DEPARTMENT OF PHYSICS

THE UNIVERSITY OF HONG KONG

Excellence in Teaching and Research

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For general enquiries or correspondence

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September 2018

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WELCOME

Dear Prospective postgraduate student,

I hope you find this booklet useful, both as a valuable reference and as a source of background information to help you during your postgraduate application process. We are justifiably proud of our record of distinguished and innovative research at HKU across a variety of fields in the physical sciences. These include condensed matter physics, materials science, nuclear and particle physics, quantum computing, astronomy and astrophysics. We believe we provide an exceptional program of M.Phil. and Ph.D. research opportunities for top students to grapple with. We believe you will be engaged, enthused, challenged and rewarded by the projects on offer. So please browse, digest and choose wisely and if you apply and are successful we look forward to welcoming you to the HKU research family.

Good luck!

Prof. M.H. Xie
Head of Department of Physics, HKU
August 2018

INTRODUCTION

POSTGRADUATE STUDY AND RESEARCH ACTIVITIES IN PHYSICS AT THE UNIVERSITY OF HONG KONG

Besides commitment to excellence in undergraduate education, the staff of the Physics Department are engaged in active research in many areas of physics. The department offers both M.Phil. and Ph.D. programs for full-time postgraduate students. Most of our researches are in condensed matter, material physics and in astrophysics. In condensed matter and related fields, our interests include correlated electron systems, topological state of matters, low-dimensional systems, surface physics, material sciences, quantum transport in nanoscale, spin and valley electronics, semiconductor physics and optics. In the field of astrophysics and astronomy, our research covers cosmological models, gamma-ray bursts, interstellar chemistry neutron stars, neutrino physics, planetary nebulae, pulsars, supernovae and their remnants, high-energy astrophysics and related projects associated with our new laboratory for space research (LSR).

- **The Facilities:**

The department houses a number of state-of-art research facilities for multi-disciplinary researches in condensed matter physics and astrophysics.

- **Theoretical Studies**

For theoretical studies, besides the central computing facility of the university, staff and students of the department have at their disposal a 100-CPU Linux computer cluster solely dedicated to research.

- **Community Service and Outreach**

The department is also involved in community service. For example, the radon analysis laboratory provides calibration services to radon and radon progeny monitors. Other specialist consulting and advising is also undertaken from time to time. Outreach is also a key factor in our activities and RPG students are encouraged to think about visiting schools to give talks on their research and the role and importance of physics in society.

- **Location of Physics Department**

The Physics Department is housed in the Chong Yuet Ming Physics Building, conveniently situated on the main campus with easy access to the Main Library and other facilities. All our main laboratories are located over the first 4 floors of this building. The main administration section is on the 5th floor. The Main University Library has an extensive collection of books and journals related to the various research fields, while the Department also runs its own small library specifically for use by staff and research students.

ACADEMIC STAFF

Head & Professor

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	Dr. X. Fang	Dr. B. Fu
	Dr. P. Gong	Dr. C.P. Hu
	Dr. S.B. Hu	Dr. F.Z. Liu
	Dr. F. Lykou	Dr. D. Paredes
	Dr. A. Ritter	Dr. W.Y. Tu
	Dr. Q.E. Wang	Dr. T.M. Wu
	Dr. T.F. Yan	Dr. J.T. Yuan
	Dr. Z. Zheng	Dr. B.R. Zhu

Distinguished Visiting Professors:	Prof. T. Hwa Prof. K.B. Luk Prof. T.M. Rice Prof. D.C. Tsui Prof. A. Zijlstra
Visiting Professor	Prof. H. Guo Prof. Z.J. Jiang Prof. F.C. Zhang
Visiting Research Professors:	Prof. T. Boardhurst
Honorary Professors:	Prof. T. Boardhurst Prof. G.H. Chen Prof. J. Gao Prof. A.K.H. Kong Prof. P.K. MacKeown Prof. D.S.Y. Tong
Honorary Associate Professors:	Dr. A.M.C. Ng
Honorary Assistant Professors:	Dr. F.K. Chow Dr. T.C. Lee Dr. P.W. Li Mr. W.K. Wong Dr. Y. Zhang
Honorary Research Associate	Dr. M.J. Brownnutt

Clerical & Technical Staff:

Assistant Technical Manager	Liu Wing Chuen
Technicians	Chan Wai Hung, Ho Wing Kin, Ip Kam Cheong, Lee Chin Ming
IT Technician	Lau Sai Kin
Executive Officer	Anna Wong
Clerks I	Rachel Liu, Michelle Lo, Eva Wong
Clerks II	Navis Lau
Clerical Assistant	Joe Poon

RESEARCH GROUPS/
CENTRE HOUSED IN DEPARTMENT OF PHYSICS, HKU

Atomic and Quantum Physics group:

1. Quantum Computing and Information Theory

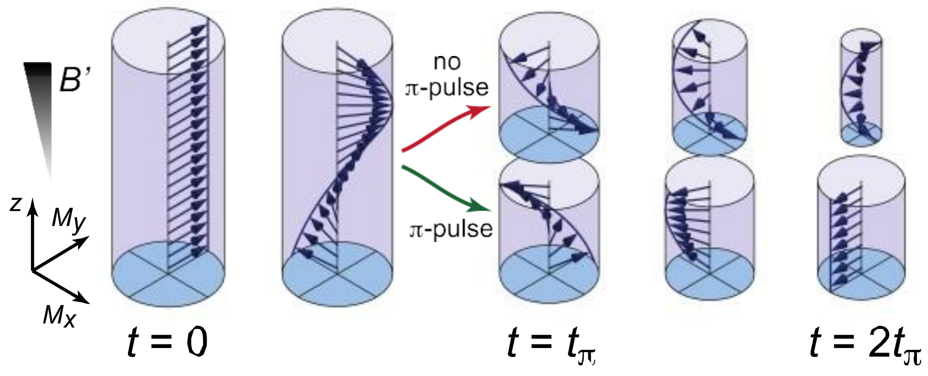
Academic staff: ***Prof. H.F. Chau***
Prof. Z.D. Wang

We focus on the theoretical study of quantum information theory and quantum computation. Our aim is to prove the security of various quantum cryptographic protocols as well as getting a better understanding of how to manipulate quantum information by quantum error-correction codes. In collaboration with researchers in HP Labs, Bristol, our group has recently proven that certain quantum key distribution scheme is unconditionally secure as well as obtained a U.S. patent on certain quantum key distribution protocols.

2. Theoretical Atomic Physics and Degenerate Quantum Gases

Academic staff: ***Dr. S.Z. Zhang***

Ultra-cold atomic gases have emerged as a multi-disciplinary subject that is at the interface of modern atomic and molecular physics, quantum optics and condensed matter physics. It proves to be an excellent laboratory for investigating strongly interacting quantum many-body systems and in particular correlated quantum phases and phase transitions. Current topics of interest include strongly interacting two-component Fermi gases and BEC-BCS crossover, synthetic gauge fields and spin-orbit couplings in atomic gases, novel mixtures of bosons and fermions.



Astronomy and Astrophysics group:

1. Facilities

Our on-campus facilities in observational astrophysics include a 40 cm- diameter reflector telescope located on the top of the CYM physics building equipped with charged couple device (CCD) imager and spectrometer, and two 2.3 m diameter Small Radio Telescopes all used for teaching, training and outreach. For professional observational astrophysics research we win access to a wide range of cutting-edge international telescopes via competitive peer review. These include ground based facilities such as the Gemini 8-metre Telescopes in Chile and Hawaii, the 8-metre telescopes of the European Southern Observatory in Chile, telescopes of the Beijing Astronomical Observatories and South African and Australian facilities. We also win access to space based facilities like the Hubble Space Telescope and Chandra X-Ray Observatory. The quality of our projects and proposals leads to success in gaining such access on a regular basis. We are currently building MoUs with key strategic partners in the mainland such as the KAVLI institute of Peking University, the Space and Astronomy group at Nanjing University and the microsatellites research group at Zhejiang University. These links will provided enhanced opportunities for our students in elite mainland research groups.

2. Theoretical Astrophysics

Academic staff: ***Prof. K.S. Cheng and***
Dr. M.H. Lee (Dept. Earth Sciences - adjunct with Dept. Physics)

The major research areas are related to neutron stars and pulsars, which are rapidly spinning and magnetized neutron stars, including X-ray and gamma-ray emission mechanisms, stellar structure, stellar cooling and heating mechanisms and the internal activities, e.g. sudden unpinning of superfluid vortices. In addition to topics related to pulsars and neutron stars, we also study topics related to gamma-ray bursts, in particular the central engine problem, and high energy phenomena resulting from the stellar capture processes by supermassive black holes in the galactic center.

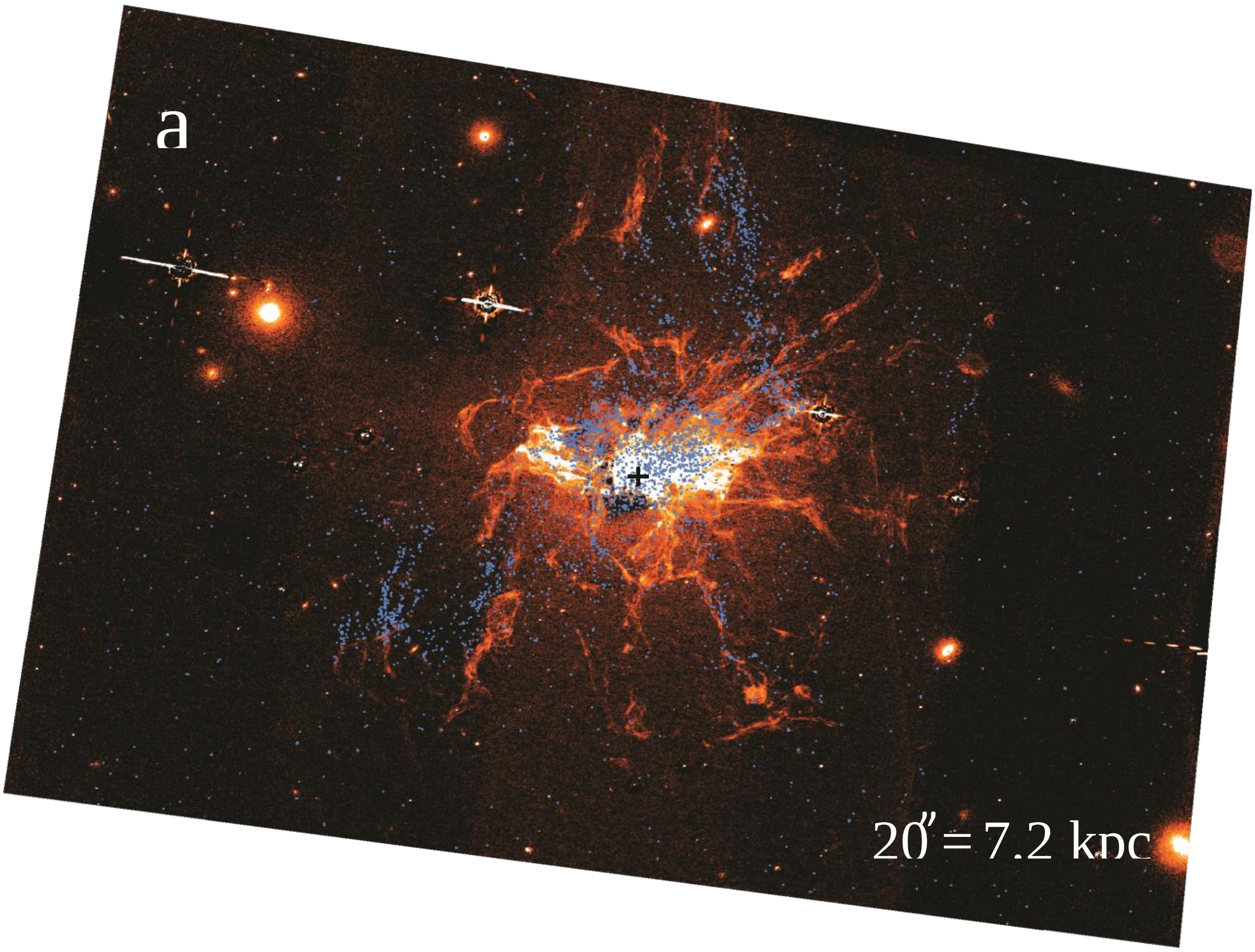
Dr. Lee is a planetary dynamicist who works on the formation and dynamical evolution of planetary bodies (planets, moons, etc.) in our Solar System and in planetary systems around other stars. He is also an expert in numerical methods for dynamical simulations of planetary systems. His current research interests include the dynamics and origins of (1) orbital resonances in extrasolar planetary systems, (2) planets in binary star systems, (3) the orbital architecture of the planets in our Solar System, and (4) the satellite systems of Jupiter, Uranus and Pluto-Charon.

3. Observational Astrophysics

Academic staff: ***Dr. J.J.L. Lim***
Dr. S.C.Y. Ng
Prof. Q.A. Parker
Dr. M. Su

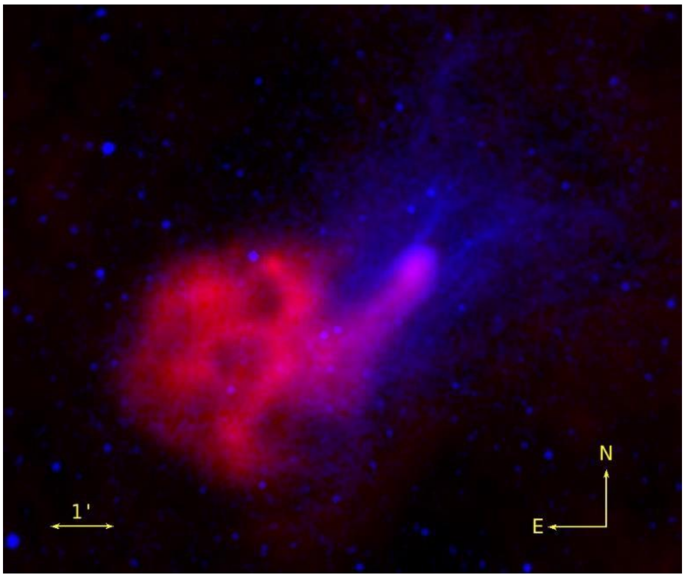
(1) Star Formation and Cooling Flows in Galaxy Clusters
Dr. Lim's research has spanned a broad range of topics, including (i) stellar coronal magnetic activity, (ii) the formation and late evolution of stars in our Galaxy, (iii) star formation and AGNs in nearby galaxies, (iv) X-ray cooling flows in galaxy clusters, and (v) astrophysical applications

of gravitational lensing, including weighing supermassive black holes, studying young galaxies, as well as the nature of dark matter. The present focus of his work is on topics (iii)-(v). As an observational astronomer, Dr. Lim uses primarily radio telescopes (e.g., VLA, SMA, ALMA) and optical-infrared telescopes (e.g., CFHT, HST). Dr. Lim has mentored many graduate students, a number of whom have gone on to PhD programs in the USA and Europe, or have since become postdoctoral fellows. He collaborates with many astronomers worldwide, bringing international exposure to his students. Over the past 5 years, in collaboration with Prof. Thomas Broadhurst at Ikerbasque, Spain, Dr. Lim has built a strong group of undergraduate and graduate students working on gravitational lensing at HKU. Dr. Lim actively recruits talented undergraduate students for casual research in preparation for their capstone and graduate studies.



(2) Dr. Ng studies extreme objects in our Galaxy, including magnetars, energetic pulsars, pulsar wind nebulae (PWNe), and supernova remnants. He has led observational projects using world-class telescopes in X-rays and radio, such as the Chandra X-ray Observatory, XMM-Newton, the Expanded Very Large Array, and the Australia Telescope Compact Array. He has identified a pulsar moving at an enormous velocity over 2,000 km/s. He has also developed a powerful 3D modeling technique to capture the X-ray torus and jet morphology of PWNe and to measure the structure and evolution of the supernova remnant 1987A.

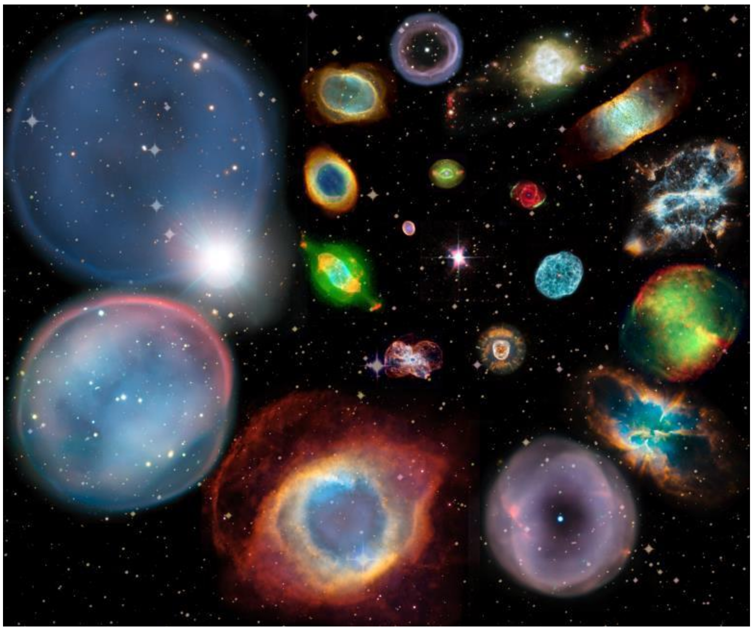
Dr. Ng's latest research focuses on the magnetic fields of neutron stars and their environments. Employing X-ray observations, he measures the surface temperature of magnetars, which are stars with the strongest magnetic fields in the Universe, to understand their extreme properties and their connection with ordinary radio pulsars. In addition, he maps the magnetic field configurations of PWNe using radio telescopes, in order to probe the cosmic ray production and transport in these systems.



Further information can be found at the webpage http://www.physics.hku.hk/~ncy/.

(3) Prof. Q.A. Parker arrived at HKU in March 2015 and is intent on establishing a world-leading group in late-stage stellar evolution that includes post-AGB stars, planetary nebulae and massive star ejecta including Wolf-Rayet shells and supernova remnants. This is assisted by i) the on-going appointment of Prof. Albert Zijlstra as a Hung Hing Ying Distinguished visiting professor to HKU who is a world leader in planetary nebula; ii) the appointment of several new postdoctoral research fellows: Dr. F. Lykou, Dr. Andreas Ritter and Dr. Xuan Fang and iiii) Three PhD students. Significant contributions to this research field have been made by this

strong team including two HKU press releases (see https://www.ras.org.uk/news-and-press/2741-planetary-nebulae and http://www.scifac.hku.hk/news/any/planebulae). Exciting research opportunities exist for additional research postgraduate students to join the group. This group also has strong synergies to existing departmental expertise in late stage stellar evolution (including supernova remnants) and to the Laboratory for Space research (http://www.lsr.hku.hk).



Subject of our recent press release: A collage showing 22 individual planetary nebulae artistically arranged in approximate order of physical size. The scale bar represents 4 light years. Each nebula's size is calculated from the authors' new distance scale, which is applicable to all nebulae across all shapes, sizes and brightnesses. The very largest planetary nebula currently known is nearly 20 light years in diameter, and would cover the entire image at this scale. Credit: ESA/Hubble & NASA, ESO, Ivan Bojicic, David Frew, Quentin Parker

(4) Dr. M. Su has a broad range of research interest, including Cosmic Microwave Background to study the Universe in the very beginning and the later evolution, observational high energy astrophysics (including gamma-ray and X-ray telescopes), searching for Dark Matter particles, cosmic ray physics (both theory and observations involving both ground-based and spaceborne instruments). We are building a CMB telescope in the west part of Tibet , which is the highest observatory worldwide! We have launched the very first Chinese astronomy satellite to look for dark matter, named Dark Matter Particle Explorer (we found some hints!). He has discovered a pair of gigantic bubbles emitting high energy of gamma-ray photons using NASA's Fermi Gamma-ray Space Telescope. He is also building satellites for dedicated space science research, including a X-ray telescope using so-called Lobster-eyed type of optics to enable the largest field of view ever, a UV telescope to help to find habitable worlds in other solar systems. He is also working on the two largest payloads onboard the future Chinese space station: a 2-meter class optical telescopes, and the

High Energy Radiation Detector which is the future of the gamma-ray and cosmic-ray detection. If you are interested in studying the Universe (or the earth!) using satellites, please talk to him.

Centre of Theoretical and Computational Physics of HKU:

Academic staff: Prof. H.F. Chau, Prof. G.H. Chen (Chemistry), Prof. K.S. Cheng, Dr. M.H. Lee (Earth Sciences), Dr. S.C.Y. Ng, Prof. S.Q. Shen, Prof. J. Wang, Prof. Z.D. Wang, Prof. W. Yao, Dr. S.Z. Zhang

The Department of Physics houses the HKU "Centre of Theoretical and Computational Physics", which was established in September, 2005. The purpose of the Centre is to enhance academic excellence in this area in Hong Kong and to serve as a platform for fostering collaboration between scientists in Hong Kong and abroad. The centre's honorary Director is Prof. Dan Tsui at Princeton University, Nobel Prize co-recipient in Physics in 1998. The Centre has a high level Advisory Committee (http://www.physics.hku.hk/~ctcp/). The Centre includes 8 faculty staff members as listed above. These members have been working in condensed matter physics, computational material sciences, quantum information, cold-atom physics and astrophysics. Most of these subfields are related to each other and cover many cutting edge researches related to today's science and tomorrow's technology.

The Centre exists to: (1). To invite scientists including distinguished scientists who have collaborated with or are potential collaborators of local scientists to Hong Kong to initiate or to carry out collaborative researches; (2). To organize lectures or public lectures given by distinguished visitors; (3). To train outstanding postdoctoral fellows and young talented graduate students to collaborate with Centre's visitors and the team members to carry out first class researches; (4). To coordinate with similar centres or institutes in Pacific Rim region and in the world to regularly organize high level international conferences and/or workshops to establish itself as the magnet of research activities in these research areas in the region.

Experimental Condensed Matter and Material Science group:

1. Facilities

(1) Nanostructure Characterization Laboratory (***X.D. Cui***)
We focus on optical and electrical properties of nanostructures and emerging semiconductors. The laboratory is equipped with a home-made confocal spectroscopy system, a time-resolved spectroscopy system and an electric charactering system.

(2) Laser Spectroscopy Laboratory (***S.J. Xu***)
The laboratory is equipped with variable-temperature (4.2 K-300 K) photoluminescence (PL), variable-temperature (1.5 K-300 K) magneto-PL (up to 7 T) with super high spectral resolution, a confocal scanning Raman microscopy/spectroscopy system, broadband variable-temperature (8 K-330 K) emission/ absorption/ reflectance/ photocurrent spectroscopy, time-resolved PL system, and a near field scanning microscope. The existing laser sources include He-Cd laser, He-Ne laser, Ar-Kr mixed gas laser, high-energy YAG pulse laser, and semiconductor laser diode array pumped femtosecond broadband lasers.

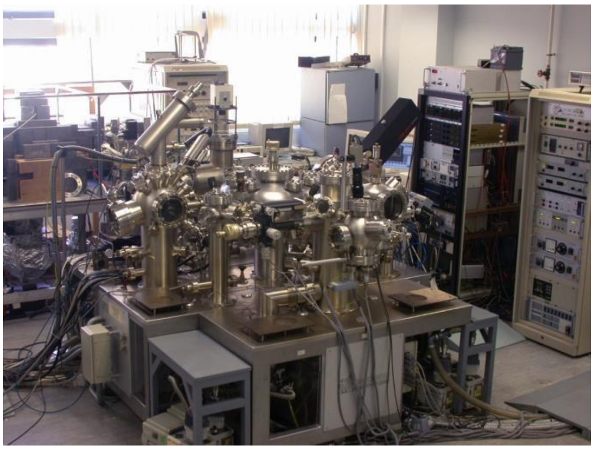
(3) Optoelectronics and Nanomaterials Laboratory (***A.B. Djurišić***)
This laboratory is equipped with fume cupboards, tube furnaces, a spin-coater, two thermal evaporators, and an electron-beam/sputtering deposition system. Our material characterization facilities include UV/Vis/NIR spectrometers for LED characterization and setups for power conversion efficiency and external quantum efficiency measurements for solar cells.

e-beam/sputter system and thermal evaporator

(4) Material Physics Laboratory (***C.C. Ling***)
Specialised equipment includes: Laplace transformed deep level transient spectroscopy system; Liquid nitrogen optical cryostat; 10 K liquid He free optical cryostat; Electrical characterization equipment: semiconductor parameter analyzer, multi-frequency LCR meter, pico-ammeter, electrometer, and etc.; Photoluminescence system: 30 mW HeCd laser, 500 mm monochrometer, PMT and CCD detecting system; UV-visible spectrophotometer; Radio frequency magnetron sputtering system; Pulsed laser deposition system; Chemical vapor deposition system; Electron beam evaporator; Thermal evaporator; Tube furnace and box furnace.

Big "off campus" equipment accessible to our students and staff: Positron beam time at the electron LINAC ELBE in the Center for High-Power Radiation Sources, Helmoltz Zentrum Dresden Rossendorf (HZDR), Germany for positron annihilation spectroscopic (PAS) study.

(5) Surface Science Laboratory (***M.H. Xie***)
This includes Multi-chamber ultrahigh vacuum (UHV) systems for material synthesis and characterizations by molecular beam epitaxy (MBE), scanning tunneling microscopy and spectroscopy (STM/S), low and high-energy electron diffraction (LEED/RHEED), and ultraviolet photo-electron spectroscopy (UPS).



2. Experimental Condensed Matter

Academic staff: ***Prof. X.D. Cui***
Dr. D.K. Ki
Prof. S.J. Xu

The facilities of the experimental condensed matter group consists of a number of experimental laboratories, carrying out concerted research in various fields of condensed matter physics, including the key areas below:

(1) Experimental Solid State Physics (***X.D. Cui***)

The emphasis of this research lab is on characterizations and applications of low dimensional materials, particularly emerging low dimensional semiconductors. Recently we focus on optical properties of atomic 2 dimensional (2D) crystals, particularly atomic layers of transition metal dichalcogenides (TMD). We explore the interplay of electron's spin, valley degrees of freedom and electron-electron interactions with semiconductor optics techniques.

(2) Quantum Nanoelectronic Devices (***D.K. Ki***)

We investigate quantum transport phenomena in various nano-electronic devices, realized by using state-of-art nano-fabrication and engineering techniques—the techniques that include electron-beam lithography, metal depositions and etching, micro-manipulation of atomically thin crystals and more. Materials of current interest are graphene and emerging 2D crystals, topological materials, and artificial heterostructures, and we take various experimental routes (*e.g.*, rotating magnetic fields, inducing strain, *etc*) to discover or engineer new quantum effects in these systems. Since these effects are often fragile against finite temperature and electrical noises (*e.g.*, fractional quantum Hall effect), we also implement cryogenic and low-noise measurement techniques. Throughout the investigation, we aim to understand and learn to control the underlying physical processes as it not only expands our view of electronic materials but also brings us one-step closer to the realization of new device applications that fully harness the quantum nature of electrons in solids. In this context, we are currently focusing on the topics below:

(1) Quantum transport in graphene and 2D materials
(2) 'Designer' electronic heterostructures and interfaces
(3) New topological states of matter

More details can be found at http://www.physics.hku.hk/~dkkilab/

(3) Novel Optical Properties of Semiconductor Nanostructures (***S.J. Xu***)

Optical properties including nonlinear optical properties, electronic structures, electron-phonon interactions, ultrafast phenomena, phonon and defect states in new semiconductor nanostructures such as self-assembled quantum dots, nanocrystals and new two-dimensional transition metal dichalcogenides are our current research interests. In addition, optoelectronic device applications of the semiconductor nanostructures are also our research interest. The materials being investigated by us include III-nitrides, SiC, traditional III-V and II-VI compound semiconductors as well as new 2D transition metal dichalcogenides. The laboratory has been already equipped by variable-temperature (4.2 K-300 K) photoluminescence system, scanning confocal micro-Raman image/spectroscopy system, variable-temperature (10 K-330 K) broadband (200 nm-1700 nm) emission/absorption/reflection spectroscopy, pump-probe based ultrafast (sub-ps) and gated integrator + boxcar averager based (20 ns to ms) time-resolved photoluminescence system, and newly-established low-temperature magneto-photoluminescence spectroscopy with super high spectral resolution. Currently, a pump-probe based fs laser source + scanning confocal microscopy system is being implemented by us, which enables us optically investigate ultrafast quantum processes and even imagine such processes occurring in individual semiconductor nanostructures.

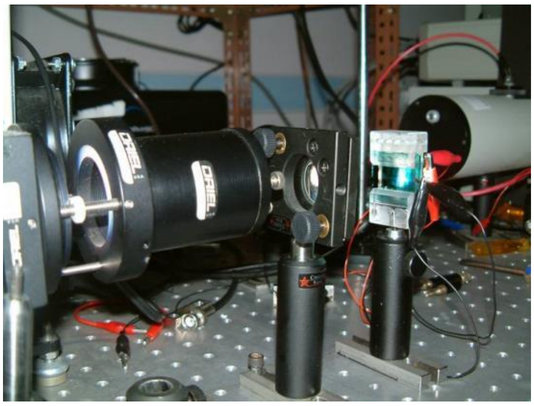
Further information of the group can be found at
http://www.physics.hku.hk/~laser

3. Materials Science

Academic staff: ***Prof. A.B. Djurišić***
Dr. C.C. Ling
Prof. M.H. Xie

The material science group conducts researches of various materials in the form of thin films and nanostructures. Examples include perovskite transition metal oxides, organic-inorganic halide perovskites, transition metal dichalcogenides, wide bandgap semiconductors (ZnO and GaN, for example), topological insulators, organic and inorganic nanocomposites. The techniques involved include various high vacuum deposition systems (e.g., sputtering, thermal and e-beam evaporation, pulse laser ablation, chemical vapor deposition, and molecular-beam epitaxy), low temperature and high B field measurement facility, x-ray and electron diffraction, scanning probe microscopy, photoelectron and Auger electron spectroscopy, temperature dependent Hall, IV and CV measurements, UV/Vis/NIR spectrometers, etc.

(1) Optoelectronics and Nanomaterials (***A.B. Djurišić***)



The research activities include fabrication and characterization of organic and organic/inorganic optoelectronic devices (organic light emitting diodes and solar cells), as well as fabrication and characterization of wide band gap semiconductor nanostructures. The laboratory is equipped with fume cupboards, tube furnaces, spin-coater, two thermal evaporators for fabrication of optoelectronic devices, and E-beam/sputtering deposition system, while characterization facilities include UV/Vis/NIR spectrometers for characterization of light emitting diodes and experimental setups for power conversion efficiency and external quantum efficiency measurements for solar cells. The study of optoelectronic devices aims at improving the understanding of the operating principles and processes taking place at interfaces. The obtained results are then used for fabrication of devices with improved performance. The study of wide band gap nanostructures includes comprehensive investigation of influence of the fabrication conditions on structural and optical properties of the nanostructures, and exploring their possible use in energy and environmental applications.

(2) Defects characterization and engineering of functional materials (***C.C. Ling***)

The current focused interests of the Material Physics Laboratory include:

(1) Defects in semiconductors: characterizations and identifications, defects influence on materials electrical, optical and magnetic properties, defect control, defects at semiconductor junctions;

(2) Electrical and optical properties of semiconductor system: deep level transient spectroscopy, temperature dependent Hall measurement, IV and CV measurements, luminescence spectroscopy;

(3) Positron annihilation spectroscopic study of vacancy type defects: These research activities are performed with the positron beam line located at the electron LINAC ELBE, Helmoltz Zentrum Dresden Rossendorf, Germany.

(4) Defects in functional oxides and wide band-gap materials: Tailoring electrical, optoelectronic, and magnetic properties of these materials via defect engineering.

(3) Experimental Surface Science (***M.H. Xie***)

The surface science laboratory aims at understanding the processes and properties that occur at the boundary of materials — surface.

Current researches focus on the growth and surface characterizations of low-dimensional materials, such as transition-metal dichalcogenides and their hetero-structures.

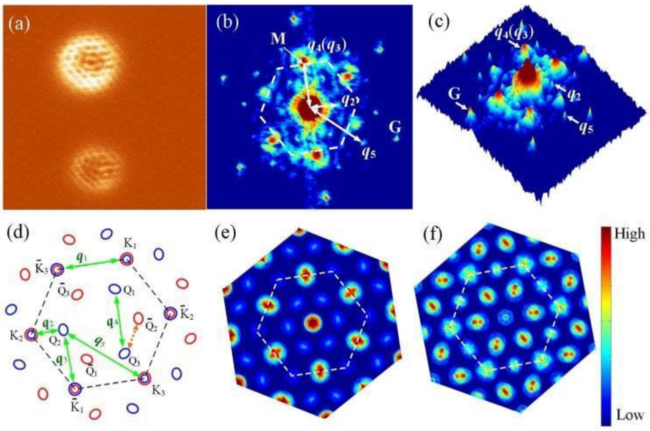


Diagram showing Intervalley Quantum Interference in epitaxial WSe_2 Monolayer

We carry out molecular-beam epitaxy (MBE) and surface studies of ultrathin layers

MBE is one of the most versatile techniques to grow materials with precise control. It allows fabrication of artificial structures by combining different materials to form the so-called "quantum wells" and "superlattices". Quantum effects and new concepts in material sciences are thus explored for modern device applications. By using STM/S and UPS, we characterize the atomic and electronic structures of film surfaces. The latter are important for the understanding various quantum effects at atomic scale.

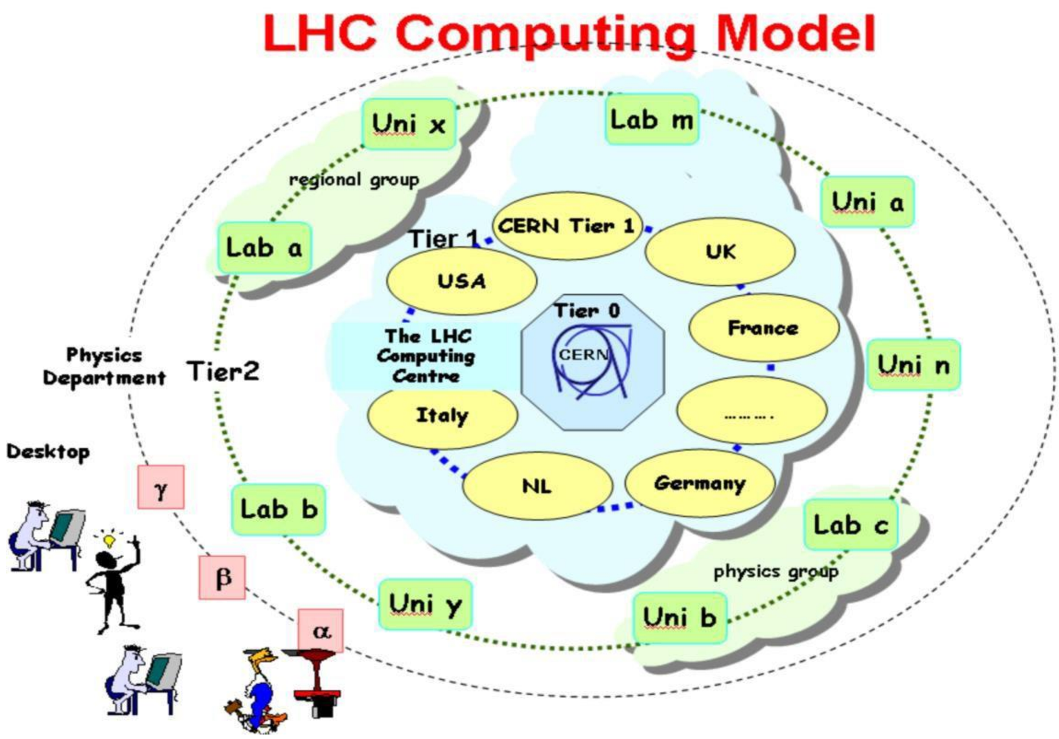
Experimental Nuclear and Particle Physics group:

1. Facilities

(1) High Energy Particle Physics Laboratory (***Y.J. Tu***)
A joint consortium for fundamental physics of the University of Hong Kong, the Chinese University of Hong Kong, and the Hong Kong University of Science and Technology, was formed in 2013. Under this umbrella, a Hong Kong cluster formally joined the ATLAS experiment at the Large Hadron Collider in June 2014. One of the missions led by the Hong Kong cluster is to build up a Tier-2 (and Tier-3) computing center in Hong Kong, which is expected to play an important role in serving both the LHC physics community and the local scientific and engineering community. The center is designed to have 1000

processing cores and 1 petabytes of disk space.

The laboratory is the part of the Tier-2 (and Tier-3) computing center for analyzing data collected by the ATLAS experiment at the LHC in CERN. The lab has access to the Worldwide LHC Computing Grid, which is the world's largest computing grid.



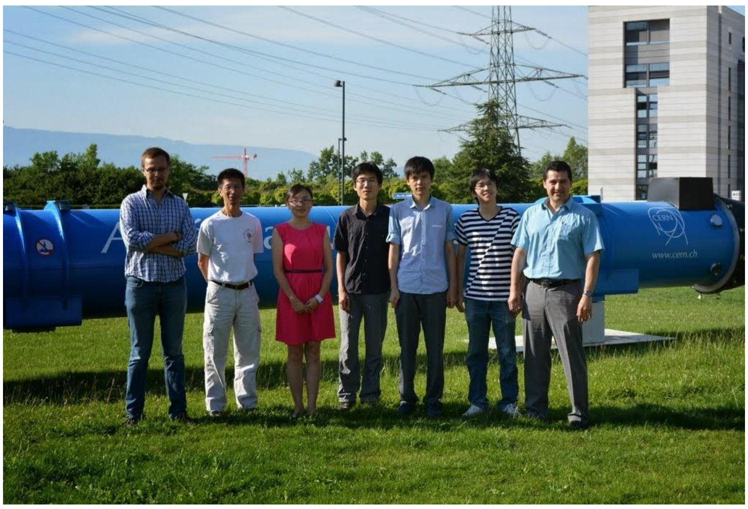
(2) Nuclear Physics Laboratory (***J.H.C. Lee***)
A cutting-edge Gamma-ray detector array and charged particle detector array, based on international collaborations, will be developed to achieve high-efficient and high-resolution measurements for the studies of nuclear structure. The arrays are designed for easy configuration and full integration with other devices to meet the detection requirements of specific major experiments, which will be performed in the Radioactive-Isotope Beams facilities worldwide such as RIKEN (Japan) and NSCL/FRIB (United States).

2. Experimental High Energy Particle Physics

Academic staff: Dr. Y.J. Tu

Dr. Tu works in experimental particle physics where the goal is to understand fundamental particles and their interactions. The startup of the Large Hadron Collider (LHC), the world's largest and highest-energy particle accelerator, in 2009 opened up a new era at the high energy frontier. The unexplored energy domain of the LHC provides unique opportunities to answer fundamental questions in particle physics, such as the cause of electroweak symmetry breaking, the mass origin of particles in the Standard Model, the generation of baryon asymmetry in the Universe and the properties of dark matter. Exploring these topics could dramatically improve our understanding of nature. The recent observation of the Higgs boson in the ATLAS and the CMS experiments represents one such success. In view of this remarkable progress, the next several years will be a critical and significant period for the field development of the HEP.

With strong support from the member institutions of the Hong Kong Joint Consortium for Fundamental Physics and the Research Grants Council, Hong Kong is now participating in the LHC ATLAS experiment. The Hong Kong particle physics group is involved in several projects including searching for supersymmetric particles, measuring the Higgs property and searching for exotic heavy gauge bosons. The group is also responsible for software and hardware upgrades: software development for muon reconstruction and testing the TDS electronic chip for the New Small Wheel of the muon detector.



A photo showing the 7 current members of Dr. Tu's group.

3. Experimental Nuclear Physics

Academic staff: ***Dr. J.H.C. Lee***

The experimental nuclear physics group is dedicated to the studies of the nuclear shell structure evolution and the nucleon correlations in nuclei. The experimental techniques include direct reactions, in-beam gamma spectroscopy and beta-decay spectroscopy. The state-of-the-art gamma-ray detector array and charged particle detector array will be constructed at the University of Hong Kong in collaboration with RIKEN (Japan) and IPN-Orsay (France). Both arrays are portable with fully integrable capability to the detection systems at the present facility RIKEN (Japan) and in the future-upgraded accelerated-based laboratories worldwide such as NSCL/FRIB (United States) and Spiral2 (France).

Theoretical and Computational Condensed Matter group:

Academic staff: ***Prof. S.Q. Shen***
Prof. J. Wang
Prof. Z.D. Wang
Prof. W. Yao
Dr. S.Z. Zhang

Theoretical condensed matter physics is a very important area in physical sciences because not only it concerns with many fundamental subjects but also it has very wide and potentially important applications in material science, biophysical science, high technology, and even economy and finance, etc. We have a very active research group in this field. Our current research interest includes:

(1) strongly correlated electron systems;

(2) topological matters;

(3) quantum materials;

(4) quantum computing;

(5) quantum magnetism;

(6) spintronics and valleytronics;

(7) quantum transport;

(8) semiconductor optics;

(9) interdisciplinary study of cold atom physics and condensed matter physics

2019/2020 POSTGRADUATE PROJECTS
DEPARTMENT OF PHYSICS
THE UNIVERSITY OF HONG KONG

The following M.Phil./Ph.D. projects are available in 2019/2020 academic year. Students are encouraged to contact their prospective supervisors directly to obtain the further detailed information of the project. We also welcome students to visit our laboratories and research facilities.

Full-time MPhil and PhD students who hold a first degree with second-class honours first division (or equivalent) or above are normally considered eligible to receive a Postgraduate Scholarship (HK$16,660 per month) during the normative study period. This year we expect to admit a large number of postgraduate students. Students please visit the homepage of HKU graduate school at www.hku.hk/gradsch/ and get the information as well as application forms there.

For other details, please contact Prof. X.D. Cui (Tel. 2859 8975, email address: xdcui@hku.hk), Department of Physics, The University of Hong Kong, Pokfulam Road, Hong Kong.

SPECIFIC RPG RESEARCH PROJECTS AVAILABLE WITHIN THE DEPARTMENT OF PHYSICS

Atomic and Quantum Physics group:

1. Quantum Computing and Information Theory

Project HFC01: Quantum Information Theory
Supervisor: Prof. H.F. Chau

A lot of activities are going on in the field of quantum information theory recently. This field is about the study of quantum mechanical system from an information theoretical point of view. We ask questions like what information can be stored, transmitted and extracted using quantum mechanical systems. In this theoretical Ph.D. project, one is expected to focus on the tradeoff between different resources in quantum information processing such as energy, time, space and communication. Knowledge in the following fields is required: quantum mechanics in Sakauri level, quantum optics, statistical mechanics, coding theory, classical information theory, computational complexity, functional analysis and algebra. Although it is not necessary for you to have all the above subjects, but the more you know them the better prepared you are. I am looking for a hardworking, self-motivated individual who is both physically and mathematically sound to take up the challenge.

Project ZDW01: Quantum Computation
Supervisor: Prof. Z.D. Wang

Quantum computers, based on principles of quantum mechanics, could efficiently solve certain significant problems which are intractable for classical computers. For the past several years, they have become a hot topic across a number of disciplines and attracted significant interests both theoretically and experimentally. In physical implementation of quantum computation, a key issue is to suppress a so-called decoherence effect, which can lead to major computing errors. A promising approach to achieve built-in fault tolerant quantum computation is based on geometric phases, which have global geometric features of evolution paths and thus are robust to random local errors. In this project, it is planned to first study geometric phases in relevant physical systems and then to design geometric quantum gates. Physical implementation of these gates in solid state systems will be paid particular attention.

2. Theoretical Atomic Physics and Degenerate Quantum Gases

Project SZZ01: Spin dynamics in ultracold atomic gases

Supervisor: Dr. S.Z. Zhang

Recent experimental advances in the manipulation of ultra-cold alkali atomic gases have made it possible to engineer synthetic gauge fields and spin-orbit interaction for neutral atoms. Together with the possibility of modifying the inter-atomic interactions using Feshbach resonance, this has led to multitude of possibilities in the investigations of interacting quantum many-body systems. It has been suggested that the new system might support exotic excitations like Majorana fermions or exhibit high transition temperature into the superfluid state. In this project, we will investigate a few aspects of the system, including its novel spin resonance and spin diffusion behavior, which is also likely to shed light on the analogous problems in solid state physics.

Astronomy and Astrophysics group:

Project KSC01: Gamma-ray Pulsar

Supervisor: Prof. K.S. Cheng

Pulsars are rapidly spinning and strongly magnetized neutron stars. They behave like monopolar generators, for young pulsars, whose potential drop in the pulsar magnetosphere can exceed 10^{15} volts. Such high potential drop can accelerate charged particles to extremely relativistic speed and emit photons with energies higher than 10^9 eV when these charged particles are forced to move along strong curved magnetic field lines in the pulsar magnetosphere. These high energy photons play very important role in understanding the electrodynamics of the pulsar magnetosphere. In fact, most pulsars except very young pulsars like the Crab pulsar, whose gamma-rays can directly escape from the emission region with very little attenuation, which can provide direct probe to the properties of acceleration regions including magnetic field structure, local electric field strength, charged density, current etc. Pulsars are only known steady gamma-ray point sources in our galaxy. However, before 2008 only 7 pulsars are confirmed to be gamma-ray pulsars, which can only provide very limited information on studying the properties of gamma-ray pulsars. After the launched of a very powerful gamma-ray satellite called "Fermi" at the end of 2008, the situation has completely changed. In less than one year Fermi has already detected 46 gamma-ray pulsars and in a little bit longer than two years observation 70 gamma-ray pulsars are found. It is interesting to note that many radio pulsars with similar parameters as those detected gamma-ray pulsars have not been detected by Fermi satellite. There are six of these non-Fermi detected young pulsars are detected in hard X-rays and soft gamma-rays and they are called soft gamma-ray pulsars. To explain the nature of soft gamma-rays and discover more pulsars in this category is a meaningful subject as a MPhil/PhD topic. In addition, some pulsars are located in binaries. The interactions between the pulsar and its companion star can produce a time dependent multi-wavelength emission. Electrons can be accelerated to extremely relativistic speed in the shock formed by the interaction between the pulsar wind and the stellar wind. Inverse Compton scattering between the shocked electrons and the stellar photons can produce multi-GeV photons. Searching for new gamma-ray binaries and transient gamma-ray emission from pulsar binaries are also possible topics for MPhil/PhD students.

Project LXD01: Simulations of Black Hole Accretion Disks and Jets

Supervisor: Dr. L.X. Dai

Black hole accretion is the central engine that powers the most luminous sources in the universe, such as quasars and X-ray binaries. Besides radiation, winds and jets are also produced in black hole accretion. The feedback carried by radiation, winds and jets can provide feedback to the hosting galaxy and influence its formation and evolution. Besides powering persistent sources, black hole accretion can also power transient flares such as tidal disruption events and gamma-ray bursts (including the ones produced in neutron star mergers). We study the physics of black hole accretion and emission using general relativistic numerical codes. In particular, we are very interested in studying a class of accretion called super-Eddington accretion, which is believed to happen in high-redshit quasars, tidal disruption events and ultra-luminous X-ray sources. This class of accretion is under-investigated, yet it is important for understanding the formation of massive black holes and galaxies in the early universe. A lot of progress has been obtained lately on the observational front, and theoretical studies are much needed to complement the fast progress in observations. MPhil/PhD projects on this topic include: 1) design and perform new general relativistic simulations of (super-Eddington) accretion flow; 2) analyze previous simulation data and carry out radiative transfer analysis; 3) comparing data to observations (if the student is also interested in working on / is familiar with observations).

Remark: Dr. Dai is expected to join the Department of Physics, HKU in mid-2019. To discuss the research project with Dr. Dai, please contact her by email at lixindai@hku.hk.

Project MHL01: Dynamics and Origins of Planetary Systems
Supervisor: Dr. M.H. Lee (Adjunct with Department of Physics)

Extrasolar planet searches have now yielded thousands of planets around other stars. The discoveries include planetary systems with two or more detected planets and planets in binary star systems. Multiple-planet systems and, in particular, those with planets in or near orbital resonances provide important constraints on the formation and dynamical evolution of planetary systems. We are investigating the current dynamical states and origins of resonant planetary systems and planets in binary star systems. In addition, there are projects related to the formation and dynamical evolution of the planets and their satellites in our Solar System. Prior knowledge of classical mechanics and numerical methods would be an asset.

Project JJLL01: Star Formation in Giant Elliptical Galaxies at the Centers of Galax Clusters
Supervisor: Dr. J.J.L. Lim

Galaxy clusters are immersed in hot X-ray-emitting gas that constitutes the bulk of their baryonic mass. In relaxed clusters where the density of this gas increases rapidly towards the cluster center, the hot gas around the center is predicted to cool rapidly so as to produce an inflow of relatively cool gas (i.e., an X-ray cooling flow). Indeed, relaxed clusters exhibit relatively cool X-ray gas in their cores, and preferentially exhibit relatively large quantities of gas at even lower temperatures. Relativistic jets from the central giant elliptical galaxy, however, can churn and reheat the cool gas, complicating our understanding of the nature of this gas. Our work focuses on determining the origin, excitation and therefore physical properties, and fate of relatively cool gas in the giant elliptical galaxies at the center of galaxy clusters; as well as the recent history of star formation in these galaxies, and the manner in which their AGNs are fueled.

Project JJLL02: Astrophysical Applications of Gravitational Lensing
Supervisor: Dr. J.J.L. Lim

When did gas in bodies comprising primarily dark matter first turn into stars, making galaxies visible for the first time? How did the different stellar components of galaxies – in the case of galaxies like our own, central bulge, disk (in which our Sun resides), and surrounding halo – assemble over time? How did their supermassive black holes grow over time? What is dark matter, which dominates not only matter in galaxies but also matter in the space between galaxies? To address these questions, Dr. Lim, his students, and his collaborators use gravitational lensing by galaxy groups or clusters as cosmic lenses to magnify background galaxies. In this way, we able to detect and study distant, and therefore young, galaxies that would otherwise be too dim to detect and too small to resolve. We can even determine, through geometry, the distances to these galaxies, the redshifts of which are often difficult to measure because these galaxies are so faint. The manner in which the number of these galaxies change over time allows us to test predictions by different forms of dark matter. Through gravitational lensing, we also are able to study the properties of the lensing clusters, allowing us to weigh supermassive black holes in cluster member galaxies, and to search for substructure in dark matter as predicted in some models. We continue to develop different exciting astrophysical applications of gravitational lensing.

Project CYN01: Particle Acceleration and Transport in Pulsar Wind Nebulae

Supervisor: Dr. S.C.Y. Ng

Pulsars lose most of their rotational energy through relativistic particle winds. The consequent interactions with the ambient medium result in synchrotron bubbles known as wind nebulae (PWNe). These sources are important cosmic ray accelerators in the Galaxy. We will study the radio and X-ray properties of PWNe using observations taken with the EVLA, ATCA, Chandra, XMM-Newton, and Fermi telescopes, in order to understand the acceleration and transport mechanism of cosmic rays.

Project QAP01: Late Stage Stellar Evolution

All the projects described below fall under the main topic of Late stage stellar evolution and exploitation of "The new Hong-Kong/AAO/Strasbourg multi-wavelength and spectroscopic Planetary Nebulae database: HASH"

Supervisor(s) for all projects include:

Prof. Q.A. Parker, Prof. A.Zijlstra (Hung Hing Ying distinguished visiting professor), Dr. Claire Lykou, Dr. Andreas Ritter, Dr Xuan Fang

Some scientific background to the projects listed below

Stars, the key building blocks of all galaxies, are born in collapsing gas clouds, live their lives as nuclear fusion reactors, and eventually die. Massive stars live fast and die young, exploding as supernovae after only a few million years. However, the vast majority of stars have lower mass and may live for billions of years. PNe derive from stars in the range ~1-8 times the mass of the Sun, representing 90% of all stars more massive than the sun. PNe form when only a tiny fraction of unburnt hydrogen remains in the core. Radiation pressure expels much of this and the hot stellar core can shine through. In a few thousand years the effective temperature rises from ~5000 degrees to as high as 250,000 degrees before falling as the core fades and contracts to a so-called White-Dwarf (WD). The radiation field ionizes the final ejected shell which is called a PN as well as the faint halo of material ejected at earlier times, *providing a visible fossil record of the entire mass loss process*. PNe have nothing to do with planets but acquired this name because the glowing spheres of ionized gas around their hot central stars resembled planets to early observers.

The study of PNe is crucial to understand both late stage stellar evolution, and the chemical evolution of our entire Galaxy. The ionised shell exhibits strong and numerous emission lines that are excellent laboratories for plasma physics. PNe are also visible to great distances where their strong lines permit determination of the size, expansion velocity and age of the PN, so probing the physics and timescales of stellar mass loss. We can also use them to derive luminosity, temperature and mass of their central stars, and the chemical composition of the ejected gas. Their radial velocities can trace a galaxy's kinematic properties and test whether the galaxy contains a substantial amount of dark matter. The kinematic properties of PNe in galaxy halos also give strong constraints both on the mass distributions and formation processes of giant elliptical galaxies. The PN formation rate also gives the death rate of lower mass stars born billions of years ago and they directly probe Galactic stellar and chemical. Their complex shapes provide clues to their formation, evolution, mass-loss processes, and the shaping role that may be played by magnetic fields, binary central stars or even massive planets. As the central star fades to a WD and the nebula expands, the integrated flux, surface brightness and radius change in ways that can be predicted by current hydrodynamic theory. *PNe are thus powerful astrophysical tools, providing a unique window into the soul of late stage stellar evolution.*

We are also in a golden age of PN discovery and Prof Parker and his team have lead programs that have more than doubled the totals accumulated by all telescopes over the previous 250 years. The scope of any future large-scale PNe studies, particularly those of a statistical nature or undertaken to understand true PNe diversity and evolution should now reflect this fresh PN population landscape of the combined sample of ~3500 Galactic PNe now available. Such studies should take into account these recent major discoveries and the massive, high sensitivity, high resolution, multi-wavelength imaging surveys now available across much of the electromagnetic spectrum.

Following this motivation we provide, for the first time, an accessible, reliable, on-line "one-stop" SQL database for essential, up-to date information for all known Galactic PN.
All the projects below will make use of and build on this world-leading new resource.

Project QAP01(a): The PNe luminosity function (LMC, SMC, Bulge and local volume)

This PNLF provides the co-eval brightness distribution of a population of PNe in a given system (such as an entire Galaxy). An exponential fit to the bright end cut off of the PNLF is a potent cosmological standard candle but how and why it works so well across all galaxy Hubble types is a mystery while the detailed form and features seen in various PNLFs (so called "Jaboby dips") are hard to interpret. Access to our highly complete PNLFs across 10dex in [OIII] magnitudes for the Bulge and LMC in particular offers strong opportunities to tackle these problems.

Project QAP01(b): PNe AGB haloes and the ejected mass budget

The main shells of PNe typically contain only ~0.1 Msun in ejected material while the residual core – on the way to becoming a white dwarf are only ~0.6Msun. However, the progenitor star may have had a mass of between one and up to 8 solar massess. The "missing mass" has been lost on the AGB and particularly post AGB and pre PNe phases of evolution. At least part of this is detectable in terms of so called AGB haloes. These can be extensive but of a surface brightness that could be 1/1000 times weaker than the main PN shell. Detailed study of such haloes especially in terms of abundances is currently lacking as is a proper understanding of where are the previously ejects mass is to be found.

Project QAP01(c): Morpho-kinematic modelling of PNe and insights in bipolarity

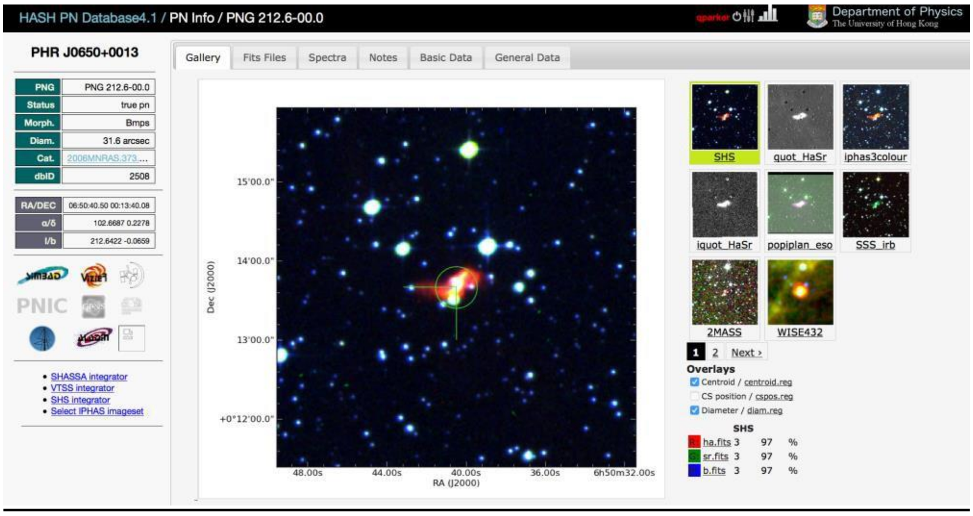
The advent of powerful integral field units (IFU) on major telescopes to perform areal point-to-point spectroscopy of resolved objects has enabled detailed 3-D data-cubes to be obtained. This has enabled both kinematic and line intensity maps to be produced for significant numbers of PNe for the first time. These data can be combined with morpho-kinematic modelling with sophisticated visualisation software such as SHAPE to permit the de-projection of 2-D PNe images into more accurate 3-D representations as matched and informed by the kinematic data available from the IFU data-cubes. More accurate determinations of true PNe morphologies can be obtained particularly for bi-polar PNe where the major axis might otherwise be poorly constrained and provide insights into connections between CSPN properties, nebular characteristics binarity and morphology.

Project QAP01(d): Central stars of PNe – discovery, description and diversity

Currently less than 25% of known PNe have unequivocally identified central stars (CSPN). The availability of significant new PNe samples, new wide field surveys and particularly access to new u-band imaging from VPHAS+ and UVEX promises to dramatically improve this number. It is the characteristics of these CSPN and possible binarity that directly affects the observed properties of the ionised nebulae. This project seeks to both discover new CSPN candidates and study their properties and diversity to inform our understanding of PN shaping, expansion and evolution.

Project QAP01(e): Abundances of planetary nebulae, Galactic gradients and the local group

Obtaining accurate abundances for PNe is a difficult enterprise. Very high S/N spectra are required for large numbers of faint emission lines in order to provide sufficient species to allow proper abundance estimates. So far only ~150 PNe have well determined abundances from a total population of over 3200 Galactic PNe. Most of these are also for the highest surface brightness PNe as these are the easiest to observe but they may not be representative of the underlying abundance patterns of most PNe. This project will attempt to improve this situation in terms of both available abundances and breadth of PNe sample selection. Results will be used to improve our understanding of nebula abundance variations as a function of PNe CSPN properties (mass and likely progenitor mass), environment and other variables.



A single page from the new HASH database of Planetary Nebulae – a powerful resource available to all these projects.

Project MS01: Studying the Universe using satellites
All the projects described below fall under the main topic of space science using satellites
Supervisor(s) for all projects: Dr. M. Su

We have access to some world leading space science facilities, including Chinese space station, Dark Matter Particle Explorer, CMB telescopes. We are also building our own satellites to do focused science, including X-ray telescopes, UV telescopes, gamma-ray detectors, microwave telescopes, and cosmic-ray detectors. A large range of projects are available from numerical simulation, hardware construction, data analysis, science forecast, data mining etc. Broadly speaking, if you are interested in using satellites or building your own ones, please talk to him.

Experimental Condensed Matter and Material Science group:

1. Experimental Condensed Matter

Project XDC01: Optical Properties in Emerging 2 Dimensional Materials
Supervisor: Prof. X.D. Cui

The emerging atomic 2D crystals offer an unprecedented platform for exploring physics in 2 dimensional systems. As the material dimension shrinks to atomically thin, quantum confinements and enhanced

Coulomb interactions dramatically modify the electronic structure of the materials from the bulk form and incur sophisticated consequences featuring strong electron-electron interactions and robust quasiparticle of excitons. We are to investigate physics properties in emerging 2D materials with emphasis in optical properties with semiconductor optics technique.

Project DKK01: Designing New Topological Quantum States in Artificial Interfaces and Superlattices

Supervisor: *Dr. D.K. Ki*

Topological states of matter represent the new class of materials that are characterized by their low-energy quasiparticles at the boundaries, such as Majorana Fermions in topological superconductors and non-Abelian anyons in even-denominator fractional quantum-Hall insulators. These states are under intense focus as they have exotic topological properties that are not only fundamentally interesting but also promise great potentials for realizing new types of device applications (*e.g.*, topological quantum computing). In this context, we will 'artificially design' the new topological states by creating atomically sharp interfaces between different 2D crystals where van der Waals interactions can engineer new properties on-demand. Examples include graphene-on-transition metal dichalcogenides (where the spin-orbit coupling—the critical element for realizing topological states—can be controlled) and multi-domain Moiré superlattices (where two topologically different states can be joined to reveal new effects). Having known that nearly hundreds of 2D crystals exist with diverse properties, we will further explore various possibilities that different combinations of these crystals may offer. This study will therefore expand the 'zoo' of topological materials available in the reality and bring us one-step closer to the realization of topological electronics.

Project DKK02: Exploring New Many-Body Physics at Zero-energy in Extremely Clean 2D Crystals

Supervisor: *Dr. D.K. Ki*

Electrons in solid interact with each other and studying the resulting many-body effects is one of the recurring main themes of condensed matter physics. Recently, atomically thin 2D crystals, such as graphene, have emerged as interesting material systems with novel electronic properties that can be tuned widely in the experiments. The objective of this project is therefore to take full advantages of such large experimental flexibilities to explore or engineer new many-body phenomena in these crystals. For this, we will realize extremely clean devices with various geometries (*e.g.*, suspended graphene devices with suspended dual-gates) and approach zero energy where the interactions become the strongest. The effects of particular interests are fractional quantum-Hall effect and spontaneous symmetry breaking in semimetallic 2D crystals, such as graphene and tungsten ditelluride (WTe_2).

Project SJX01: In-depth Investigation of Fundamental Optical and Optoelectronic Processes in Semiconductors and Luminescent Materials

Supervisor: Prof. S.J. Xu

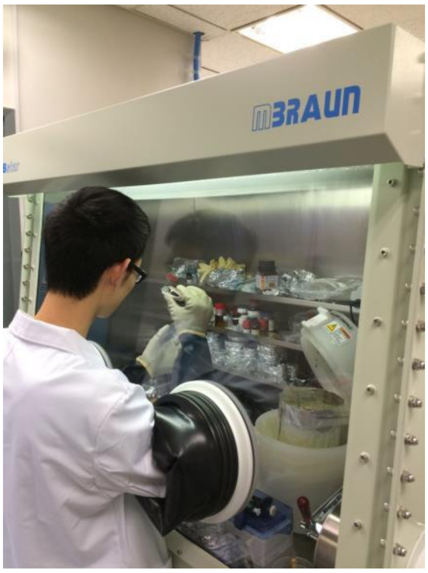
In this project, we employ a variety of optical spectroscopic techniques to get know more about some fundamental optical and optoelectronic processes occurring in semiconductors and luminescent materials, focusing on luminescence and energy transfer mechanisms inside the materials. We try to understand these complicated processes and phenomena in terms of a few simple principles.

2. Materials Science

Project AD01: Organic and Perovskite Optoelectronic Devices

Supervisor: Prof. A.B. Djurišić

Even though the present state-of-the-art realizations are still less efficient compared to the inorganic ones, the low cost production of large-area organic solar cells represents a great attraction of these devices and the feature of a greatly reduced fabrication cost adds significant impetus to research in this area. In particular, recent advances in organometallic halide perovskite solar cells have resulted in increasing interest in next generation solar cells based on organic materials. In spite of great interest for practical applications of organic materials and devices, there are still a number of unanswered questions concerning their fundamental properties and principles of operation. The objective of this project is to investigate the influence of doping, interface modifications and device architecture changes on the performance of solar cells. The objectives are to improve the device efficiency and stability, as well as develop devices on flexible substrates. Particular emphasis is placed on the development of novel perovskite materials for both LED and solar cells applications, and studies of the device degradation and improvement of the device stability. The student should have basic knowledge of optics and solid state physics. Some knowledge of chemistry would be beneficial.

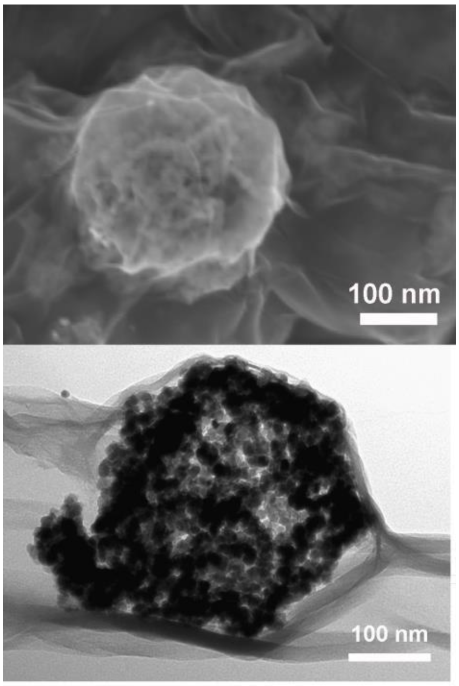


A PG student making a solar cell in a glove box

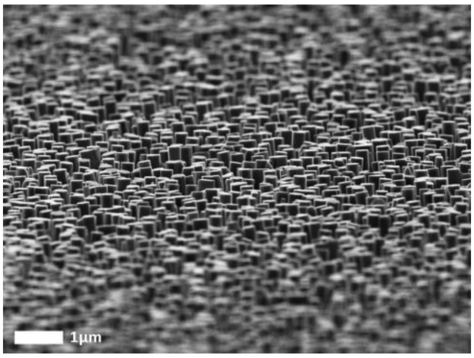
Project AD02: Wide Band Gap Nanostructures

Supervisor: Prof. A.B. Djurišić

Due to exceptional properties different from bulk materials, nanostructures of different semiconductors have been attracting increasing attention. The obtained morphology of the nanostructures and their optical properties are strongly dependent on the fabrication conditions. The objective of this work is to investigate the dependence of structural and optical properties of wide band gap (ZnO, TiO_2, SnO_2, CeO_2 and GaN) on the fabrication conditions. The fabricated nanostructures will be characterized using scanning electron microscopy (SEM), transmission electron microscopy (TEM), X ray diffraction (XRD), photoluminescence and photoluminescence excitation (PL and PLE). The project will involve extensive experimental work. The application of prepared nanomaterials in LEDs, solar cells, photocatalysis, catalysis, sensors, or Li-ion batteries (depending on the material chosen) will also be studied.



Electron microscopy image of graphene wrapped SnO_2 hollow sphere



SEM image of ZnO nano rod

Project CCL01: Room temperature ferromagnetism in ZnO related materials

Supervisor: Dr. C.C. Ling

Dilute magnetic semiconductor (DMS) is a class of material receiving extensive attention because of its potential application spintronic, which is a new class of device based on the degree of freedom of the electron spin. For practical device applications, the Curie temperature of the DMS material has to be above the room temperature. There was theoretical and experimental results showing that room temperature ferromagnetism (RTFM) in ZnO:Tm (Tm=transition metal) could be stabilized by electron and hole mediations. It is interesting to notice that RTFM can also be achieved in non-magnetic element doped (like Cu) ZnO and undoped ZnO, which is proposed to be associated with the intrinsic defects (like V_O and V_{Zn}). However, the origins of the observed room temperature ferromagnetism are controversial and the physics is far from completely understood. The present project aims to fabricate non-magnetic element doped ZnO with RTFM and to understand the physics and the origin of the RTFM. It is also to achieve electric bias modulated magnetization in the corresponding device structure.

Project CCL02: High dielectric constant oxides via defect engineering

Supervisor: Dr. C.C. Ling

Materials with high dielectric constant and low dielectric loss are essential for the miniaturization of capacitive microelectronic devices, and also have the potential in compact high-density energy storage applications. Colossal dielectric constant $>10^4$ with low dielectric loss <0.1 have been acheived in acceptor-donor co-doped oxides, and was speculated to be associated with the electron-pinning defect complex. The physics and the action of the electron-pinning defect is totally unclear. The current project aims to fabricate oxide materials with high dielectric constant and low dielectric loss, to study the physics of the colossal dielectric constant, as well as to explore the identity and the action of the electron-pinned defect.

Project CCL03: Zn vacancy cluster and complex in Zinc Oxide Materials

Supervisor: Dr. C.C. Ling

Zinc oxide is a wide band gap II-VI semiconductor with a band gap of 3.4 eV. Because of its excellent electrical and optical properties, it is a potential material for a variety of applications in devices including ultra-violet optoelectronic, spintronic, photovoltaic, sensor and transparent conductive electrode. Although defects play crucial role in determining the material electrical and optical properties and there are studies involving simple point defects, not much is known in defect complex and vacancy cluster. Despite that majority of device applications involves ZnO thin film, relatively few defect studies were performed in particular in thin film focusing in optoelectronic applications. This project aims to study Zn-vacancy cluster and complex in ZnO films grown by pulsed laser deposition (PLD), focusing on how they influence the materials' electrical and optical properties as well as on manipulating the film electrical and optical properties via the defect engineering approach.

Project MHX01: MBE Growth and Surface Studies of Two-Dimensional Materials

Supervisor: Prof. M.H. Xie

Two-dimensional (2D) materials exhibit many interesting properties, which are attracting extensive research attentions in recent years. Examples include monolayers of transition metal dichalcogenides (TMDCs) and phosphorene, which hold potentials for nano electronic, optoelectronic, spin- and valley-tronic applications. In this project, ultrathin films of 2D materials and their heterostructures will be fabricated by molecular beam epitaxy and characterized by the surface tools, such as electron diffraction (LEED/RHEED), scanning tunneling microscopy and spectroscopy (STM/S), ultraviolet photoemission spectroscopy (UPS), etc.

Experimental Nuclear and Particle Physics group:

1. Experimental High Energy Particle Physics

Project YJT01: Searching for Supersymmetry at the Large Hadron Collider

Supervisor: Dr. Y.J. Tu

The Standard Model (SM) has worked beautifully to predict and explain various experimental results. However, the SM has many open questions thus it is believed not a complete theory. Among many models, supersymmetry is the most promising candidate for new physics. SUSY predicts a partner particle for each particle in the SM. These new particles would solve a major problem in the SM, hierarchy problem - The masses of the W, Z particles are 1016 smaller than that of the Planck mass. SUSY also provides good dark matter candidate and a solution to the baryon asymmetry of the universe. We will search for super particles decaying into SM leptons plus missing transverse energy. Such experimental signatures have rich interpretations in various new physics scenarios, e.g. in SUSY, when the charginos and neutralinos (mixtures of superpartners of the gauge bosons and the Higgs bosons) produced via electroweak interactions and decay into the W, Z or H plus the lightest neutralino or gravitino (Dark Matter candidate), where W, Z further decay into leptons and Higgs decays invisibly, the final state will contain leptons plus missing transverse momentum. The same final states also appear in the slepton decays, which are superpartners of the SM leptons. Therefore, the projects are not only key searches for SUSY, but also good probes for Dark Matter and beyond the SM Higgs physics.

Project YJT02: Searching for Higgs Beyond the Standard Model at the Large Hadron Collider

Supervisor: Dr. Y.J. Tu

The Standard Model (SM) has worked beautifully to predict and explain various experimental results. However, the SM has many open questions thus it is believed not a complete theory. Among various new theories, models with an extended Higgs sector are extensively existing and well motivated, such as SUSY, Two Higgs Doublet Model (2HDM) and Composite Model. The group will work on searching for Higgs predicted in physics beyond the Standard Model. The focus will be in the scenario where such Higgs decays into top quarks.

2. <u>Experimental Nuclear Physics</u>

Project JHCL01: Spectroscopy of neutron-rich Ca isotopes
Supervisor: Dr. J.H.C. Lee

We will perform in-beam gamma spectroscopy measurements of ^{56}Ca and ^{53,} ^{55}Ca at RIBF facility (RIKEN) via one nucleon knockout reactions, with the use of MINOS device coupled with DALI2 gamma spectrometer and ZeroDegree Spectrometer. The measurement of ^{56}Ca extends the systematic studies of the energies of $2_1{}^+$ and other low-lying states beyond ^{54}Ca (N=34). The location of $2_1{}^+$ energy of ^{56}Ca gives a direct measure of the difference between 0^+ and 2^+ two-body matrix elements in the $f_{5/2}{}^2$ which has not yet been determined. This new experimental data is also valuable in accessing the accuracy of the calculated $E_x(2_1{}^+)$ of ^{56}Ca using different effective interactions in shell-model the theories and ab-initio calculations. The spectroscopy of ^{53,55}Ca could reflect the nature of the N=34 shell closure and the contribution of the $g_{9/2}$ state. The single-particular properties (angular momentum and spectroscopic factor) of the low-lying states will be extracted from the cross sections and parallel momentum distributions of the residues.

<u>Theoretical and Computational Condensed Matter group:</u>

Project GC01: Spin-orbit-coupled correlated materials
Supervisor: Dr. G. Chen

The discovery of topological insulator and semimetal has pushed the spin-orbit coupling to the forefront of modern condensed matter physics. As we know, topological insulator and semimetal with protected surface states are non-interacting electron band structure physics. It is naturally to understand the effect of the correlation on top of the non-trivial band structure topology. Besides this theoretical motivation, the 4d/5d transition metal compounds with iridium, osmium, even 4f rare-earth compounds are natural material systems to explore such phenomena. This is a field where both theoretical ideas and experimental efforts converge. In spin-orbit-coupled correlated material, we have discovered and/or proposed novel quantum phases of matter and the unconventional multipolar orders. We will continue to explore the rich and fascinating behaviors of quantum materials with both strong spin-orbit coupling and strong correlation.

Project GC02: Frustrated and quantum magnetism
Supervisor: Dr. G. Chen

Frustration in condensed matter physics usually means competing interactions that cannot be optimized simultaneously. When frustration meets with quantum mechanics in quantum many-body systems, it not only enhances the effect of the quantum fluctuations but also enriches the quantum phenomena. Various exotic and quantum phases such as the quantum spin liquid with emergent excitations and gauge structures are proposed.

In last 1-2 decades, the field of frustrated quantum magnets has grown rapidly. Many quantum magnets have been discovered, studied and characterized. Frustration often but not always comes in the form of geometrical frustration. That is the reason that many existing frustrated quantum magnets come in the form of geometrical lattice such as triangular, kagome, FCC, pyrochlore, hyperkagome lattices. Our work is to provide physical and realistic models to describe the interaction between the microscopic degrees of freedom, and give explanation and prediction of interesting experimental phenomena.

Project GC03: Ultracold atoms on optical lattices
Supervisor: Dr. G. Chen

Ultracold atomic and molecular systems provide another but very different fertile ground for looking for novel quantum phenomena. The most distinct and exciting part in this field is the tunability of experimental parameters and the new probing methods (that are special to the atomic systems). Both (especially the former) are often very difficult in a regular solid state system. For example, magnetic or optical

Feshbach resonance can vary the effective interaction from weak to strong in a continuous fashion. A well-known application is the unitary boson or fermion gas with infinite scattering length that will be discussed in the next section. The SU(N) Heisenberg model and Hubbard model are a very good example of quantum many- body problems that can be realized in ultracold atomic and molecular systems but are almost impossible in solid state systems. We propose an novel chiral spin liquid phase for a SU(N) Hubbard model on an optical lattice. In cold atom systems, new experimental probes (like noise correlation, quenched measurement, etc) are available. We want to understand the experimental consequence of the various quantum phases in these new measurements. In general, we are interested in the many-body problems that can be realized in cold atom systems and also support interesting experimental consequences.

Project SQS01: Novel Topological States of Quantum Matter
Supervisor: Prof. S.Q. Shen

A topological insulator is a novel topological state of quantum matter which possesses metallic edge or surface states in the bulk energy gap. The edge or surface states consist of an odd number of massless Dirac cones, and result in quantum spin Hall (QSH) effect, which is analogous integer quantum Hall effect. The physical properties of this kind of insulator are unchanged by smooth modifications to their geometry and are robust against non-magnetic impurities and interactions. The edge states and surface states are robust against the nonmagnetic impurities. The primary objective of this proposal is to explore novel topological quantum materials, and to investigate quantum transport in topological insulators, metals and superconductors. Quantum transport and quantum phenomena will be investigated in various forms for the purpose of application.

Project CJW01: Topological Phases of Matter with Strong Correlation
Supervisor: Dr. C.J. Wang

Topological phases of matter have gained lots of attention due to their richness and wide connections to other fields of physics. In particular, in certain systems, there exist so-called non-Abelian anyon excitations that can be used for fault-torrent quantum computation. While topological phases with weak correlation can be well understood through conventional mean field theories, it requires many new concepts and tools to understand strongly correlated topological phases. We work on two general aspects of topological phases: (i) fundamental theories of topological phases, in particular in higher dimensions and (ii) search of anyons in experimental systems such as fractional quantum Hall liquids and quantum spin liquids. More specifically, we will investigate the deep interplay between symmetry and topology --- two key fundamental concepts in modern physics --- in various quantum systems. Also, we study quantum transport properties for detecting experimental topological systems. When it comes to realistic models, we also plan to perform numerical studies, e.g., using algorithms based on tensor network states.

Project JW01: First Principles Calculation of Quantum Transport through Nanostructures

Supervisor: Prof. J. Wang

Currently we are interested in the field of nano-scale physics and technology. It has been demonstrated in several laboratories that many important quantum interference features such as the conductance quantization are observable for atomic wires at the room temperature. As a result, atomic device has important potential device applications and can be operated in room temperature. As theoreticians, we investigate quantum transport through atomic and molecular scale structures where a group of atoms are electrically contacted by metallic leads. Using Density functional analysis and the non-equilibrium Green's function method, we study conductance, capacitance, current-voltage characteristics, and other molecular device characteristics.

Project ZDW02: Topological Metals/Semimetals and Quantum Simulations

Supervisor: Prof. Z.D. Wang

Topological quantum materials have significantly intrigued research interest. Investigations of the gapless and gapped systems pave the way for discovering new topological matter. Recently, our group at HKU established a unified theory for topological gapless systems, including novel metals and semimetals consisting of topological Fermi surfaces. Based on our basic theory, we plan to explore various exotic quantum properties of topological metals/semimetals for different dimensions and their quantum simulations with artificial systems.

Project WY01: Valley-spintronics in 2D materials and their van der Waals heterostructures

Supervisor: Prof. W. Yao

A trend in future electronics is to utilize internal degrees of freedom of electron, in addition to its charge, for nonvolatile information processing. Suitable candidates include the electron spin, and the valley pseudospin. The latter labels the degenerate valleys of energy bands well separated in momentum space. 2D materials, in particular the group-VI transition metal dichalcogenides, offer an exciting platform to explore valleytronics and spintronics. Van der Waals stacking of the 2D materials further provide a powerful approach towards designing quantum materials that can combine and extend the appealing properties of the building blocks. In this project, we will investigate the valley dependent physics in a group of 2D materials, namely, group VI transition metal dichalcogenides. We will look into the possibility of controlling valley dynamics in these materials and their van der Waals heterostructures by external magnetic, electric and optical fields.

POSTGRADUATE COURSES OFFERED BY DEPARTMENT OF PHYSICS, HKU

PHYS8950 Postgraduate Seminar

Course Objectives:
This course aims to initiate students into research culture and to develop a capacity for communication with an audience of varied background.

Course Contents & Topics:
Students will be required to attend and take part in a specified number of seminars organized by Department of Physics. Students will be also required to follow a course of independent study on a topic to be selected in consultation with his/her supervisor, and to give a presentation of 30-40 mins duration.

PHYS8001 Selected Topics in Computational Modelling and Data Analysis in Physics

Course Objectives:
This course aims to familiarise students with research oriented techniques in computer modelling and data analysis.

Course Contents & Topics:
Topics include:
1. Advanced techniques, with emphasis on recently developed techniques, in branches of experimental physics
2. Data analysis and computer modelling relevant to experiments
Topics in condensed matter physics and the physics of materials will predominate but other fields such as nuclear physics, astrophysics etc will also be featured from time to time.

PHYS8002 Advanced Topics in Theoretical Physics

Course Objectives: To provide an opportunity for students to extend their studies in theoretical aspects of fundamental physics.

Course Contents & Topics: A series of lectures on advanced topics in theoretical physics, including quantum theory, electromagnetism and statistical mechanics, and their application to several fields of physics of contemporary interest, including astrophysics and condensed matter physics.

PHYS8201 Basic Research Methods in Physical Science

Course Objectives:
Introduction to basic research methods in physical science

Course Contents & Topics:
Basics of research methods will be provided for postgraduates of physical science. The following topics will be covered in the courses:
1. Research techniques: using the common problems encountered by postgraduate physics students to illustrate the modeling and problem solving skills
2. Theoretical physics: mathematical techniques, and general principles of different theories
3. Experimental physics: principles of experimental set-up
4. Data collections and analysis: statistics, probability and physical modeling
5. Mathematical modeling: models from those based on experimental data to first-principles theories
6. Presenting scientific information: written or oral presentation, the principles behind an effective presentations

PHYS8351 Graduate Quantum Mechanics

Course Objectives:
This course introduces postgraduates to theory and advanced techniques in quantum mechanics, and their applications to select topics in condensed matter physics.

Course Contents & Topics:
The course will cover the following topics: Dirac notation, quantum dynamics, the second quantization, symmetry and conservation laws, permutation symmetry and identical particles, perturbation and scattering theory, introduction of relativistic quantum mechanics.

PHYS8450 Graduate Electromagnetic Field Theory

Course Objectives:
The aim of this course is to provide students with the advanced level of comprehending on the theory of classic electromagnetic field, enabling them to master key analytical tools for solving real physics problems.

Course Contents & Topics:
This course will introduce and discuss the following topics: Boundary-value problems in electrostatics and Green Function method, Electrostatics of Media, Magnetostatics, Maxwell's equations and conservation laws, Gauge transformations, Electromagnetic waves and wave guides.

PHYS8550 Graduate Statistical Mechanics

Course Objectives:
This course intends to introduce some advanced topics in the field of equilibrium statistical physics.

Course Contents & Topics:
Ensemble theory: the micro-canonical ensemble, the canonical ensemble, and the grand canonical ensemble. Quantum mechanical ensemble theory. Theory of simple gases, ideal Bose systems, ideal Fermi systems. Statistical mechanics of interacting systems. Some topics in the theory of phase transition may be selected.

PHYS8551 Graduate Solid State Physics

Course Objectives:
To provide students with an understanding of more advanced topics in selected areas of solid state physics.

Course Contents & Topics:
Bloch theory. Nearly free electrons and tight binding model. Band structure calculations for realistic systems. The semi-classical model of electron dynamics. Ab initio total energy calculations and other advanced topics.

PHYS8552 Physics of Quantum Liquids

Course Objectives:
The collective behavior of systems consisting of many particles (bosons or fermions) gives rise to new states of matter, which emerge at low temperatures where interactions are important. This course aims to introduce the students to those novel quantum states, emphasizing the general themes such as elementary excitations, broken symmetry, hydrodynamic description of condensed matter. Theoretical language useful in the interpretation of experiments, such as response functions, will be discussed. The emphasis will be on a selected few examples that illustrate the above concepts and techniques. The course is intended for both experimentalists and theorists.

Course Contents & Topics:
This course will concentrate on the phenomena of emergent many-body states that require not only the effects of quantum mechanics, but also that of quantum statistics to its proper explanation. Examples include: superfluidity, superconductivity and the quantum Hall states. We will emphasize on the interaction effects and discuss the primary feature brought about by the interaction. Some general themes related to these quantum states, such as elementary excitation, Ginzburg-Landau description and symmetry breaking will be discussed.

PHYS8654 General Relativity

Course Objectives:
To introduce students to the field of general relativity. To provide conceptual skills and analytical tools necessary for astrophysical and cosmological applications of the theory.

Course Contents & Topics:
The Principle of equivalence. Inertial observers in a curved space-time. Vectors and tensors. Parallel transport and covariant differentiation. The Riemann tensor. The matter tensor. The Einstein gravitational field equations. The Schwarzschild solution. Black holes. Gravitational waves detected by LIGO.

PHYS8701 Physics Experimental Techniques

Course Objectives:
This course provides a detailed account of some common experimental techniques in physics research. It introduces the basic working principles, the operational knowhow, and the strength and limitations of the techniques.

Course Contents & Topics:
This course will discuss and train students of the following techniques:

1. Noise, Data Analysis, and Computer Grid
2. Vacuum technology and deposition techniques
3. Raman spectroscopy and photoluminescence (PL)
4. Electrical Characterizations
5. Thermodynamic Methods
6. Scanning Probe Microscopy (STM and AFM)
7. Electron and X-Ray Diffraction (LEED/RHEED/XRD)
8. Photoemission Spectroscopy (PES)
9. Scanning Electron Microscopy (SEM)
10. Transmission Electron Microscopy (TEM)
11. Radiation Detection and Measurements in Nuclear Physics
12. Particle Detection in Space and Microwave Measurements with Superconducting Detector

PHYS8750 Nanophysics

Course Objectives:
This course is designed to let fresh postgraduate students know fundamental concepts and principles of nano physics, such as two-dimensional electron gas, quantum Hall effects, one-dimensional electron system, quantum wires and nanotubes, zero-dimensional electron systems, single electron effects and quantum dots.

Course Contents & Topics:
Introduction to nano physics and quantum size effect. Dimensionalities and density of states. Optical and transport properties of two-dimensional electron gas formed at heterostructures and within novel graphene monolayers with external fields. Quantum Hall Effects. Physics of one-dimensional electron systems including carbon nanotubes and semiconductor nanowires. Fundamental physics of zero-dimensional electron systems. Single electron effects. Quantum dots and nanocrystals. Fundamental principles and applications of scanning tunneling microscopy in the study of nano physics. If time permits, the making and application aspects of nanomaterials will also be discussed

REPRESENTATIVE PUBLICATIONS OF FACULTY MEMBERS

H.F. Chau

"Decoy-State Quantum Key Distribution With More Than Three Types Of Photon Intensity Pulses", H. F. Chau, *Physical Review A (Rapid Communications)*, 97, 040301(R) (2018)

"Quantum Key Distribution Using Qudits That Each Encode One Bit Of Raw Key", H. F. Chau, *Physical Review A*, 92, 062324 (2015)

"Metrics on Unitary Matrices and their Application to Quantifying the Degree of Non-commutativity between Unitary Matrices", H.F. Chau, *Quantum Information and Computation*, 11, 721-740 (2011)

"Unconditionally Secure Key Distribution in Higher Dimensions by Depolarization", H.F. Chau, *IEEE Transactions on Information Theory*, 51, 1451-1468 (2005)

"Practical Scheme to Share a Secret Key through a Quantum Channel with a 27.6% Bit Error Rate", H.F. Chau, *Physical Review A*, 66, 060302 (R): 1-4 (2002)

"Unconditional Security of Quantum Key Distribution over Arbitrarily Long Distances", H.K. Lo and H.F. Chau, *Science*, 283, 2050-2056 (1999)

"Is Quantum Bit Commitment Really Possible?", H.K. Lo and H.F. Chau, *Physical Review Letters*, 78, 3410-3413 (1997)

K.S. Cheng

"Probing gamma-ray emissions of Fermi-LAT pulsars with a non-stationary outer gap model", Takata, J., Ng, C. W., Cheng, K. S., *MNRAS*, 455, 4249-4266 (2016)

"Origin of the Fermi Bubble", K.S. Cheng, D. Chernyshov, V. Dogel, C.M. Ko and W.H. Ip, *The Astrophysical Journal Letters*, 731, L17: 1-4 (2011)

"A Three-Dimensional Outer Magnetospheric Gap Model for Gamma-Ray Pulsars: Geometry, Pair Production, Emission Morphologies, and Phase-Resolved Spectra", K.S. Cheng, M. Ruderman and L. Zhang, *The Astrophysical Journal*, 537, 964-976 (2000)

"High-energy Radiation from Rapidly Spinning Pulsars with Think Outer Gaps", L. Zhang and K.S. Cheng, *The Astrophysical Journal*, 487, 370-379 (1997)

"Energetic Radiation from Rapidly Spinning pulsars. I: Outermagnetosphere Gaps", Cheng, K.S., Ho, C. & Ruderman, M., *Astrophysical Journal*, 300, 500-521 (1986).

X.D. Cui

"Manipulating spin-polarized photocurrents in 2D transition metal dichalcogenides", L. Xie, X. Cui, *Proceedings of the National Academy of Sciences*, 113, 14, 3746-3750 (2016)

"Anomalously robust valley polarization and valley coherence in bilayer WS_2", B. Zhu, H.L.Zeng, J.F. Dai, Z.R. Gong and X.D. Cui, *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, 111, 11606-11611 (2014)

"Optical signature of symmetry variations and spin-valley coupling in atomically thin tungsten dichalcogenides", H. Zeng, G.B. Liu, J. Dai, Y. Yan, B. Zhu, R. He, L. Xie, S. Xu, X. Chen, W. Yao and X.D. Cui, *Scientific Reports*, 3, 1068 (2013)

"Valley polarization in MoS_2 monolayers by optical pumping", H.L. Zeng, J.F. Dai, W. Yao, D. Xiao and X.D. Cui, *Nature Nanotechnology*, 7, 490-493 (2012)

"Magnetoelectric Photocurrent Generated by Direct Interband Transitions in InGaAs/InAlAs Two-Dimensional Electron Gas", J.F. Dai, H.F. Lu, C.L. Yang, S.Q. Shen, F.C. Zhang and X.D. Cui; *Physical Review Letters*, 104, 246601 (2010)

"Observation of exciton-phonon sideband in individual metallic single-walled carbon nanotubes", H.L. Zeng, H.B. Zhao, F.C. Zhang and X.D. Cui, *Physical Review Letters*, 102, 136406 (2009)

A.B. Djurišić

"Cesium Doped NiO_x as an Efficient Hole Extraction Layer for Inverted Planar Perovskite Solar Cells", W. Chen, F.Z. Liu, X.Y. Feng, A.B. Djurišić, W.K. Chan, Z.B. He, *Advanced Energy Materials,* 1700722 (2017)

"Is excess PbI_2 beneficial for perovskite solar cell performance?", F.Z. Liu, Q. Dong, M.K. Wong, A.B. Djurišić, A. Ng, Z.W. Ren, Q. Shen, C. Surya, W.K. Chan, J. Wang, A.M.C. Ng, C.Z. Liao, H.K. Li, K.M. Shih, C.R. Wei, H.M. Su, and J.F. Dai, *Advanced Energy Materials*, 6, 1502206 (2016)

"Hydrothermally synthesized Cu_xO as a catalyst for CO oxidation", M.Y. Guo, F.Z. Liu, J.K. Tsui, A.A. Voskanyan, A.M.C. Ng, A.B. Djurišić, W.K. Chan, K.Y. Chan, C.Z. Liao, K.M. Shih and C. Surya, *Journal of Materials Chemistry A*, 3, 3627-3632 (2015)

"Mechanisms of Antibacterial Activity of MgO: Non-ROS Mediated Toxicity of MgO Nanoparticles Towards Escherichia coli", Y.H. Leung, A.M.C. Ng, X.Y. Xu, Z.Y. Shen, L.A. Gethings, M.T. Wong, C.M.N. Chan, M.Y. Guo, Y.H. Ng, A.B. Djurišić, P.K.H. Lee, W.K. Chan, L.H. Yu, D.L. Phillips, A.P.Y. Ma and F.C.C. Leung, *Small*, 10, 1171-1183 (2014)

"In situ synthesis of CuxO/SnOx/CNT and CuxO/SnOx/SnO2/CNT nanocomposite anodes for lithium ion batteries by a simple chemical treatment process", X. Liu, F.Z. Liu, Q. Sun, A.M.C. Ng, A.B. Djurišić, M.H. Xie, C.Z. Liao, K.M. Shih, *ACS Appl. Mater. & Interfaces*, 6, 13478-13486 (2014)

J.H.C. Lee

"Low-Lying Structure of ^{50}Ar and the N=32 Subshell Closure", D. Steppenbeck, S. Takeuchi, N. Aoi, P. Doornenbal, M. Matsushita, H. Wang, Y. Utsuno, H. Baba, S. Go, J.H.C. Lee, K. Matsui, S. Michimasa, T. Motobayashi, D. Nishimura, T. Otsuka, H. Sakurai, Y. Shiga, N. Shimizu, P.-A. Söderström, T. Sumikama, R. Taniuchi, J. J. Valiente-Dobón, and K. Yoneda, *Phys. Rev. Lett.* 114, 252501 (2015)

"Neutron spectroscopic factors of ^{55}Ni hole-states from (p,d) transfer reactions", A. Sanetullaev, M.B. Tsang, W.G. Lynch, J.H.C. Lee, D.Bazin, D.Coupland, V.Henzl, D.Henzlova, M.Kilburn, A.M.Rogers, Z.Y.Sun, M.Youngs, R.J.Charity, L.G.Sobotka, M.Famiano, S. Hudan, D. Shapira, W.A. Peters, C. Barbieri, M. Hjorth-Jensen, M. Horoi, T. Otsuka, T. Suzuki and Y. Utsuno, *Physics Letters B*, 736, 137 (2014)

"Evidence for a new nuclear `magic' number from the structure of ^{54}Ca", D. Steppenbeck, S. Takeuchi, N. Aoi, P. Doornenbal, M. Matsushita, H. Wang, H. Baba, N. Fukuda, S. Go, M. Honma, J. Lee, K. Matsui, S. Michimasa, T. Motobayashi, D. Nishimura, T. Otsuka, H. Sakurai, Y. Shiga, P.-A. Soderstrom, T. Sumikama, H. Suzuki, R. Taniuchi, Y. Utsuno, J.J.Valiente-Dobon, and K. Yoneda, *Nature*, 502, 207 (2013)

"In-Beam γ-Ray Spectroscopy of $^{34, 36,38}$Mg: Merging the N=20 and N=28 Shell Quenching", P. Doornenbal, H. Scheit, N. Aoi, S. Takeuchi, K. Li, M. Matsushita, D. Steppenbeck, H. Wang, H. Baba, E. Ideguchi, N. Kobayashi, Y. Kondo, G. Lee, J.H.C. Lee, S. Michimasa, T. Motobayashi, H. Sakurai, M. Takechi and Y. Togano, *Phys. Rev. Lett.*, 111, 212502 (2013)

"Neutron-hole states in ^{45}Ar from ^{1}H(^{46}Ar,d)^{45}Ar reactions", F. Lu. J.H.C. Lee, M.B. Tsang, D. Bazin, D. Coupland, V. Henzl, D. Henzlova, M. Kiburn, W.G. Lynch. A.M. Rogers. A. Sanetullaev, Z.Y Sun, M. Youngs, R.J. Charity, L.G. Sobotka, M. Famiano, S. Hudan, M. and Horoi, Y. Ye, *Phys. Rev. C*, 88, 017604 (2013)

"A Laser Based Alignment System (LBAS) for Nuclear Physics Experiments", A.M. Rogers, J.H.C. Lee, B.E. Netta,M.S. Wallace, W.G. Lynch, H.K. Cheung, L. El-Mogaber, R. Fontus, T.K.Ghosh, V. Henzl, D. Henzlova, M. Kilburn, D.J. Oostdyk, D. Sanderson, Z.Y. Sun and M.B. Tsang, *Nucl. Instrum. Meth. A*, 707, 64 (2013)

"Well-developed deformation in ^{42}Si", S. Takeuchi, M. Matsushita, N. Aoi, P.

Doornenbal,K. Li, T. Motobayashi, H. Scheit, D. Steppenbeck, H. Wang, H. Baba, D. Bazin, L. C`aceres, H. Crawford, P. Fallon, R. Gernhauser, J. Gibelin, S. Go, S. Grevy, C. Hinke, C. R. Hoffman, R. Hughes,E. Ideguchi, D. Jenkins, N. Kobayashi, Y. Kondo, R. Krucken, T. Le Bleis, J.H.C. Lee, G. Lee, A. Matta, S. Michimasa, T. Nakamura, S. Ota, M. Petri, T. Sako, H. Sakurai, S. Shimoura, K. Steiger, K. Takahashi, M. Takechi, Y. Togano, R. Winkler and K. Yoneda, *Phys. Rev. Lett.*, 109, 182501 (2012)

"Neutron spectroscopic factors of ^{34}Ar and ^{46}Ar", J.H.C. Lee, M.B. Tsang, D. Bazin, D. Coupland, V. Henzl, D. Henzlova, M. Kilburn, W.G. Lynch, A. Rogers, A. Sanetullaev, A. Signoracci, Z.Y. Sun, M. Youngs, K.Y. Chae, R.J. Charity, H.K. Cheung, M. Famiano, S. Hudan, P. O'Malley, W.A. Peters, K. Schmitt, D. Shapira and L.G. Sobotka, *Phys. Rev. C*, 83, 014606 (2011)

"Neutron-proton asymmetry dependence of spectroscopic factors in Ar isotopes", J.H.C. Lee, M.B. Tsang, D. Bazin, D. Coupland, V. Henzl, D. Henzlova, M. Kilburn, W.G. Lynch, A. Rogers, A. Sanetullaev, A. Signoracci, Z.Y. Sun, M. Youngs, K.Y. Chae, R.J. Charity, H.K. Cheung, M. Famiano, S. Hudan, P. O'Malley, W.A. Peters, K. Schmitt, D. Shapira and L.G. Sobotka, *Phys. Rev. Lett.*, 104, 112701 (2010)

J.J.L. Lim

"A likely Supermassive Black Hole revealed by its Einstein radius in Hubble Frontier Field Image," Chen, M. C., Broadhurst, T., Lim, J., Diego, J. M., Ohyama, Y., Ford, H., & Benítez, N, *The Astrophysical Journal*, in press (2018)

"Magnification Bias of distant Galaxies in the Hubble Frontier Fields: Testing Wave vs. Particle Dark Matter predictions," Leung, E., Broadhurst, T., Lim, J., Diego, J. M., Chiueh, T., Schive, H.-Y., & Windhorst, R., *The Astrophysical Journal* , in press (2018)

"Geometric Corroboration of the Earliest Lensed Galaxy at z $\simeq$ 10.8 from Robust Free-form Modelling," Chan, B. Y. M., Broadhurst, T., Lim, J., Diego, J. M., Zitrin, A., Coe, D., & Ford, H., *The Astrophysical Journal*, 835, 44 (2017)

"The Role of Electron Excitation and Nature of Molecular Gas in Cluster Central Elliptical Galaxies," Lim, J., Dinh-V-T., Vrtilek, J., David, L. P., & Forman, W., *The Astrophysical Journal*, 850, 31 (2017)

"The High-Velocity System: Infall of a Giant Low-Surface-Brightness Galaxy towards the center of the Perseus Cluster", A. Yu, J. Lim, Y. Ohyama, J. C. C. Chan, & T. Broadhurst, *The Astrophysical Journal*, 814, 101 (2015)

"A Rigorous Free-form Lens Model of A2744 to Meet the Hubble Frontier Fields Challenge", D. Lam, T. Broadhurst, J.M. Diego, J.J.L. Lim, D. Coe, H.C. Ford and Z. Wei, *The Astrophysical Journal*, 697, 98 (2014)

"Molecular Gas in the X-Ray Bright Group NGC 5044 as Revealed by ALMA", L.P. David, J.J.L. Lim, et al., *The Astrophysical Journal*, 792, 94 (2014)

"A Molecular Hydrogen Nebula in the Central cD Galaxy of the Perseus Cluster", J.J.L. Lim, Y. Ohyama, C.H. Yan, D.V. Trung and S.Y. Wang, *The Astrophysical Journal*, 744, 112 (2012)

C.C. Ling

"Thermal evolution of defects in undoped zinc oxide grown by pulsed laser deposition", Zilan Wang, Shichen Su, Francis Chi-Chung Ling, W. Anwand, and A. Wagner, *J. Appl. Phys.* 116, 033508 (2014).

"Impedance analysis of secondary phases in a Co-implanted ZnO single crystal", M. Younas, L. L. Zou, M. Nadeem, Naeem-ur-Rehman, S. C. Su, Z. L. Wang, W. Anwand, A. Wagner, J. H. Hao, C. W. Leung, R. Lortz, and F. C. C. Ling, *Phys. Chem. Chem. Phys.* 16, 16030 (2014)

"Low-threshold lasing action in an asymmetric double ZnO/ZnMgO quantum well structure", S.C. Su, H. Zhu, L.X. Zhang, M. He, L.Z. Zhao, S.F. Yu, J.N. Wang and F. C.C. Ling, *Appl. Phys. Lett.* 103, 131104 (2013)

"Current transport studies of ZnO/p-Si heterostructures grown by plasma immersion ion implantation and deposition", X. D. Chen, C. C. Ling, S. Fung, C. D. Beling, Y. F.Mei, Ricky K. Y. Fu, G. G. Siu, Paul K. Chu, *Appl. Phys. Lett.* 88, 132104 (2006)

"Low energy electron irradiation induced deep level defects in 6H-SiC: The implication for the microstructure of the deep levels E_1/E_2", X.D. Chen, C.L. Yang, M. Gong, W.K. Ge, S. Fung, C.D. Beling, J.N. Wang, M.K. Lui and C.C. Ling, *Phys. Rev. Lett.* 92, 125504 (2004)

S.C.Y. Ng

"Chandra Phase-Resolved Spectroscopy of the High-Magnetic-Field Pulsar B1509-58", Chin-Ping Hu, C.-Y. Ng, J. Takata, R. M. Shannon, and S. Johnston, *the Astrophysical Journal*, 838, 156 (2017)

"Discovery of a Synchrotron Bubble Associated with PSR J1015-5719", C.-Y. Ng, R. Bandiera, R. W. Hunstead, and S. Johnston, *the Astrophysical Journal*, 842, 100 (2017)

"Radio Polarization Observations of the Snail: A Crushed Pulsar Wind Nebula in G327.1-1.1 with a Highly Ordered Magnetic Field", Y. K. Ma, C.-Y. Ng, N. Bucciantini, P. O. Slane, B. M. Gaensler, & T. Temim, *the Astrophysical Journal*, 820, 100 (2016)

"Hunting for Orphaned Central Compact Objects among Radio Pulsars", J. Luo, C.-Y. Ng, W. C. G. Ho, S. Bogdanov, V. M. Kaspi, & C. He, *the Astrophysical Journal*, 808, 130 (2015)

"An anti-glitch in a magnetar", R.F. Archibald, C.-Y. Ng, K. N. Gourgouliatos, D. Tsang, P. Scholz, A.P. Beardmore, N. Gehrels, & J. A. Kennea, *Nature*, 497, 591 (2013)

Q.A. Parker

"The binary fraction of planetary nebula central stars - III. the promise of VPHAS+", H. Barker, A. Zijlstra, O. De Marco, D.J. Frew, J.E. Drew, R.L.M. Corradi, J. Eislöffel, Q.A. Parker, *MNRAS,* 475, 4504 (2017)

"HASH: The Hong Kong/AAO/Strasbourg H-alpha planetary nebula database", Q.A. Parker, I. Bojcic & D.J. Frew, *11th Pacific Rim Conference held in Hong-Kong in Dec 2015, JPhCS*, 728 (2016)

"Fast, Low-ionization Emission Regions of the Planetary Nebula M2-42", A. Danehkar, Q.A. Parker, W. Steffen, *The Astrophysical Journal*, 151, 38 (2016)

"The H-Alpha Surface Brightness - Radius Relation: A Robust Statistical Distance Indicator for Planetary Nebulae", D.J. Frew, Q.A. Parker and I. Bojicic, *MNRAS*, 455, 1459 (2016)

"New light on Galactic post-asymptotic giant branch stars - I. First distance catalogue", S. Vickers, D.J. Frew, Q.A. Parker and I.S. Bojičić, *MNRAS,* 447, 1673 (2015)

"Kathryn's Wheel: A Spectacular Galaxy Collision Discovered in the Galactic Neighbourhood" Q.A. Parker, A.A. Zijlstra, M. Stupar, M. Cluver, D.J. Frew, G. Bendo and I. Bojici, *MNRAS*, 452, 3759 (2015)

"Four New Planetary Nebulae Towards the Small Magellanic Cloud", D. Draskovic, Q.A. Parker, W.A. Reid and M. Stupar, *MNRAS*, 425, 1402 (2015)

"Spatially resolved kinematic observations of the planetary nebulae Hen 3-1333", A. Danehkar, Q.A. Parker, *MNRAS,* 449, 56 (2015)

"New light on Galactic post-asymptotic giant branch stars - I. First distance catalogue", S.B.Vickers, D.J.Frew, Q.A.Parker and I.S. Bojicic, *MNRAS*, 447, 1673 (2015)

J.C.S. Pun

"Measurement of cosmic-ray muons and muon-induced neutrons in the Aberdeen Tunnel Underground Laboratory", S. Blyth, et al. (Aberdeen Tunnel Underground Experiment collaboration), *Physical Review D,* 93, 072005 (2016)

"The destruction of the circumstellar ring of SN1987A", C. Fransson, J. Larsson, C.S.J. Pun, G. Sonneborn and B. Sugerman, *The Astrophysical Journal Letters*, 806, L19 (2015)

"Contributions of artificial lighting sources on light pollution in Hong Kong measured through a night sky brightness monitoring network", C.S.J. Pun, C.W. So, W.Y. Leung and C.F. Wong, *Journal of Quantitative Spectroscopy & Radiative Transfer*, 139, 90-108 (2014)

"The discovery of an X-ray / UV stellar flare from the late-K/early-M dwarf LMC 335", B.T.H. Tsang, C.S.J. Pun, R. DiStefano, K.L. Li and A.K.H. Kong, *The Astrophysical Journal*, 754, 107 (2012)

"Observation of Electron-Antielectron Disappearance at Daya Bay", F.P. An, et al. (Daya Bay Reactor Neutrino Experiment collaboration), *Physical Review Letters*, 108, 171803 (2012)

S.Q. Shen

"Negative magnetoresistance in Dirac semimetal Cd_3As_2", H. Li, H. He, H.Z. Lu, H. Zhang, H. Liu, R. Ma, Z. Fan, S.Q. Shen, and J. Wang, *Nature Communications* 7, 10301 (2016)

"Topological superconducting states in monolayer FeSe/$SrTiO_3$", N.N. Hao and S.Q. Shen, *Physical Review B* 92, 165104 (2015)

"Weak antilocalization and localization in disordered and interacting Weyl semimetals", Hai- Z. Lu and S.Q. Shen, *Physical Review B* 92, 035203 (2015)

"Finite temperature conductivity and magnetoconductivity of topological insulators", H.Z. Lu and S.Q. Shen, *Physical Review Letters* 112, 146601 (2014)

"Quantum transport in magnetic topological insulator thin film", H.Z. Lu, A. Zhao and S.Q. Shen, *Physical Review Letters* 111, 146802 (2013)

"Intervalley scattering and localization behaviors of spin-valley coupled Dirac fermions", H.Z. Lu, W. Yao, D. Xiao, and S.Q. Shen, *Physical Review Letters* 110, 016806 (2013)

"Competition between Weak Localization and Antilocalization in Topological Surface States" H.Z. Lu, J.R. Shi and S.Q. Shen, *Physical Review Letters* 107, 076801 (2011)

"Topological Anderson Insulator", J. Li, R.L. Chu, J.K. Jain and S.Q. Shen, *Physical Review Letters*, 102, 136806 (2009)

M. Su

"Degree-Scale Cosmic Microwave Background Polarization Measurements from Three Years of BICEP1 Data", M. Su and BICEP1 Collaboration, *The Astrophysical Journal*, 783, 2 (2014)

"Is the 130 GeV line real? A search for systematics in the Fermi- LAT data", Douglas P. Finkbeiner, Meng Su, Christoph Weniger, *Journal of Cosmology and Astroparticle Physics*, 1, 29 (2013)

"Evidence for Gamma-Ray Jets in the Milky Way", Meng Su, Douglas P. Finkbeiner, *The Astrophysics Journal*, 753, 61 (2012)

"Giant Gamma-ray Bubbles from Fermi-LAT: AGN Activity or Bipolar Galactic Wind?", Meng Su, Tracy R. Slatyer, Douglas P. Finkbeiner, *The Astrophysical Journal*, 724, 1044-1082 (2010)

"Impact of instrumental systematic contamination on the lensing mass reconstruction using the CMB polarization", Meng Su, Amit P. S. Yadav, Meir Shimon, Brian G. Keating, *Physical Review D*, 79, 123002 (2009)

Y.J. Tu

"Measurements of $t\bar{t}$ charge asymmetry using the dilepton decay channel in pp collisions at $\sqrt{s}$ =7 TeV", Y.J. Tu, with CMS Collaborators, *Journal of High Energy Physics*, 4, 191 (2014)

"Measurements of $t\bar{t}$ Spin Correlations and Top-Quark Polarization Using Dilepton Final States in pp Collisions at $\sqrt{s}$ =7 TeV", Y.J. Tu, with CMS Collaborators, *Phys. Rev. Lett.*, 112, 182001 (2014)

"Search for heavy, top-like quark pair production in the dilepton final state in pp collisions at $\sqrt{s}$ =7 TeV", Y.J. Tu, with CMS Collaborators, *Phys. Lett. B*, 716, pp103-121 (2012)

"Search for R-Parity Violating Decays of Sneutrinos to $e\mu$, $\mu\tau$, and $e\tau$ Pairs in $p\bar{p}$ Collisions at $\sqrt{s}$ =1.96 TeV", Y.J. Tu, with CDF Collaborators, *Phys. Rev. Lett.*, 105, 191801 (2010)

J. Wang

"A Spin Cell for Spin Current", Q.F. Sun, H. Guo and J. Wang, *Phys. Rev. Lett.*, 90, 258301 (2003)

"Dynamic Conductance of Carbon Nanotubes", C. Roland, M.B. Nardelli, J. Wang and H. Guo, *Phys. Rev. Lett.*, 84, 2921 (2000)

"Carbon Nanotube Based Magnetic Tunnel Junctions", H. Mehrez, J. Taylor, H. Guo, J. Wang and C. Roland, *Phys. Rev. Lett.*, 84, 2682 (2000)

"Current Partition: Nonequilibrium Green's Function Approach", B.G. Wang, J. Wang and H. Guo, *Phys. Rev. Lett.*, 82, 398 (1999)

"Capacitance of Atomic Junctions", J. Wang, H. Guo, J.L. Mozos, C.C. Wan, G. Taraschi and Q.R. Zheng, *Phys. Rev. Lett.*, 80, 4277 (1998)

Z.D. Wang

"Novel Z_2 topological metals and semimetals", Y. X. Zhao and Z. D. Wang, *Phys. Rev. Lett*. 116, 016401 (2016).

"Unified theory of *PT* and *CP* invariant topological metals and nodal superconductors", Y. X. Zhao, A. P. Schynder, and Z. D. Wang, *Phys. Rev. Lett***.** 116, 156402 (2016).

"Disordered Weyl semimetals and their topological family", Y.X. Zhao and Z.D. Wang, *Phys. Rev. Lett.*, 114, 206602 (2015).

"Topological classification and stability of Fermi surfaces", Y.X. Zhao and Z.D. Wang, *Phys. Rev. Lett.*, 110, 240404 (2013).

"Unconventional Geometric Quantum Computation", S.L. Zhu and Z.D. Wang, *Phys. Rev. Lett.*, 91, 187902 (2003).

"Implementation of Universal Quantum Gates Based on Nonadiabatic Geometric Phases", S.L. Zhu and Z.D. Wang, *Phys. Rev. Lett.*, 89, 097902 (2002).

M.H. Xie

"One-dimensional phosphorus chain and two-dimensional blue phosphorene grown on Au (111) by molecular-beam epitaxy", J.P. Xu, J.Q. Zhang, H. Tian, H. Xu, W.K. Ho, M.H. Xie. *Phys. Rev. Mater.*, 1, 061002(R)(2017)

"Inversion Domain Boundary Induced Stacking and Bandstructure Diversity in Bilayer MoSe2", J.H. Hong, C. Wang, H.J. Liu, X.B. Ren, J.L. Chen, G. Wang, J.F. Jia, M.H. Xie, C.H. Jin, W. Ji, J. Yuan, Z. Zhang, *Nano Letter*, 17, 11, 6653-6660 (2017)

"Quantum effects and phase tuning in epitaxial hexagonal and monoclinic MoTe2 monolayers", J. Chen, G.Y. Wang, Y.A. Tang, H. Tian, J. Xu, X.Q. Dai, H. Xu, J.F. Jia, W.K. Ho, M.H. Xie, *ACS Nano*, 11, 3282 (2017)

"Observation of intervalley quantum interference in epitaxial monolayer tungsten diselenide", H.J. Liu, J.L. Chen, H.Y. Yu, F. Yang, L. Jiao, G.B. Liu, W.K. Ho, C.L. Gao, J.F. Jia, W. Yao, M.H. Xie, Nat. Comm., 6, 8180 (2015)

"Line and point defects in MoSe2 bilayer studied by scanning tunneling microscopy and spectroscopy", H.J. Liu, H. Zheng, F. Yang, L. Jiao, J.L. Chen, W.K. Ho, C.L. Gao, J.F. Jia, M.H. Xie, ACS Nano., 9, 6619 (2015)

"Molecular-beam epitaxy of monolayer and bilayer WSe_2: a scanning tunneling microscopy / spectroscopy study and deduction of exciton binding energy", H.J. Liu, L. Jiao, L. Xie, F. Yang, J.L. Chen, W.K. Ho, C.L. Gao, J.F. Jia, X.D. Cui, M.H. Xie, *2D Mater.*, 2, 034004 (2015)

"Dense network of one-dimensional midgap metallic modes in monolayer $MoSe_2$ and their spatial undulations" H.J. Liu, L. Jiao, F. Yang, Y. Cai, X. Wu, W.K. Ho, C.L. Gao, J.F. Jia, N. Wang, H. Fan, W. Yao, M.H. Xie, *Phys. Rev. Lett.*, 113, 066105 (2014)

"Anisotropic topological surface states on high-index Bi_2Se_3 films", Z.J. Xu, X. Guo, M.Y. Yao, H.T. He, L. Miao, L. Jiao, H.C. Liu, J.N. Wang, D. Qian, J.F. Jia, W.K. Ho, M.H. Xie, *Adv. Mater.*, 25, 1557 (2013)

S.J. Xu

"Luminescence and thermal behaviors of free and trapped excitons in cesium lead halide perovskite nanosheets", Xiangzhou Lao, Zhi Yang, Zhicheng Su, Zilan Wang, Honggang Ye, Minqiang Wang, Xi Yao, and Shijie Xu, *Nanoscale* 10, 9949 (2018)

"Effective Photon Recycling and Super Long Lived Minority Carriers in GaInP/GaAs Heterostructure Solar Cell: A Time-Resolved Optical Study", Z. C. Su, Shijie Xu, X. H. Wang, J. Q. Ning, Rongxin Wang, Shulong Lu, Jianrong Dong, and Hui Yang, *IEEE Journal of Photovoltaics* 8, 820 (2018).

"Understanding and manipulating luminescence in carbon nanodots", Z. C. Su, H. G. Ye, Z. Xiong, Q. Lou, Z. Zhang, F. Tang, J. Y. Tang, J. Y. Dai, C. X. Shan, and S. J. Xu, *Carbon* 126, 58 (2018)

"Luminescence Anisotropy and Thermal Effect of Magnetic and Electric Dipole Transitions of Cr^{3+} Ions in Yb: YAG Transparent Ceramic", Fei Tang, Honggang Ye, Zhicheng Su, Yitian Bao, Wang Guo, and Shijie Xu, *ACS Applied Materials & Interfaces* 9, 43790 (2017)

"Extinction of the zero-phonon line and the first-order phonon sideband in excitonic luminescence of ZnO at room temperature: the self-absorption effect", Honggang Ye, Zhicheng Su, Fei Tang, Changcheng Zheng, Guangde Chen, Jian Wang, and Shijie Xu, *Science Bulletin* 62, 1525 (2017)

“Electroluminescence Probe of Internal Processes of Carriers in GaInP Single Junction Solar Cell”, Z.C. Su, S.J. Xu, R.X. Wang, J.Q. Ning, J.R. Dong, S.L. Lu, and H. Yang, *Solar Energy Materials and Solar Cells* 168, 201 (2017).

“A generalized model for time-resolved luminescence of localized carriers and applications: Dispersive thermodynamics of localized carriers”, Zhicheng Su and Shijie Xu, *Scientific Reports* 7, 13 (2017)

“Triplet harvesting in luminescent Cu(I) complexes by thermally activated luminescence mechanism transition: Impact of molecular structure”, Z.C. Su, C.C. Zheng, G. Cheng, C.-M. Che, and S.J. Xu, *Journal of Materials Chemistry C* 5, 4488 (2017)

“Excitation Dependent Phosphorous Property and New Model of the Structured Green Luminescence in ZnO”, Honggang Ye, Zhicheng Su, Fei Tang, Mingzheng Wang, Guangde Chen, Jian Wang, and Shijie Xu, *Scientific Reports* 7, 41460 (2017)

“Carrier Localization Effects in InGaN/GaN Multiple-Quantum-Wells LED Nanowires: Luminescence Quantum Efficiency Improvement and “Negative” Thermal Activation Energy”,Wei Bao, Zhicheng Su, Changcheng Zheng, Jiqiang Ning, and Shijie Xu, *Scientific Reports* 6, 34545 (2016)

“A set of manganese ions activated fluoride phosphors ($A_2BF_6:Mn^{4+}$, A=K, Na, B=Si, Ge, Ti): Synthesis below 0 ºC and efficient room-temperature photoluminescence”, F. Tang, Z.C. Su, H.G. Ye, M.Z. Wang, X. Lan, D.L. Philips, Y.G. Cao, and S.J. Xu, *Journal of Materials Chemistry C* 4, 9561 (2016)

"Transition of radiative recombination channels from delocalized states to localized states in a GaInP alloy with partial atomic ordering: a direct optical signature of Mott transition?", Z. C. Su, J. Q. Ning, Z. Deng, X. H. Wang, S. J. Xu, R. X. Wang, S. L. Lu, J. R. Dong, and H. Yang. *Nanoscale* 8, 7113-7118 (2016)

W. Yao

"Topological Mosaic in Moiré superlattices of van der Waals heterobilayers", Q. Tong, H. Yu, Q. Zhu, Y. Wang, X. Xu, Wang Yao, *Nature Physics*, 13, 356 (2017)

"Excitonic luminescence upconversion in a two-dimensional semiconductor", A. Jones, Hongyi Yu, J. Schaibley, J. Yan, D. Mandrus, T. Taniguchi, K. Watanabe, H. Dery, W. Yao and X. Xu, *Nature Physics*, 12, 323 (2016)

"Anomalous light cones and valley optical selection rules of interlayer excitons in twisted heterobilayers", Hongyi Yu, Y. Wang, Qingjun Tong, X. Xu and Wang Yao, *Phys. Rev. Lett.* 115, 187002 (2015)

"Magnetic control of valley pseudospin in monolayer WSe_2", G. Aivazian, Z.R. Gong,

A. Jones, R. Chu, J. Yan, D. Mandrus, C. Zhang, D. Cobden, W. Yao and X. Xu, *Nature Physics*, 11, 148 (2015)

"Nonlinear valley and spin currents from Fermi pocket anisotropy in 2D crystals", H.Y. Yu, Y. Wu, G.B. Liu, X.D. Xu and W. Yao, *Phys. Rev. Lett.* 113, 156603 (2014)

"Dirac cones and Dirac saddle points of bright excitons in monolayer transition metal dichalcogenides", H.Y. Yu, G.B. Liu, P. Gong, X.D. Xu and W. Yao, *Nature Communications*, 5, 3876 (2014)

"Spins and pseudospins in layered transition metal dichalcogenides", X. Xu, W. Yao, D. Xiao and T. F. Heinz, *Nature Physics*, 10, 343 (2014)

"Optical generation of excitonic valley coherence in monolayer WSe_2", A. Jones, H.Y. Yu, N. Ghimire, S.F. Wu, G. Aivazian, J. Ross, B. Zhao, J.Q. Yan, D. Mandrus, D. Xiao, W. Yao, X.D. Xu, *Nature Nanotechnology*, 8, 634 (2013)

"Magnetoelectric effects and valley controlled spin quantum gates in transition metal dichalcogenide bilayers", Z.R. Gong, G.B. Liu, H.Y. Yu, D. Xiao, X.D. Cui, X.D. Xu, W. Yao, *Nature Communications*, 4, 2053 (2013)

"Coupled Spin and Valley Physics in Monolayers of MoS_2 and Other Group-VI Dichalcogenides", D. Xiao, G.B. Liu, W.X. Feng, X.D. Xu and W. Yao, *Physical Review Letters*, 108, 196802 (2012)

S.Z. Zhang

"Evidence for Universal Relations Describing a Gas with p-Wave Interactions", C. Luciuk, S. Trotzky, S. Smale, Z. Yu, S. Zhang, and J. H. Thywissen, *Nature Physics*, 6, 599-605 (2016)

"Universal Relations for a Fermi Gas Close to a p-Wave Interaction Resonance", Z.H. Yu, J.H. Thywissen, S.Z. Zhang, *Physical Review Letters*, 115, 135304:1-5 (2015)

"Transverse Demagnetization Dynamics of a Unitary Fermi Gas", A.B. Bardon, S. Beattie, C. Luciuk, W. Cairncross, D. Fine, N.S. Cheng, G.J.A. Edge, E. Taylor, S.Z. Zhang, S. Trotzky, J.H. Thywissen, *Science*, 344, 722-724 (2014)

"Theory of quantum oscillations in the vortex-liquid state of high-T_c superconductors", S. Banerjee, S.Z. Zhang, M. Randeria, *Nature Communications*, 4, 1700:1-7 (2013)

"Bose-Einstein condensates with spin-orbit interaction", T.L. Ho and S.Z. Zhang, *Physics Review Letter*, 107, 150403 (2011)

"BEC-BCS crossover induced by a synthetic non-abelian gauge field", J.P. Vyasanakere, S.Z. Zhang and V. Shenoy, *Physics Review B*, 84, 014512 (2011)

"Atom loss maximum in ultracold Fermi gases", S.Z. Zhang and T.L. Ho, *New Journal of Physics*, 13, 055003 (2011)

"Universal properties of the ultracold Fermi gas", S.Z. Zhang and A.J. Leggett, *Physics Review A*, 79, 023601 (2009)