phases with integer topological invariants, and bridge equilibrium topological phases and non-equilibrium quantum dynamics. The theory is expected to have broad impact on topological quantum phases, and has pushed forward active experimental studies in this new field. (Refs. Science Bull. 63, 1385 (2018); Science Adv. 4, eaao4748 (2018); PRL 121, 250403 (2018); Nat. Phys. 15, 911 (2019)).

The theory was developed for the generic d-dimensional topological phases, with different phases being distinguished by different integer topological invariants like the winding numbers or Chern numbers. The non-equilibrium dynamics can be induced by quench, in which process one suddenly tunes the system from an initial trivial phase to a final topological regime. The authors found that, while the bare quench dynamics behave randomly, the time-averaged non-equilibrium dynamics exhibit emergent nontrivial topological pattern in the lower (d-1)-dimensional hypersurfaces, dubbed band-inversion surfaces, of the Brillouin zone. Such emergent topological pattern uniquely corresponds to and so characterizes the bulk topology of the equilibrium phase through an emerging dynamical topological invariant, rendering the generic non-equilibrium characterization of equilibrium topological phases. This theory bridges the studies of topological phases and non-equilibrium quantum physics. For one side, the work advances the characterization of topological phases from equilibrium theory to non-equilibrium theory, and provides fundamentally new schemes to detect topological states beyond the equilibrium scenarios. The dynamical schemes show explicit advantages over the conventional equilibrium schemes in the detection of topological states. For another side, the work shows insights into the characterization of complex non-equilibrium quantum dynamics by topology. In condensed matter physics, to characterize non-equilibrium quantum physics is usually more complicated than to characterize equilibrium phases. For example, even fixing the initial and final phases for the quench study, there are numerous paths to perform the quench, and in di erent quench process the induced bare non-equilibrium quantum dynamics can be sharply different. Importantly, from Liu et al.'s theory all the seemingly distinct quench dynamics manifest identical hidden universal behavior: they exhibit the same emergent nontrivial topological pattern on band inversion surfaces, and so belong to the same topological class.

The proposed theory has already motivated very active experimental studies of the quench dynamics for ultracold atoms. In particular, applications of this theory to 1D symmetry-protected topological phase, 2D quantum anomalous Hall model, and 3D nodal line semimetal have been reported recently (PRL 121, 250403(2018); Science Adv. 4, eaao4748 (2018); PRL 123, 190603 (2019); Nat. Phys. 15, 911 (2019)). More experimental studies are ongoing.

2018 5 14 《 》

https://doi.org/10.1038/s41586-018-0122-2。

(Nat. Commun. 9, 122 (2018))

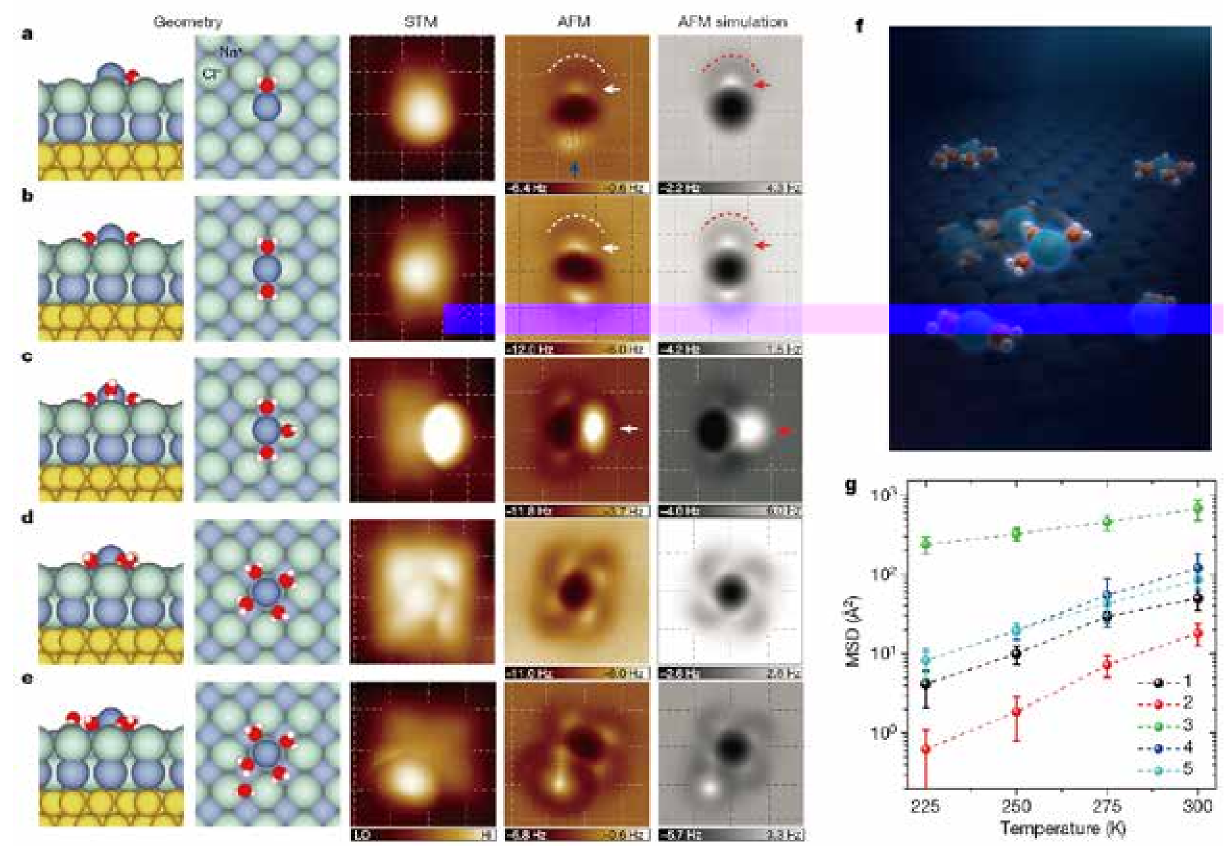
19

(a-e)。

[1-2]

"2018

f g)。



: a-e, 。 1.5 nm ×1.5 nm。f, NaCl 3 。g, 225K-300K 1ns 。

Figure: a-e, Geometries and high-resolution STM/AFM images of Na^+ hydrates. a-e, The atomic models (left: side view; right: top view), STM/AFM images (acquired with a CO-tip) and AFM simulations of $Na^+{\bullet}nD_2O$ clusters (n=1-5), respectively. The size of the images: 1.5 nm × 1.5 nm. f, Schematic showing the magic number e ect in the transport of ion hydrates: the Na^+ hydrated with three water molecules di uses one to two orders of magnitude faster than other Na+ hydrates. g, Mean-square displacement (MSD) in 1 ns of $Na^+{\bullet}nH_2O$ (n=1-5) between 225 K and 300 K.

III. Visualizing the atomic structure and magic-number e ect of hydrated ions

It is well known that salts will dissolve in the water and the water molecules are bounded with the dissolved ions, forming hydrated ions. The existence of the hydrated ions has already been realized at the end of 19 century. However, many key issues are still under debate so far, such as the water number and configuration in the hydration shells, the effect of hydrated ions on the water structure and dynamics, the microscopic factors that govern the transport of the hydrated ions, and so on. The main reason lies in the lack of experimental tools, which can really "see" and "manipulate" the hydrated ions with atomic precision.

The teams led by Prof. Ying Jiang, Prof. Limei Xu and Prof. Enge Wang of International Center for Quantum Materials (ICQM) of Peking University unravel, for the first time, the microscopic structures of Na+ ion hydrates on the NaCl surface and discover a magic-number effect on the transport of ion hydrate, through a combined study using scanning probe microscope (SPM), density functional theory (DFT) calculations and molecular dynamics (MD) simulations. This work is published in Nature on May 14, 2018 (https://doi.org/10.1038/s41586-018-0122-2).

The researchers figured out a novel method to manipulate individual ions and water molecules by scanning tunneling microscopy (STM). They were able to construct individual Na+ hydrates containing one-to-five water molecules on a NaCl(001) surface, which paves the way for high-resolution imaging of the ion hydrates. Another challenge is to avoid the disturbance of the scanning probes on the ion hydrates, which are highly fragile and flexible. To overcome this di culty, the researchers developed a weakly-perturbative imaging technique（Nat. Commun. 9, 122 (2018)）, which relies on the weak high-order electrostatic force by noncontact atomic force microscopy (AFM). Such a technique yields the first-ever atomically resolved images of the ion hydrates, in direct comparison with DFT calculations and simulations (Figure a-e).

Furthermore, the researchers found an interesting magic-number effect: the Na+ hydrated with three water molecules diffuses one to two orders of magnitude faster than other Na+ hydrates and even much faster than the Na+ in dilute bulk solution. Ab initio calculations and MD simulations revealed that such high ion mobility arises from the degree of the symmetry match between the hydrate and substrate. The magic-number effect applies within a wide range of temperatures (up to room temperature) according to the classical MD simulations (Figure f and g).

This work established, for the first time, direct correlation between the atomic structure and transport mechanism of hydrated ions, which may completely renovate the traditional understanding of ion transport in nanofluidic systems. In addition, those results point out a new way to control the ion transport in nanofluidic systems by interfacial symmetry engineering, which is of great importance for an extremely wide range of technologically and biologically relevant processes, including corrosion, water desalination, electrochemistry, and biological ion channel, etc.. This work was selected as one of "2018 Top-ten Science Advances in China".

12 Kavli Institute for Astronomy and Astrophysics

Kavli 2006 6 , 2007 。 , , 。 。 , , 、 。 Kavli : 1) , ; 2) , ; 3) ; 4) 。 、 , , LAMOST — 。 , 。 20% 、50% 。 , , 。 “ ” 、“ ” “ ” , , 。 , 、Gregory J. Herczeg, 。 (SAC) 、 、 。 。 , , , , 25 , 35 , 5 。

The Kavli Institute for Astronomy and Astrophysics (KIAA) is an international center of excellence in astronomy and astrophysics jointly supported by Peking University and the Kavli Foundation, USA. The KIAA has promoted basic astrophysical research at the frontiers of observational and theoretical fields since start of operations in 2007, with a mission that includes training of undergraduate and graduate students and postdoctoral fellows. The program of KIAA focuses on four major areas of astrophysics: 1) observational cosmology, galaxy formation and evolution; 2) star formation, stellar and planetary systems; 3) gravitational physics and high-energy phenomena; and 4) computational astrophysics. Recent high-impact results include discoveries of the most superluminous supernova, the most luminous high-redshift quasar, the largest galaxy cluster at high redshift, and a new group of exoplanets called Hoptunes.

In addition to supporting scientific excellence, KIAA also serves an interface between the Chinese and international astronomy communities; 20% of full-time faculty and 50% of postdoctoral researchers are foreigners, in addition to regular visitors and partnerships between PKU astronomy and a wide network of universities and astronomy centers in China and abroad. KIAA regularly sponsors thematic workshops, conferences, and a range of other academic activities to facilitate scientific exchanges with the domestic and international astronomy community. Major international conferences have included the annual series, "KIAA Forum on Gas in Galaxies", "Cosmic Evolution of Quasars", and an upcoming conference "The 24th International Microlensing Conference". KIAA also regularly hosts the KIAA-PKU Astrophysics Forum, which serves as a platform for the domestic astrophysics community to discuss future directions. English is the working language of the KIAA.

The Institute is under the leadership of its Director Luis C. Ho, Associate Directors X.-B. Wu and Gregory J. Herczeg, and coordinator J. S. Chen. An international Science Advisory Committee provides guidance concerning proposed academic activities, assistance on major projects to set research directions, and review of new faculty appointments. A Governing Board, which reports to the President of Peking University, has been established to oversee the management and operations of the Institute. KIAA works closely with the Department of Astronomy, via coordination of research activities, sharing of research facilities and resources, training and supervising of students, and joint participation in the routine operations of the Institute. Together with several joint appointments with the Department of Astronomy and other institutions, KIAA currently has 25 professors, approximately 35 postdoctoral fellows, many visiting scholars, and five administrative sta members.

, ” KIAA

2 6

4 , 9.5 11

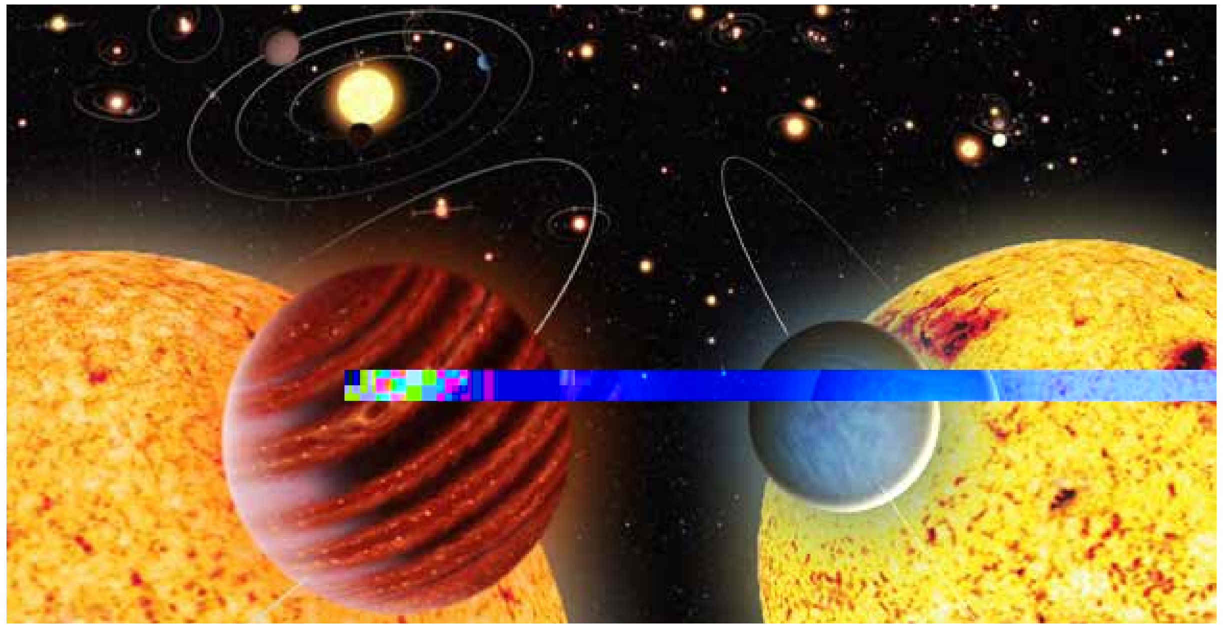
(NASA) (Kepler)

(LAMOST)。LAMOST “ ”,

。LAMOST

“LAMOST

, ”



NASA / ESA / ESO）；Danielle Futselaar Franck Marchis，SETI ; NASA / JPL-Caltech; ; NASA / SDO）。

In this exoplanetary collage, the left side is an artist's depiction of a hot Jupiter exoplanet in a tight orbit around its host sun. The right side depicts a newly described population of exoplanets, dubbed Hoptunes. These worlds range in size from a bit smaller to a bit larger than Neptune. Like their bigger Jovian cousins, Hoptunes also encircle their stars in close, scorching orbits. The background displays some of the diversity of solar systems. (Credit: Composite image by Jin Ma at the Beijing Planetarium, using public domain and Creative Commons-licensed images with credits belonging to NASA/ESA/ESO; Danielle Futselaar and Franck Marchis, SETI Institute; NASA/JPL-Caltech; NASA's Goddard Space Flight Center; and NASA/SDO)

I. Introducing "Hoptunes", a New Class of Exoplanets that Could Help Solve the Mystery of Worlds in Scorching Orbits

In this exoplanetary collage, the left side is an artist's depiction of a hot Jupiter exoplanet in a tight orbit around its host sun. The right side depicts a newly described population of exoplanets, dubbed Hoptunes. These worlds range in size from a bit smaller to a bit larger than Neptune. Like their bigger Jovian cousins, Hoptunes also encircle their stars in close, scorching orbits. The background displays some of the diversity of solar systems. (Credit: Composite image by Jin Ma at the Beijing Planetarium, using public domain and Creative Commons-licensed images with credits belonging to NASA/ESA/ESO; Danielle Futselaar and Franck Marchis, SETI Institute; NASA/JPL-Caltech; NASA's Goddard Space Flight Center; and NASA/SDO)

Among the most baffling worlds discovered so far in the universe are "hot Jupiters." These gas giants orbit their host stars far closer than the innermost planet in our Solar System, Mercury, orbits the Sun. Many astronomers think hot Jupiters could not have formed in such searing, star-kissed conditions, suggesting the planets somehow moved in toward their suns after initially taking shape.

Now a new study offers fresh insight into the planets' perplexing provenance, thanks to a newly described clutch of toasty worlds — dubbed Hoptunes — that are like hot Jupiters' smaller cousins. Led by Subo Dong of the Kavli Institute for Astronomy and Astrophysics (KIAA) at Peking University and Ji-Wei Xie of Nanjing University, the study finds striking similarities between the two planetary types. Akin to their bigger brethren, Hoptunes often orbit stars with higher abundances of what astronomers call metals — elements heavier than helium. Hoptunes also tend to be loner worlds, again like hot Jupiters, hogging host stars all to themselves in single-planet solar systems.

Evidently, the processes that bring about Hoptunes likely extend to the rise of hot, giant planets, too, pointing to a shared, ultimately knowable origin.

"Understanding how hot Jupiters form has been a detective story for decades, and the discovery of Hoptunes adds important new clues to this ongoing investigation," said Dong, the Youth Qianren Research Professor of astronomy at KIAA. "Our study shows Hoptunes probably develop in similar conditions as hot Jupiters, which means we're zeroing in how those conditions permit scorching planets."

Dong coined the name "Hoptunes" for worlds that possess anywhere from two to six times the diameter of Earth. This size range goes a bit below and above the diameter of the planet Neptune, which has a diameter of four Earths — far less than the 9.5 and 11 Earths, respectively, needed to equal Saturn's and Jupiter's tremendous girths. The masses for Hoptunes remain unknown, however, so astronomers do not know which of them are rocky, like Earth, or mostly gaseous, like Neptune. Thus, Dong opted against broadly calling this planetary class "hot Neptunes," because some of them are likely more terrestrial than Neptunian in character.

The research team first got onto the trail of Hoptunes with Kepler, NASA's exoplanet hunting spacecraft. Kepler detects exoplanets through the slight dimming in starlight they cause when crossing the faces of their host stars.

The team dug deeper into a large set of close-in planets initially spotted by Kepler. In order to accurately measure the planets' sizes and the metal levels in their stars, the scientists turned to the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST), located in northern China. Also known as the Guo Shoujing Telescope, it uses a technique called spectroscopy to break apart the light from stars, revealing their chemical makeup. Spectroscopy also indicates the strength of gravity at the surfaces of stars which, when cross-referenced with their color-coded temperature — hot stars shine blue, cool stars glow red — discloses their sizes. LAMOST can uniquely perform spectroscopy on thousands of stars simultaneously, providing astronomers with huge amounts of critical data.

"LAMOST is currently the world's most e cient machine in mass-producing stellar spectroscopy," said Dong. "Using LAMOST, we were able to identify and characterize the solar systems and the host stars that harbor Hoptunes."

The similarities discovered between Hoptune- and hot Jupiter-hosting solar systems might support astronomers' working theories for how colossal worlds can form. Take the observed levels of metals, or metallicity, for instance. Some astronomers think higher metallicity means greater amounts of solid material available to form planets in the gassy, dusty disks surrounding young stars. Bit by bit, the materials in the disks glom together, growing into ever larger, rocky bodies. Particularly massive bodies with powerful gravitational pulls can capture deep atmospheres of gases, forming Jupiter-like worlds or, on the smaller side, Neptunes or Uranuses. Systems with low metallicities, however, struggle to generate big planets.

It is generally believed that giant planets need massive, solid cores to build up before they can accrete a large amount of gas. In close quarters to stars, not enough solid materials may be available to build up such suitably bulky cores. Therefore, hot Jupiters and gassy Hoptunes must somehow migrate toward their stars after initially forming. Yet the role that metal levels actually play in this migration remains unclear. One possibility is that disks with high metallicity could give birth to a large number of big planets, fostering violent gravitational interactions. This process might encourage some planets to migrate inward.

Finally, the migration process may also have something to do with why Hoptunes and hot Jupiters are usually the only planets in their respective solar systems. The inward movement of a large world can gravitationally kick out other planets, leaving behind just a single, bullying scorcher. Notably, the team also found that Hoptunes are somewhat less "lonely" than hot Jupiters, probably because their smaller sizes make them generally less capable of expelling their fellow planets.

To further unravel the origins of planets in tight orbits around their stars, Dong and colleagues are looking forward to soon having boatloads of new specimen worlds to study. The Transiting Exoplanet Survey Telescope (TESS), a spacecraft launching in March 2018 and led by the Kavli Institute for Astrophysics and Space Research at the Massachusetts Institute of Technology, should discover thousands of exoplanets around the closest, brightest stars. Many of the planets will be in tight orbits and, being nearby, quite amenable to detailed study.

"With TESS and other upcoming missions, we expect to find a lot more hot Jupiters and Hoptunes to study," said Dong. "I am especially looking forward to high-resolution spectroscopic studies of Hoptunes that could yield their masses, which could provide important evidence to crack the case of these roaster planets."

Other members of the research team and paper co-authors are Ji-Lin Zhou of Nanjing University, Zheng Zheng of the University of Utah, and Ali Luo of the National Astronomical Observatories of the Chinese Academy of Sciences. The research is funded, in part, by the National Natural Science Foundation of China, the Chinese Academy of Sciences, the Key Development Program of Basic Research of China, and the Foundation for the Author of National Excellent Doctoral Dissertation of People ' s Republic of China.

Paper: http://www.pnas.org/content/115/2/266.full
PKU News: http://pkunews.pku.edu.cn/xwzh/2018-01/17/content_301049.htm

, 41 。
（ SXDS_gPC）
, 110 , 353
（ 2.5 ）。 , （ 3.26、 ），
, 5.7 6.6 。
。
。 , 、 。
。 。
, SXDS_gPC
, , ,
，SXDS_gPC
。 。
SXDS_gPC ,
4 。 SXDS_gPC
, 5.7 3.6×10^{15} 。
（LAE） 。 , 、
SXDS 5.7 ,
、 。 。

Figure 1: An artist ' s conception of a giant protocluster of galaxies in the distant Universe.

（ ）

5.7 （127 ），

。2018 10 15 ，

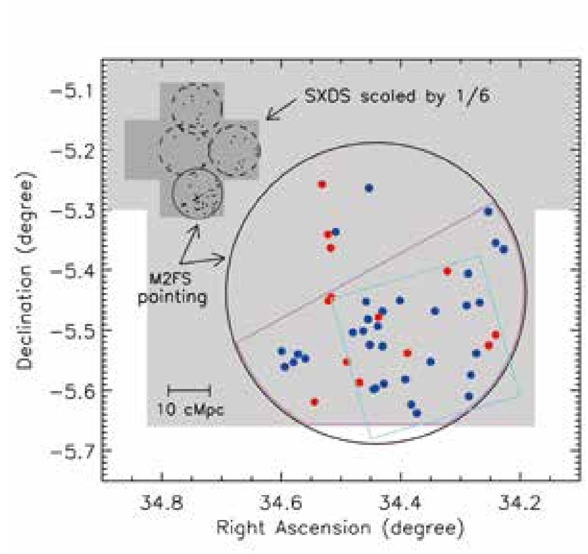
“A giant protocluster of galaxies at redshift 5.7” 《 - 》（Nature Astronomy,2018,DOI:10.1038/s41550-018-0587-9），（highlight）。

Paper link: https://www.nature.com/articles/s41550-018-0587-9

Nature highlights: https://www.nature.com/articles/d41586-018-07028-2

Nature views: https://www.nature.com/articles/s41550-018-0618-6

PKU News: http://pkunews.pku.edu.cn/xwzh/2018-10/17/content_304633.htm



SXDS_gPC 。 SXDS_gPC， 6.6 ， 3.6×1015 。

Figure 2: Schematic representation of the SXDS_gPC region. The blue and red solid points represent spectroscopically confirmed, luminous LAEs. The cyan rectangle represents the giant protocluster SXDS_gPC, which is embedded in the large overdense region outlined by the magenta, half-circle-like shape.

II. Discovery of the Largest Protocluster of Galaxies in the Distant Universe

Galaxy clusters trace the largest structures of the Universe and provide ideal laboratories for studying galaxy evolution and cosmology. Protoclusters of galaxies are the progenitors of galaxy clusters. They are a powerful tool for understanding cosmic structure formation in the early Universe. It is, however, very challenging to find the largest protoclusters at early times when they start to assemble. According to cosmological simulations, the largest protoclusters extend over tens of co-moving megaparsecs (cMpc) at the epoch of their early formation, and thus deep, wide-area spectroscopic surveys are needed to reliably identify these giant structures at high redshift.

Jiang and colleagues are carrying out a deep spectroscopic survey of galaxies in four square degrees on the sky, aiming to build a homogeneous sample of Lyα-emitting galaxies (LAEs)at z ≈ 5.7. They are observing five well-studied fields. In one of the fields called SXDS, they identified a large overdense region at z ≈ 5.7. With follow-up spectroscopy, they confirmed at least 41 luminous LAEs. A giant protocluster (SXDS_gPC for short) within a volume of ~ 353cMpc3is embedded in this overdense region. The galaxy density in SXDS_gPCis about 6.6 times the average density at z ≈ 5.7. Protoclusters like SXDS_gPC at high redshift have not been reported before. Jiang's team estimated that such systems are very rare in the distant Universe.

The high overdensity of SXDS_gPC well exceeds the collapse threshold in the classical theory of spherical collapse. Cosmological simulations also suggest that an overdense region like SXDS_gPC will inevitably fall into a giant galaxy cluster. Two methods have been used to estimate its present-day mass, which is the total mass of baryonic matter and dark matter in SXDS_gPC. The resultant mass is roughly 3.6 × 10^{15}solar masses, comparable to those of the most massive clusters or protoclusters known to date. This makes SXDS_gPC the most massive protocluster at high redshift.

The cold dark matter model (currently the standard model of cosmology) predicts that small structures merge hierarchically to form large structures. Therefore, larger structures are expected to form in the later cosmic times. The discovery made by Jiang's team is remarkable that giant protoclusters like SXDS_gPC already exist when the Universe was only 7% of its current age. Such protoclusters may be ideal probes for understanding early structure formation.

This work is supported by the National Key R&D Program of China and the National Science Foundation of China. The paper was published on Nature Astronomy on Oct. 15, 2018.

Paper link: https://www.nature.com/articles/s41550-018-0587-9

Nature highlights: https://www.nature.com/articles/d41586-018-07028-2

Nature views: https://www.nature.com/articles/s41550-018-0618-6

PKU News: http://pkunews.pku.edu.cn/xwzh/2018-10/17/content_304633.htm

10km，。1.4 。Bayes 。Bayes 。40

GPS 。 JPL （Guo et al., 2018 MNRAS），

。

，。

：

（Guo et al., 2018 MNRAS）。

Reference

1.Guo Y. J., Lee, K., Caballero, R. 2018, MNRAS, A dynamical approach in exploring the unknown mass in the Solar system using pulsar timing arrays, 475, 3644

2.Guo, Y. J.; Li, G. Y.; Lee, K. J.; Caballero, R. N.2018, Studying the Solar system dynamics using pulsar timing arrays and the LINIMOSS dynamical model, 489, 5573

3.Li, Z., Lee, K., Caballero, Measuring clock jumps using pulsar timing, 2020, , 63, 21951

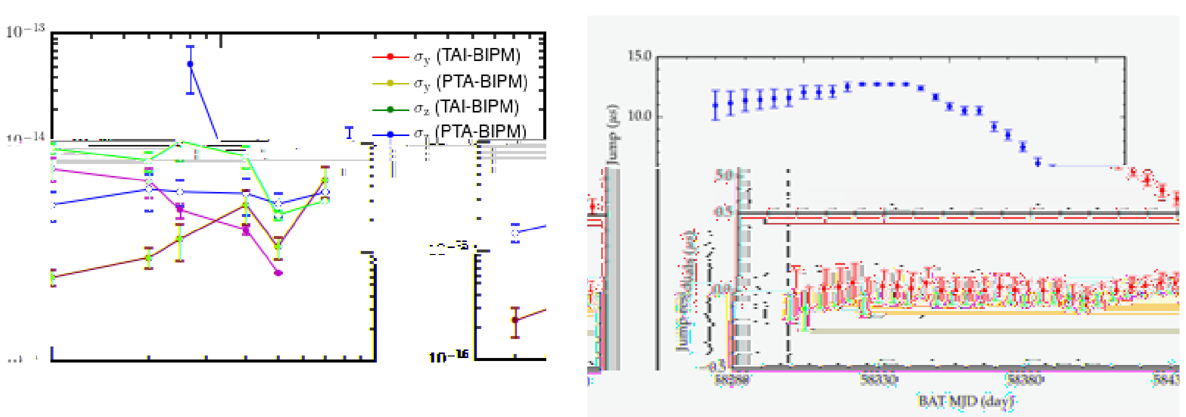
4.Caballero, R. N.; Guo, Y. J.; Lee, K. J.; et al., Studying the Solar system with the International Pulsar Timing Array, 2018, MNRAS, 481, 5501

。

（Caballero et al.,2018 MNRAS） 8 。 IAU 。 2019 《 》（ARA&A） 。

。 。

， JPL IMCEE。 ， 。 JPL ，



（Hobbs et al., 2019，MNRAS）。 （Li et al., 2019, SCPMA）

Figure 1. Left：Comparison between international atomic clock standard and pulsar time scale（Hobbs et al., 2019，MNRAS）。Right:Measuring clock jumps using pulsar timing（Li et al., 2019, SCPMA）

At the final stage of massive star, its fusion fuel runs out and the core of the star collapse to a neutron star, which has 10 km radius and 1.4 solar mass. Due to the compactness and high mass, the rotation of neutron star is highly stable. A fraction of neutron star can be detected in the radio band, where radio pulses with very regular period were observed. Such stars are named as pulsars. Scientists can carry out high precision metrology experiment with radio pulsars. Recently, large amount works indicate that it is possible to construct long-termly stable clock ensemble and deep-space reference frame by observing multiple pulsars.

Kejia Lee ' s research group studied the details of technology to realize the pulsar clock and pulsar reference frame. The Bayesian algorithm in the clock correction inference between the pulsar and ground-based atomic clock is developed. The algorithm is also capable to extrapolate. Using European pulsar timing array data, capability of the algorithm is demonstrated. They also joined the international pulsar timing array collaboration, and carried out related research. They show that, over timescale longer than years, the pulsar clock is more stable than the current international atomic standard. They could provide better time standard with pulsar timing. They further investigated the nonstationary problem in pulsar clock application, namely the clock jump. Clock jump is seen in atomic clocks, they need to correct it for any practical pulsar timing scale. They demonstrate their new algorithm using data from Yunnan observatory. It shows that using 40m telescope, it is possible to realize GPS-level precision in clock-jump correction.

Lee ' usi60.5 ((pul50.6 (sa)0.6 trov)0.5 (i)0.mrov)0.5 (i)0.im(nc)0.w6 (n t)0.6 (h)0.6 (a)0.6 (t)0.5 (t)0.75 (e)0.6 (p)0.55

Reference

5.Guo Y. J., Lee, K., Caballero, R. 2018, MNRAS, A dynamical approach in exploring the unknown mass in the Solar system using pulsar timing arrays, 475, 3644

6.Guo, Y. J.; Li, G. Y.; Lee, K. J.; Caballero, R. N.2018, Studying the Solar system dynamics using pulsar timing arrays and the LINIMOSS dynamical model, 489, 5573

7.Li, Z., Lee, K., Caballero, Measuring clock jumps using pulsar timing, 2020, , 63, 21951

8.Caballero, R. N.; Guo, Y. J.; Lee, K. J.; et al., Studying the Solar system with the International Pulsar

2014

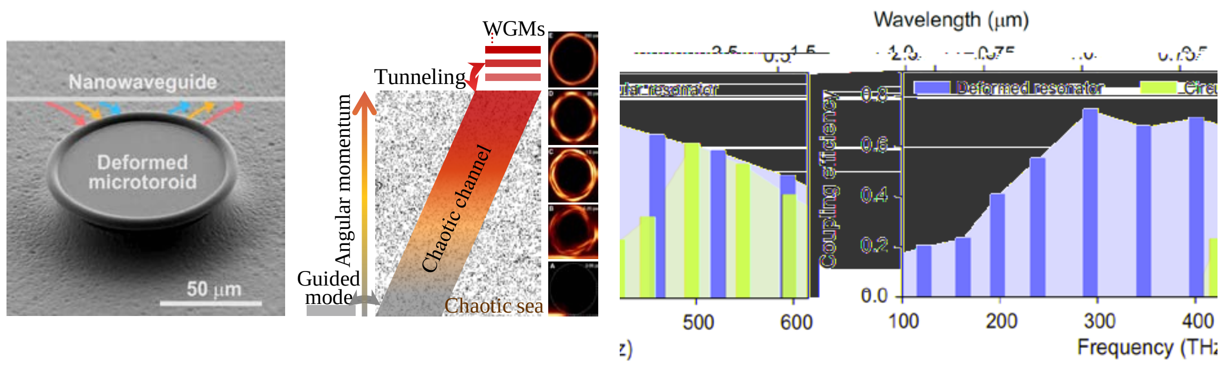
2014

Marko Loncar

2012

Jan Wiersig

(500 2900



Left: SEM image of a deformed microresonator coupled with a nanowaveguide. Middle: Schematic for the chaos-assisted momentum-transformed coupling process. Inset: Short-time snapshots in 3D FDTD simulations of spatial intensity distribution. Right: 3D FDTD simulation showing coupling e ciencies of a deformed (red) and a circular (blue) microresonator coupled with a nanowaveguide.

I. Momentum transformation in a chaotic optical microresonator

The law of momentum conservation is one of the fundamental laws of the nature, which dominates the movements of matters in an isolated system, ranging from galaxies to elementary particles. In optics and photonics, this conservation law regulates many interesting physical processes. Taking optical whispering gallery mode (WGM) microresonator, which confines resonant photon by total internal reflection, for example. Traditional WGM microresonators possess the rotational symmetry, in which the total internal reflection angle, i.e., the angular momentum of a photon in a WGM keeps constant, and thus rule out many desired broadband photonics processes.

To this end, a group led by Prof. Yun-Feng Xiao and Prof. Qihuang Gong from School of Physics at Peking University reports the broadband momentum transformations of chaotic photons in an asymmetric WGM microresonators. A special shaped asymmetric (deformed) microresonator was designed to create chaotic channels that transform momenta of light. Consequently, via dynamic tunneling, such chaotic channels can serve as a liaison to connect light in the external couplers and the high-Q WGMs, by lifting or lowering the angular momenta of light between them in a few picoseconds. As a result, the broadband coupling of light from visible band to near-infrared (500 nm to 2,900 nm) simultaneously between a fiber nanowaveguide and a WGMs microresonator can be achieved, confirmed in full three-dimensional finite-difference-time-domain (3D FDTD) simulation. Experimentally, a nanofiber waveguide coupled with an ultrahigh Q factor deformed microtoroid was used to realize the momentum transformation process, possessing great advantages in nonlinear frequency conversions, such as broadband cascaded Raman laser, third harmonic generation, and frequency comb.

The proposed momentum-transformed scheme could find applications in a great number of fields, including not only multimode lasers, cascaded Raman lasers, and frequency comb generation, but also broadband quantum memories, multiwavelength optical networks, supercontinuum light source, and quantum information processing. The results were published in Science.

Professor Jan Wiersig from Otto-von-Guericke-Universitat Magdeburg, Professor Marko Loncar from Harvard University and Professor Lan Yang from Washington University in St. Louis also contribute to this work.

Si GaN

Si GaN GaN

Si GaN

Si GaN

ε ‐ α̈

α̈ , C ε

α̈ ذ 。 ﾉ

‡ ح ῦ , ｢

Si˛ GaN AlGaN/GaN (Appl. Phys. Lett. 110, 192104 (2017)),

ذ / ذ , ذ

/ ذ , Si˛

｢ InAl(Ga)N/GaN (Appl. Phys. Lett. 110, 172101 (2017))。 C ‐

GaN GaN ,

α̈ C GaN ﾉ ‡ 。

IV C GaN ε ,

, Si˛ GaN

, GaN

, ,

GaN C ｢ Ά ,

ε , ｢ Ά C

N (CN) c Ά A1

c Ά E ,

α̈ CN -1 。 ｢

C GaN N ,

, 2018

PRL (Phys. Rev. Lett. 121, 145505 (2018))。

α̈ Ḃ ,

Stanford 、MIT、 P. Grünberg α̈ 、

α̈

｢ ｢ 。

‐ 《Semiconductor Today》

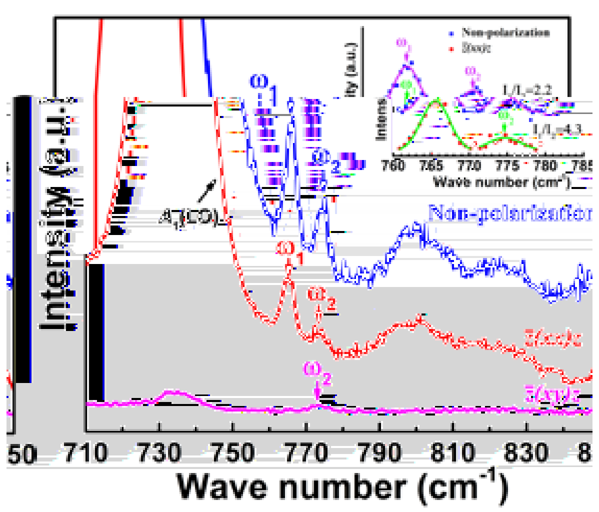
｢ 。 Ḃ

｢ 。

/ 、

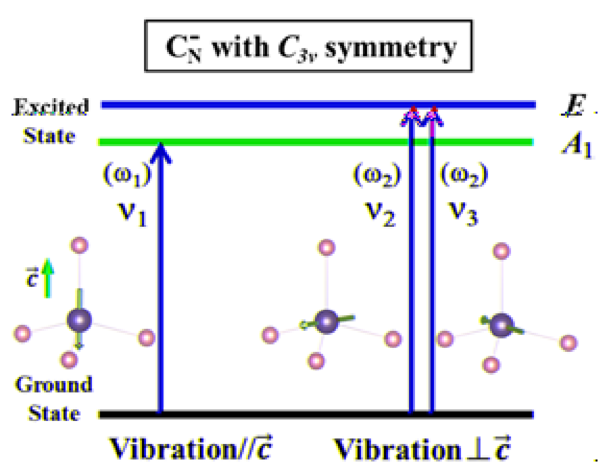
、2011 、 /

ε 。



1

Fig.1 Polarized Raman spectra.



2 CN ｢ Ά

Fig.2 Two local vibrational modes of CN.

II. Epitaxial growth with large lattice mismatch and defect physics of GaN on Si

GaN based materials and power devices on Si substrates have attracted much attentions due to their promising applications in next generation mobile communications, power supply, and electric vehicles. However, there are several challenges for the material and device reliability including the growth dynamic of heteroepitaxy with large lattice mismatch of GaN on Si, stress and defect control, and the physical properties of impurity/defects and their controlling mechanisms.

Bo Shen and Xuelin Yang′group at Research Center for Widegap Semiconductor in School of Physics, has deeply studied the heteroepitaxy with large lattice mismatch and the carbon doping mechanism in GaN. They proposed a large lattice-mismatch induced stress control technology and obtained high quality GaN layers and AlGaN/GaN heterostructures on Si substrates (Appl. Phys. Lett. 110, 192104 (2017)). They also developed a novel method to improve the surface/interface quality of the heterostructures and obtained high quality InAlGaN/GaN heterostructures with high mobility at high electron sheet density (Appl. Phys. Lett. 110, 172101 (2017). Carbon (C) doping is of extreme importance for producing semi-insulting GaN which are critical for fabricating GaN based power electronics. Identification of the lattice location of C impurity in GaN is essential for the improvement of device performance. As a group IV element, C is amphoteric in GaN, and the doping mechanism is very complicated. To address this issue, they solved the problem of the strong Reststrahlen-related band by designing the sample structure of thick GaN layers on Si substrate. Two local vibrational modes (LVMs) in C doped GaN were observed for the first time by using polarized Fourier-transform infrared (FTIR) and Raman spectroscopies. By combination with the first-principles calculations, the two LVMs are assigned to the nondegenerate A_1 mode vibrating along the c axis, and the doubly degenerate E mode confined in the plane perpendicular to the c axis, respectively. They are identified to originate from isolated C_N^- with local C_{3v} symmetry. They thus provide an unambiguous evidence of the substitutional C atoms occupying the N site with -1 charge state in GaN and therefore bring essential information to a long-standing controversy. The work was published PRL (Phys. Rev. Lett. 121, 145505 (2018).

The work was highlighted by the international counterparts such as Standford University, MIT, P. Grünberg Institute, Leibniz-Institut fur Kristallzuchtung and TMSC. The work was also reported many times by the famous magazine "Semiconductor Today". The relevant achievements have been used for cooperative research and development of technologies and products with domestic high-tech companies such as Huawei.

This work was partially supported by the NSFC, the MOST of China, the State Key Laboratory of Artificial Microstructure and Mesoscopic Physics, and Collaborative Innovation Center of Quantum Matter.

in fabricating nanoporous polymeric membranes with unprecedentedly high permeability and selectivity of cations, outperforming all the other reported membranes in fast ion sieving. The newly developed fabrication process, namely, the track-UV technique, is highly reproducible, and potentially

[At. Data Nucl. Data Tables 125, 193 (2019)].

Apart from energy and electromagnetic transition, it is interesting and helpful to depict the chiral geometry in the intrinsic frame of reference. However, it is a big challenge to examine the chiral geometry, in particular, in the angular momentum projection approach. The reason is that the projected basis is defined in the laboratory frame and forms a nonorthogonal set. The team led by Prof. Jie Meng has overcome these difficulties by treating the Euler angles, which describes the orientation of the intrinsic frame with respect to the laboratory frame, as generator coordinates and by considering the relation between the tilted angles of the angular momentum with respect to the intrinsic frame and the Euler angles. For the first time the chiral geometry is demonstrated in the angular momentum projected states and the projected shell model with configuration mixing [Phys. Rev. C 96, 051303(R) (2017); Physics Letters B 785, 211 (2018)]. Figure 2 shows the azimuthal plots (A-Plots), i.e., the profiles of the angular momentum orientation for the chiral doublet bands in ^{128}Cs for I = 11 $\hbar$, 14 $\hbar$, and 18 $\hbar$. For the partner band A and band B, the angular momenta orientate equally at two directions of aplanar rotation at I = 14 $\hbar$, which demonstrates the occurrence of static chirality. Whereas for band A, the static chirality disappears at 11 $\hbar$ and 18 $\hbar$. Thus, the chiral geometry in the symmetry-restored states is illustrated by the azimuthal plot, which provides a powerful tool to investigate nuclear chirality. Potential applications of the A-plot include many other exotic rotational modes, such as the wobbling motion.

The results were recently published in Journals such as Physical Review C (Rapid Communication) and Physics Letters B. This work was partly supported by the Chinese Major State 973 Program, the National Key R&D Program of China, the National Natural Science Foundation of China, and the China Postdoctoral Science Foundation.

15 Center for High Energy Physics

。8 ，31 ，6 ，7 。：、、、。

With Prof. T. D. Lee as the director, the Center for High Energy Physics at Peking University now has 8 senior fellows from abroad, 8 research associates, 31 junior fellows and 6 postdocs. The research interests include: cosmology, quantum field theory, particle physics phenomenology and hadronic physics.

（、），PDFs 。。QCD “”，（QCD） PDFs 40 ，QCD ，QCD PDFs。（PDFs）。，PDFs 。2013 ，QCD quasi-PDFs，。quasi-PDFs PDFs。，，

《》【Phys.Rev.Lett. 120 (2018) 022003】。，，quasi-PDFs PDFs，。quasi-PDFs 。2018 9 —，2019 “”。《》【Phys.Rev.Lett. 122 (2019) 062002】。

I. Exploring internal structure of hadrons based on ab initio calculation

Study of the internal structure of hadrons, like the proton or neutron, is crucial to understand both the nature of strong interaction and the constitutive substance of the real world. However, this problem is so hard that, 40 years after the establishment of the fundamental theory of strong interaction, quantum chromodynamics (QCD), one is still unable to calculate parton distribution functions (PDFs) of quarks or gluons inside of the proton based on QCD. Significant breakthroughs of ab initio calculations for PDFs are achieved in recent years.

In 2013, Xiangdong Ji proposed some time-independent quantities, called quasi-PDFs, which can be calculated directly by using lattice QCD. At the same time, it was argued that these quasi-PDFs approach PDFs when momentum is large enough. Recently, Yan-Qing Ma and his collaborator generalized Ji's idea, and proposed the most general method "lattice cross section". In this method, the requirement of time independence is retained, but the relation to PDFs is guaranteed by factorization theory. Ma and his collaborator constructed a series of "lattice cross sections" that are convenient for lattice calculation, and proved it rigorously in quantum field theory that these quantities can be related to PDFs via factorization theory. This study makes it possible to rigorously calculate PDFs from lattice QCD. The result is published in Phys.Rev.Lett. 120 (2018) 022003.

Besides, to make it possible to calculate PDFs using quasi-PDFs, a condition is that quasi-PDFs should be multiplicatively renormalizable in quantum field theory. Yan-Qing Ma and his collaborators proved this property rigorously, which is an important theoretical foundation for quasi-PDFs. This result was submitted to PRL in September, 2018, and it was published in early 2019, Phys.Rev.Lett. 122 (2019) 062002.

2017 9 2 , ε / 。 。

On September 2, 2017, the School of Physics organized volunteers to welcome freshmen.

2017 9 5 , ε | 2017 ∧ 。 2017 . 。

On September 5, 2017, the School of Physics held the 2017 opening ceremony.

2017 8 , ε 2016 。

In August 2017, the 2016 undergraduates participated in military training.

2017 9 , ε , ᾶ ש 。

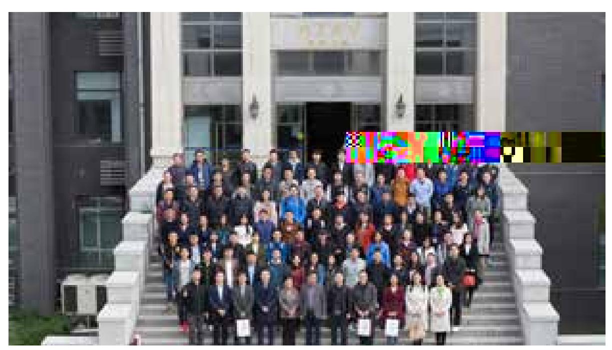
In September 2017, the School held an orientation party to help freshmen students integrate into the big family.

2017 10 31 , ε | ש。
ε 2017 ذ
ذ , 。

On October 31, 2017, the School held a dean luncheon. School Dean had a face-to-face communication with the 2017 freshmen representatives to answer the students' confusion about university life.

ï , ᾰ “ ” ש。
“ ” ש。

In order to promote the employment development of students, the School regularly organizes corporate visits and holds "Ivy League" alumni job fairs every year.



2017 12 , ε ⁄ |
。

In December 2017, the School visited enlisted student in a certain army in Hainan.

2017 12 9 , ε ε ﾒ 2017 “ ”
“ · ᾰ ” Ά 812 ‘ ש 《 》, 。

On December 9, 2017, freshmen representatives from the School performed chorus "Xinghe" at Peking University's 2017 freshman "Philadelphia" project and a memorial event and won rounds of warm applause from the audience .

2017 12 ש, 。

In December 2017, the School students organizeed the New Year's pary.

2018 4 4

خ， خ， ق ， ，2018

“ ” ̈A。

In order to enhance students' cohesion and cooperative ability and encourage students to go out of dormitory, the School held the second session of the "Outstanding PKUer" student outdoor development activities.

, 、 , , ǐ "
" " " " ש 。

The School organized a number of groups to carry out social practices on the themes of "frontiers of reform" and "technology exploration" in all parts of the country.

, ש、 ᾱ ש 、 、 、 Ά
ש , "Ά " 。2018 . ɛ 892 Ḃ
。

In order to enhance students' physical fitness, the students participated in sports events such as the Freshmen's Cup, Peking University Cup, Masters Cup, and the Spring and Autumn Games, and designed a series of "Momentum Cup" games. In 2018, the School ranked first in sports competitions with a score of 892 points.

2018 5 4 ɛ ᆟ 120 Ά。

On May 4, 2018, the student representatives participated in the 120th anniversary celebration of Peking University.

ɛ 2017 ∧ ∧ , ɛ 1997
; ɛ 2018 ∧ ,
⋆ " ᆟ " „ . 。

The 2017 graduation ceremony was held and the 1997 alumnus Wenping Liu attended the ceremony and delivered a speech. The 2018 graduation ceremony was held and the special guest Ms. Danli Liu presented the certificate to students who have won the honorary title of "Beijing Outstanding Graduates".

On October 28, 2017, the first alumni enterprise job fair of Peking University School of Physics was held. Lixin Zhang, director of PKU Student Employment Guidance Service Center, Xiaohua Dong, deputy secretary of the School, and about 200 alumni representatives and students attended the opening ceremony.

On December 9, 2017, the School visited Shenzhen alumni to hold a special session of the “PKU Salon”, inviting Jijie Duan, a 2000 alumnus and Jiaxin Zhang, a 2004 alumnus, to share their research results.

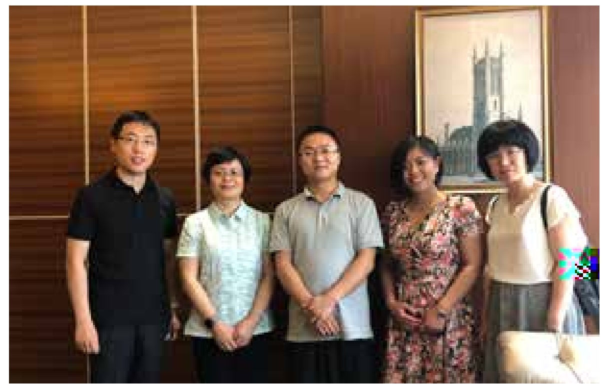
On February 23, 2018, the School held a 1983 undergraduate alumnus Haiyun Zhang's report.

On March 10, 2018, the seventh council of the Alumni Association of School of Physics was held.

In May, 2018, Peking University celebrated its 100th anniversary. During the school celebration, the School had about 53 grades and classes, more than 1,600 alumni returned to school, and 106 students participating in volunteer service. The School organized dean's report, and invited Dean Xincheng Xie to introduce the academic, research, talent introduction, and financial support of the School in recent years; the School held an alumni forum, and invited Junwei Bao, Shuang Wu, and Tian Feng to share their work; the School also organized an alumni dance party, and invited alumni to gather and relive their campus times.

2018 5 28 , ع ښ ڄ ⁄ 。

On May 28, 2018, the School visited Hefei Alumni.



2018 5 30 , ع ښ
ﻼ ⁄ 。

On May 30, 2018, the School visited alumni working at Nanjing University.

2018 5 31 , ع ښ ⁄ 。

On May 31, 2018, the School visited alumni of the 14 Institute of China Electronics Technology Corporation.

2018 6 1 , ع ښ ⁄ 。

On June 1, 2018, the School visited the alumni of Zhejiang University.

2018 10 27 , ﻼ ع ښ ع ‖ 。

On October 27, 2018, the School’s 2nd

Alumni Funds:

Time of	Project Title	Donators
	Qisun Ye Experimental Physics Fund	Mr. Qisun Ye, his friends and students
	Yibing Xie Fund	Mr. Yibing Xie, his students (Mr. Jietai Mao et al.)
	77 '77 Physics Class Fund	77 The '77 physics class
	Paul Shin-Piaw Choong Educational Fund for Physics	Mr. Philip Tsi Shien Choong and Ms. Hsia Shaw-lwan Choong
	80 '80 Ellen Yi Lan Woman Physicist Scholarship	80 The '80 physics class, Ms. Yi Lan's family and friends
	86 '86 Physics Class Fund	86 The '86 physics class
	88 '88 Physics Class Fund	88 The '88 physics class
	Huxiong Chen Educational Fund for Physics	Mr. Jingxiong Chen and Ms. Jufang Chang
	Ning Hu Scholarship	Mr. Ning Hu's family, Ms. Danhua Qin, the Zhaobing Su couple, and Mr. Guangda Zhao et al.
	Kaihua Zhao Educational Fund for Physics	PKU alumni and concerned departments
	Truth-seeking Scholarship	80 Mr. Yi Tang and Ms. Hong Yang
	Wenxin Zhang Educational Fund for Physics	49 Mr. Wenxin Zhang
	Ou Hai Scholarship	78 Mr. Xingyun Zhang and Ms. Pei Fan
	91 '91 Physics Class Fund	91 The '91 physics class
	PKU Physics Students Development Fund	00 Mr. Chuan Li, Yingzi Xia, the Tianmei company and et al.
	Keqi Shen Educational Fund for Physics	88 Mr. Duoxiang Wang
	Institute of Modern Physics Fund	The Institute of Modern Physics
	85 '85 Physics Class Fund	85 The '85 phyics class (Ms. Jing Fang, Mr. Yi'an Lei and et al.)
	Emergency Aid for Physics at PKU	PKU physics alumni and community
	PKU Physics Lecture Hall Chair Donation Fund	PKU physics alumni and community
	79 '79 Physics Class Fund for Garden Donation	79 The '79 physics class
	PKU Physics Video Meeting Room Fund	77 Mr. Tingkang Xia
	Physics Building Front-garden Fund	78 Mr. Ming Hu
	7802 PKU Physics 7802 Meeting Room Fund	78 The '78 physics class
	PKU Partnership Fund	2012 The '12 physics graduates Ji Li, Hua Zong, and Jianbo Fu
	78 '78 Nuclear Physics Class Fund	78 The '78 nuclear physics class (Liqiang Ji et al.)
	PKU Xingcheng Fund	79 A '79 technical physics alumnus
2014	80 '80 Physics Class Fund	80 The '80 physics class
2014	PKU Physics New Liabrary Reading Room Fund	PKU physics alumni and community
	212 PKU Physics Buidling 212 Middle Room Chair Donation Fund	PKU physics alumni and community
	PKU Physics Jinhui Students Development Fund	97 Mr. Chenyang Wang and Ms. Ya Cheng
		PKU physics alumni and community
		05 /
		05 /

The Centennial Physics Lectures

2017 Ḃ |“ ⅄ 、 ɛ ” 、 。
、2016 ɛ F. Duncan M. Haldane 。

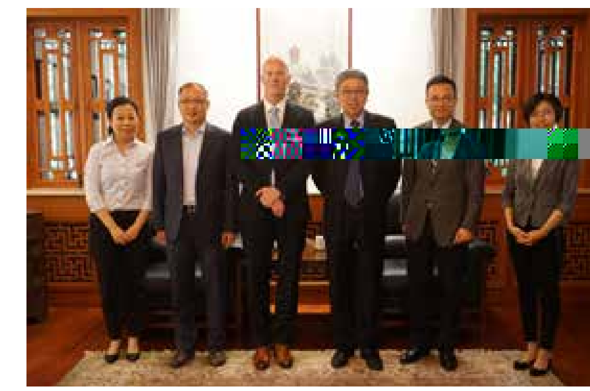
In 2017, the school held the 17th and 18th sessions of The Centennial Physics Lectures. The 17th Lecture was given by the 2016 Nobel Laureate in Physic Prof. F. Duncan M. Haldane from Princeton University.

“ ⅄ 、 ɛ ” 、 Plumian
Robert Kennicutt ‖ 。

The 18th lecture was given by Prof. Robert Kennicutt, Academician of the American Academy of Sciences and Plumian Professor of Astronomy and Experimental Philosophy at University of Cambridge.

2018 Ḃ |“ ⅄ 、 ɛ ” ᾰ、 、 。 ᾰ
、 Edward Sargent ‖ 。

We held the 19th to 21th lectures in 2018. The 19th lecture was given by Prof. Edward Sargent, Vice President and worldly noted material scientist.



ɛ 、 、 Wilson Ho ‖
。

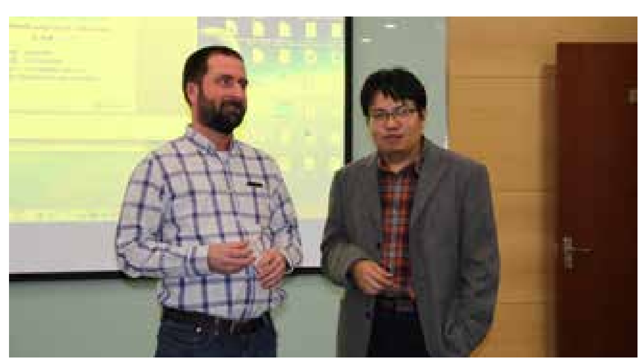
The 20th lecture was given by Prof. Wilson Ho, Academician of the American Academy of Sciences and worldly famous physicist..

2018 ε 、 Gérard Mourou ﾑ
。

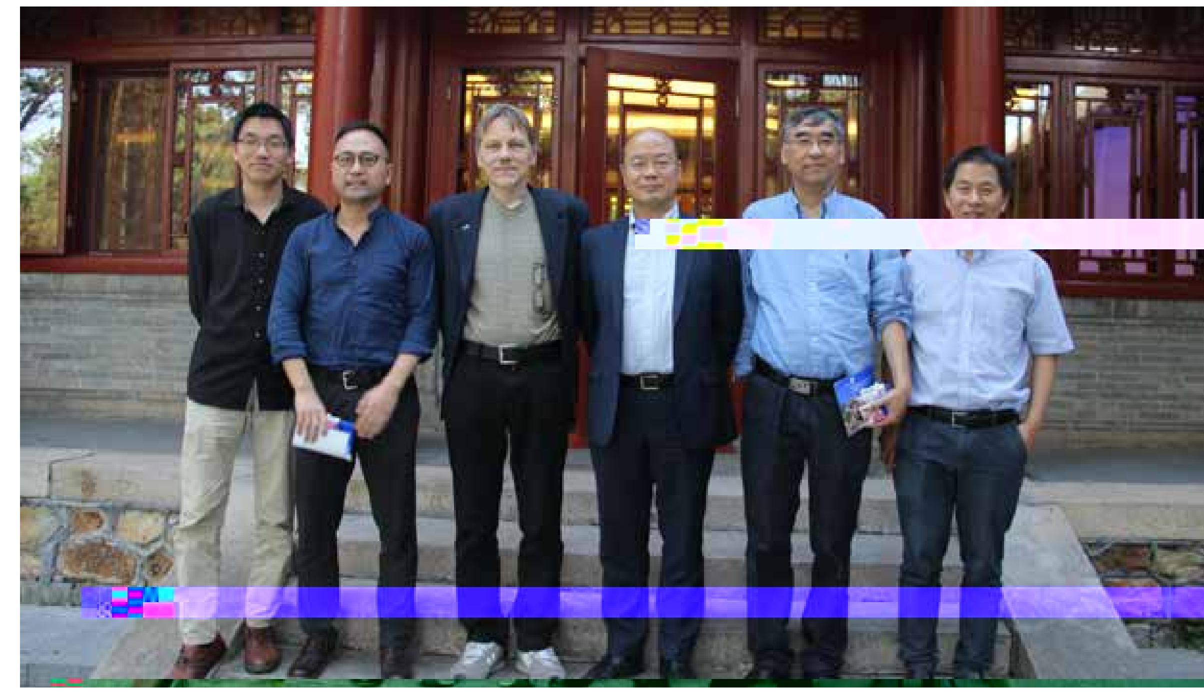
The 21th lecture was given by Prof. Gérard Mourou, the French scientist and the 2018 Noble Laureate in physics.

Exchange Activities

2017 1 ，
， 2 10
Ḃ， ， ﾑ
ε 64 。 ε
ݓ ， ݒ
。



In January, 2017, a Linfield College delegation of 2 professors and 10 undergraduate students led by Prof. Tianbao Xie, the 1964 PKU physics alumnus, visited the School of Physics. Prof. Shuhua Zhu, Vice Dean of the School of Physics, warmly welcomed the delegation. Prof. Lixin Xiao from School of Physics held a discussion with the delegation.



5 ， Michael Hoch ﾑ ， Stephan Conermann，
ε ᾱ̈ 、 Ulf Meißner 。 ﾑ 、
ᒋ ݓ ， ε ݓ 。 ，
ε ， ε ε ᾱ̈ 、 ᾱ̈ 、 ε
ε ᾱ̈ ዐ ᾱ̈ 、 ε ˜ 。

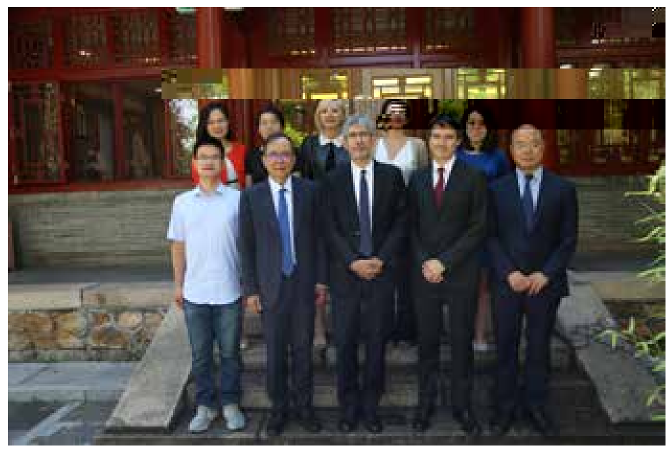
In May, a University of Bonn delegation led by Rector Michael Hoch and accompanied by Prof. Ulf Meißner visited Peking University. Academician Song Gao, Provost and Vice President of Peking University, met with the delegation. After the meeting, Rector Hoch and Prof. Meißner attended a discussion with the faculty representatives from the School of Physics: Prof. Yongyun Hu, Associate Dean of School of Physics, Prof. Boqiang Ma from the Institute of Theoretical Physics, Prof. Yunquan Liu from the Institute of Modern Optics, Prof. Xinzheng Li from the Institute of Condensed Matter and Material Physics, Postdocs Qibo Chen and Xiulei Ren from the Department of Technical Physics.

8 , ‸ ٤ ⁄ Stefan Östlund 、 Ramon Wyss 、KTH
Yingfang He ﾒ 。 ﾒ 、 ' ש
, ﾒ , ٤ , ٤ ٤ ש 。

In August, a KTH Royal Institute of Technology delegation led by Vice President Prof. Stefan Östlund, Former

6 , Gilles Bloch, Guillaume Garreta ,
Stephanie Balme, Sophie de Bentzmann 。

In June, a University of Paris-Saclay delegation led by President Prof. Gilles Bloch, accompanied by Director of International Relations Guillaume Garreta, Ms. Stephanie Balme and Ms. Sophie de Bentzmann from the Embassy of France, visited Peking University and met with Faculty of School of Physics. President of Peking University Prof. Jianhua Lin met with the delegation, joint by Associate Dean of School of Physics Yongyun Hu. The delegation discussed with faculty members of School of Physics, including Researchers Zongmei Fu, Lin Zhang and Yonggang Liu from the Department of Atmospheric and Oceanic Sciences and Researcher Yuan Li from the International Center of Quantum Materials.



12 , Eric Labaye , Dominique Rossin,
Rachel Maguer, Sara Tricarico, Gaëlle LE GOFF

In December, an École Polytechnique Paris delegation led by President Eric Labaye, visited Peking University, accompanied by Vice Provost Dominique Rossin, O cer of International and Media Relations Sara Tricarico, Deputy Director of International Development Gaëlle LE GOFF, etc. President of Peking University, Ping Hao, met with the delegation, accompanied by Provost Academician Qihuang Gong, Vice Deans of School of Physics Profs. Yongyun Hu and Shouhua Zhu as well as representatives from other Schools. After the meeting, the delegation held a discussion with School Representatives.

/ International/Hong Kong/Macao/Taiwan Conferences

2017 7 12-14 , “ ICQs ”
“The World of Topological Matters”。 2016
Duncan Haldane 。

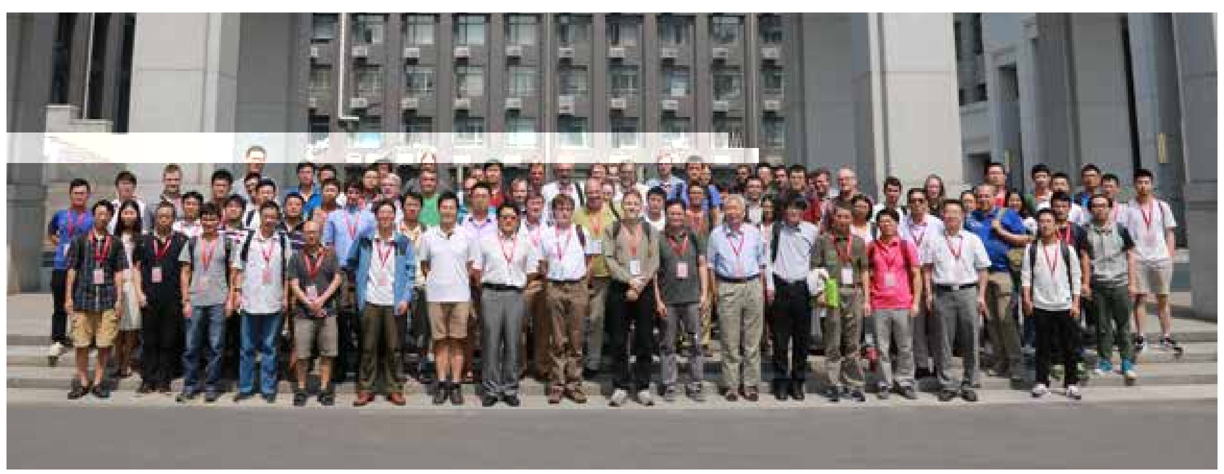
“The 7th ICQs Joint Annual Workshop on The World of Topological Matters” was held during July 12th-14th, 2017. A group of top scientists in the world, including Professor Duncan Haldane (the Noble laureate in 2016), on topological properties of condensed matter and materials were invited to give talks on related topics.

2017 8 17-19 , (KIAA) “ ”,
。

“The Workshop on Astroparticle Physics II” was held by KIAA at Peking University on August 17 to 19, 2017. More than 70 scholars from US, Europe, Jpan and other countries and areas attended this workshop.

“ QCD ” 2017 8 28-31 。
、 。

“CRC110 General Meeting of 2017” was held on August 28-31, 2017. The meeting was attended by nearly 40 foreign experts from Germany and Russia and over 40 domestic experts.



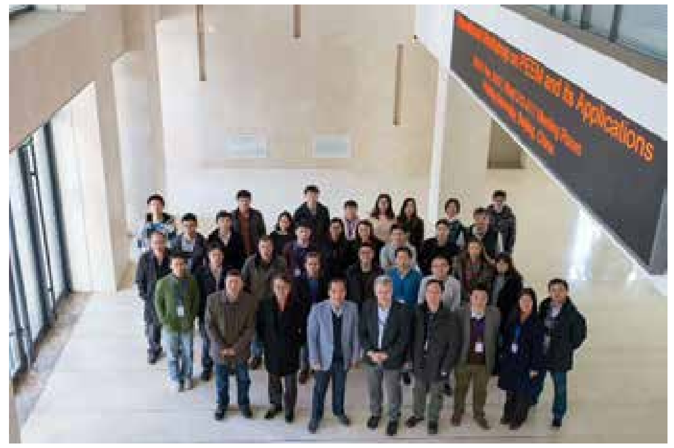
“ ” 2017 10 15 -18 ，
120 ， 15 。

“The 2nd China-US-RIB Meeting” was held by School of Physics on October 15-18, 2017. The meeting was attended by 120 attendees including 15 foreign experts.

12 2017 11 6-10 。 、
、 、 、 。

“The 12th International Workshop on Heavy Quarkonium” was held by School of Physics Peking University on September 6-10, 2017. The workshop was well attended with about 200 attendees including nearly 80 from US, France, Germany, Russia and other countries and areas.

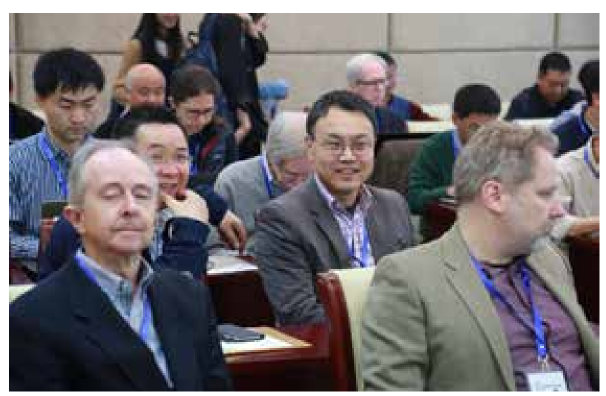
2017 11 22-23 ，
α̈ ש̇ ﾉ Ḃ
｜。 、 、 、 、
Ḃ
、 ש̇。



“The International Workshop on PEEM and Its Applications” was held by Peking University on September 22-23, 2017. Worldly noted experts from China, Germany, UK, Japan, and Hong Kong area attended this workshop.

“2018 sPHENIX ש̇” 2018 4 22-23 ﾉ Ḃ 。ש̇
ﾉ ‖。

“2018 sPHENIX” was held at Peking University during April 22-23, 2018. Noted scholars from US were invited to give talks on related topics.

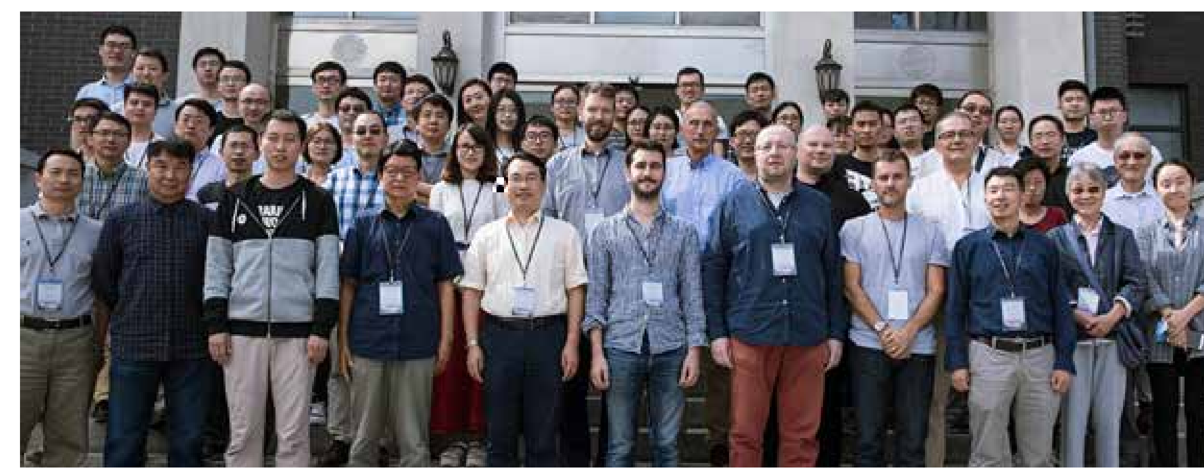


“ 25 ש̇” 2018 8 26-30 ﾉ Ḃ 。
ש̇ 23 400 ש̇。

“The 25th International Workshop on Rare-Earth and Future Permanent Magnets and their Applications (REPM 2018)” was held at Peking University on August 26-30, 2018. More than 400 experts and industrial personnel from more than 23 countries and areas attended this workshop.

“ ̈A خ̇ خ̇ ש̇” 2018 9 17-20 ﾉ ε ｜。 ש̇
70 ， 10 ， 35 ， α̈ 25 。

“The PKU-CUSTIPEN workshop on low energy nuclear dynamics and e ective nuclear interactions” was held by School of Physics on September 17-20, 2018. The workshop was attended by 70 attendees including 10 foreign experts, 35 domestic experts and 25 graduate students.



“ ﾉ - ﾉ ̈E ש̇” 2018 9 25-28 ﾉ ε
｜，ש̇ 、 、 、 ﾉ ‖。

During September 25-28, 2018, the “2nd Joint PKU-Kyoto-TMS International Workshop” was held at Peking University. Around 40 worldly renowned experts from China, Japan, US, Korea and so on were invited to give talks on related topics.

2017
In 2017,

- Yunfeng Xiao and Qihuang Gong ’ s group won the Ten Major Scientific Progress of Higher Education in China.
- Qingfeng Sun was elected as chief of National Key R & D Project.
- Jiahong Gao was approved by the Natural Science Foundation of China for National Major Projects.
- Ying Jiang, Ji Feng, Liangyou Peng, Qinghong Cao and Haijun Yang were awarded the National Funds for Distinguished Young Scientists.
- Rui Zhu was awarded the National Funds for Excellent Young Scientists.
- Qingfeng Sun, Xiaoyong Hu and Xinqiang Wang was included into the Science and Technology Innovation Talent of “ Ten Thousand Talents Program. ” Jintai Lin was included into the Young Topnotch Talents of “ Ten Thousand Talents Program. ”
- Xue-Bing Wu was awarded the first-class prize of Natural Science Award of Higher Education Science Research Excellent Achievement (Science and Technology).
- Chunsheng Zhao was awarded the second prize of Natural Science Award of Higher Education Science Research Excellent Achievement (Science and Technology).
- Academician Qihuang Gong was elected Chairman of the 8th Council of the Chinese Optical Society and Vice Chairman of the International Optics Commission.
- Yuxin Liu won the Outstanding Teacher title of “ Ten Thousand Talents Program. ”
- Zhongshui Ma won the title of Outstanding Teacher of Beijing.
- Liangyou Peng won the Rao Yutai Physics Award of the Chinese Physical Society.
- Weihong Qian won the second prize of Meteorological Scientific and Technological Progress by China Meteorological Society.

2018
In 2018,

- Bo Shen ’ s group won the second prize of National Technology Invention Award.
- Ying Jiang and Enge Wang's group won the Top Ten Progress in China.
- Yunfeng Xiao was awarded the Youth Science Medal of Higher Education Science Research Excellent Achievement (Science and Technology).
- Nanlin Wang ’ s group was approved the National Basic Science Center Project.

ص、 、 、 、 。
Zhimin Liao, Haitao Quan, Xiongjun Liu, Bin Qiao and Yunfeng Xiao were awarded the National Funds for Distinguished Young Scientists.

ت ɛ / ḅ 。
Jie Meng was elected Foreign Member of the European Academy of Sciences.

Ḃ ï 。
Enge Wang won the Lifetime Achievement Award in International Advanced Material.

2018 〃 。
Ying Jiang won the Tan Kah Kee Young Scientist Award.

“ Ã 2018 ”。
Yonggang Liu won the Young Scientist Medal by Shi Yafeng Cryosphere and Environment Fund.

、 。
Zhim6n W amhouhu ao5 (aZhuZhim6n g Liu wonay(ngsecoQiao5 (aprizec4ay9Y)9fn Internati1 (W)tea6.6)0.5 (W)86.6 (Achieve1 (A)9fnhigCry)8 (W)educInter, Fund.)]T2/C2_1