Huazhong University of Science and Technology (HUST) is pleased to invite a group of current Oxford students to take part in research internships in Wuhan, China. This year, HUST offers 17 projects, including 32 positions in total, which provide interns with challenging and meaningful scientific research experiences and Chinese cultural immersion classes over the summer.

The duration of 2023 Summer internship program is from the end of June to the end of August, 2023.

Besides, please feel free to watch our promotional video for hands-on information of HUST campus views, scientific strength, and internship details:
http://discover.hust.edu.cn/fore/courses/courseDetail.do?sid=221101101950128117166 42

#1 Focal Stacking Images Fusion (Positions: 3)

Focal stacks imaging is a vital imaging method for computational photography, macroscopic and microscopic imaging. Focal stack images (FoSIs) captured in focal stack imaging are a set of images focusing on multiple depth of scene, which have complementary spatial information. Integrating the vital and complementary information from FoSIs to synthesize an all-in-focus image is suitable for observing the cells, structures and tissues in microscope imaging, and a comprehensive description of scene in computational photography.

Image fusion is a vital technology in many application fields such as object detection, remote sensing, medical imaging, industry and civilian fields, etc. The target of image fusion is to generate a synthesized image by integrating complementary information from several source images that are captured with different sensors or optical settings. Thus, image fusion is an effective way to integrate the complementary information in FoSIs.

In this project, methods based on traditional fusion framework and methods based on deep learning will be studied for FoSIs fusion task. In the existing work, methods based on traditional fusion framework can be roughly divided into transform domain fusion and spatial domain fusion. For transform domain-based method, the source images are decomposed into different transform coefficients, which are fused by certain fusion rule. Then, the fused image is the constructed by performing the inverse transform on the fused coefficients. The most commonly used transform domain fusion methods are based on multi-scale transform. Examples of multi-scale algorithms include pyramid transform, wavelet transform, contourlet transform, shearlet transform, etc. In addition, robust principal component analysis, sparse representation methods have also been discussed. If spatial consistency is not well considered in the fusion process, the above methods may lose some spatial information, and result in brightness or color distortion. Different from transform domain-based methods, the spatial domain methods perform the fusion process in spatial domain directly. The simplest method calculates the average of source images pixel-by-pixel, but it leads to many details loss, contrast reducing, and high sensitivity to noise. Aiming to make full use of spatial context, a number of block and region based-methods have been proposed. These methods perform well for multi-focus image fusion, but suffer from computational efficiency or robustness to noise. For methods based on deep learning, the fusion problem is solved by relying on ground truth for supervised learning or the specifically designed metrics for unsupervised learning. However, the ground truth is difficult to obtain or even does not exist, and the no-reference metrics are also difficult to design. These issues form the major stumbling blocks in the application of supervised and unsupervised learning.

In our research, in order to overcome the spatial consistency problem in the transform domain-based method and the misalignment of focus map with object boundaries in spatial domain methods, an efficient edge-aware filter, guided filter is used to measure the focus. The FoSIs are fused by the pixel-wise spatial consistency of structures rule with focus map of guided filter measurement to obtain an all-in-focus image of scene. For the above method, focus map and fusion rule are calculated and designed, respectively. To jointly generate focus map and fusion rule, and improve the computation efficient. A method based on deep learning are proposed. In this method, a deep convolutional network can be trained to encode the mapping between source images and focus map. Similar to the fusion process of traditional fusion framework, the FoSIs are fused with the focus map detected by the convolutional network to obtain the result image.

The proposed method based on traditional fusion framework and method based on deep learning will be verified via 6 test sequences respectively, and the experimental results will show that state-of-the-art performance can be obtained.

Applicant profile:

-

We are interested in the undergraduate and graduate interns.

The interns should have an interest in the field of big data analysis, machine learning, optical imaging, and have already demonstrated strong research potential.

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly image processing, learning based models for image processing, signal processing, and optics.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Positions:3

Duration: from the end of June to the end of August，2023

#2 To observe thermodynamic signatures of the field-induced topological phase transition in Weyl semimetal TaP (Position: 1)

The Weyl semimetal TaP hosts two types of Weyl nodes. The W1 Weyl fermions can couple with magnetic field and their lowest Landau levels can shift to above the Fermi level, inducing a sign reversal in Hall response around 34.4T. To date, this dramatic transition was only observed in transport measurement. More thermodynamic signatures are highly expected (Nature Physics 13, 979 (2017)).

Project Aims:

To observe the signatures of this field-induced Weyl-node annihilation through thermodynamic techniques, such as magnetostriction and torque.

Methods:

magnetostriction and torque under pulsed magnetic field

Project summary

By measuring magnetic torque and magnetostriction under a pulsed high pulsed magnetic field up to 65 T and a low temperature of 1.5K, we will uncover the field-induced Weyl-node annihilation by thermodynamic signatures.This project will take 6 weeks. The participator will learn the transport and thermodynamic techniques frequently used in condensed matter physics. The participator will also be familiar with the equipment used in the pulsed magnetic field and low temperature.

Assessment

Oral presentation is required by the end of internship.

Applicant profile:

We are interested in the undergraduate (in 3rd or 4th year) and graduate interns, major in physics.

Position:1

Duration: from the end of June to the end of August, 2023

#3 Fabrication of de Haas-van Alphen pick-up coil and measurements in high magnetic fields(Position: 1)

Extreme experimental conditions play more and more important role in modern physics and material science research. As an extreme condition, high magnetic field can directly interact with spins or electrons. Thus, it becomes an efficient mean to explore novel physical phenomena in quantum matters. Moreover, the magnetic field is higher, the scientific research area is wider. At present, the highest field generated by a commercial magnetic measurement system is 7T, while this is up to 45T for a steady field generated by a hybrid magnet. For a higher field strength, pulsed magnetic field is necessary and desirable, which has a short duration time at a level of milliseconds but the peak field can reach 60-100T by a nondestructive pulsed magnet. With continuous developments over past decades, experimental techniques such as electrical transport, magnetization, torque, magnetostriction, magneto-optics etc. have been available in pulsed magnetic fields.

When magnetic field is applied on a metal, a quantum phenomenon called Shubnikov-de Haas oscillation may occur, exhibiting an oscillatory resistivity with the increasing fields. This effect is often detected at very low temperatures and in sufficient high magnetic fields, which has been already studied in pulsed fields by electrical transport measurement. For a magnetic insulator, magnetization is usually measured in pulsed fields to explore various magnetic field induced phase transitions or nontrivial quantum states. Whereas for a metallic magnet, another kind of quantum oscillation, namely, de Haas-van Alphen oscillation may be observed with a periodicity in 1/B. This weak quantum effect can be measured by the superconducting quantum interference device (SQUID) with a high sensitivity (~10^{-7}emu). However, magnetization measurement in pulsed magnetic fields adopts a conventional induction method different from SQUID. This technique has a relatively low sensitivity; fabrication of a high density (>1000 turns) pick-up coil within a small sample space (DF~3mm) is challenging.

The Wuhan National High Magnetic Field Center (WHMFC), which is the first pulsed high magnetic field facility in China, supplies ultrahigh magnetic field, pulsed flat-top magnetic field, and continuously pulsed magnetic field for scientific research. The WHMFC facility provides different types of pulsed magnets and magnetic field wave forms for various experimental needs, ranging from 50 to 94.8T with a pulse duration from 8 to 2000ms. It has been equipped with highly sophisticated infrastructure for specific measurements under high magnetic fields. Eight experimental stations for measuring the electrical transport properties, magnetic properties, magneto-optical properties, electron spin resonance, and other properties of materials can be used in parallel. Figure 1(a) shows the magnetization measurement system in pulsed high magnetic fields. This project will be carried out in the magnetization station at the WHMFC.

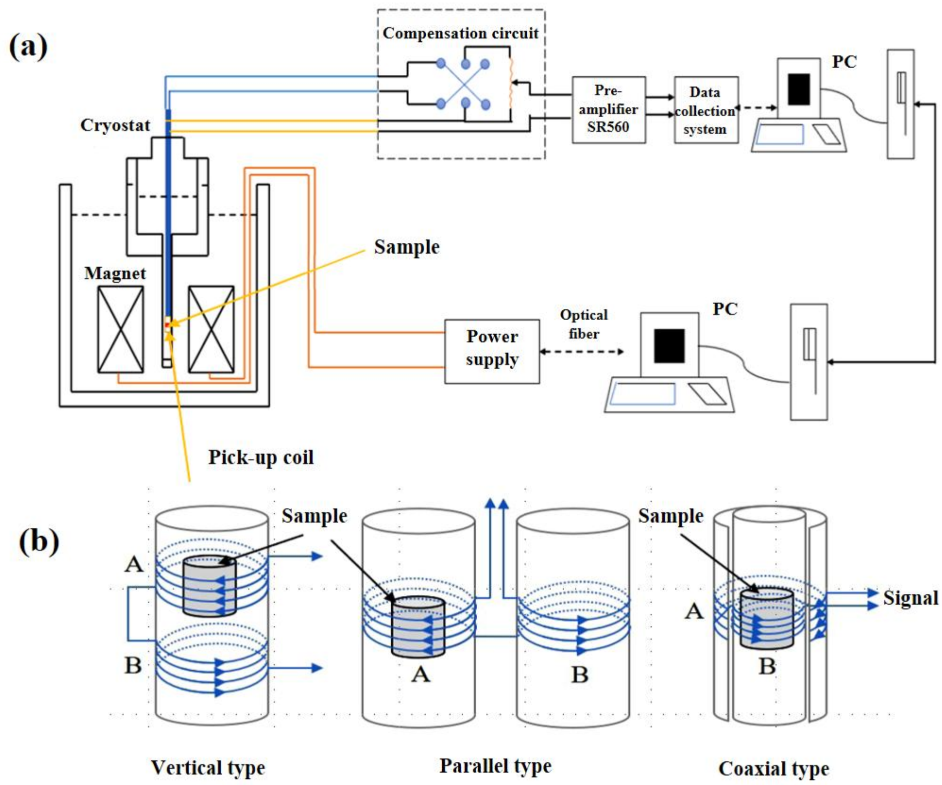

Fig. 1. Magnetization measurement system in pulsed magnetic fields (a) and three different designs of the pick-up coil (b).

Project Aims:

De Haas-van Alphen effect is one of the macroscopic quantum phenomena where the magnetic susceptibility or magnetization of a sample shows 1/B (B is the magnetic field) periodic oscillations with increasing magnetic field strength. Currently, magnetization measurement under pulsed high magnetic fields adopts Maxwell's electromagnetic induction method. The corresponding pick-up coil has few turns and low sensitivity, which makes it difficult to detect this weak quantum effect. In this project, we will optimize design of the pick-up coil, and assemble high density with winding more turns in a limited sample space. Meanwhile, we will design the control circuit to eliminate influence of the increasing inductance of the coil on the physical property measurements in such a short pulse time. Through this work, we expect to realize an accurate measurement of de Haas-van Alphen quantum oscillations under pulsed high magnetic fields.

Methods:

The pick-up coil is the key for magnetization measurement in pulsed magnetic fields. The coil contains part A and part B which are well compensated in applied external fields with opposite winding directions. Figure 1(b) shows several designs of the pick-up coil at the WHMFC. The coil is wound using the copper wire with an insulating layer. The diameter of the coil should be limited toF=5mm to match the narrow space of the tail in Helium cryostat. The winding of the pick-up coil under the microscope is a tough work. To make a high density coil, a thin copper wire with a diameter of 10-20mm is used. Glue should be added carefully between the thin wires to avoid any expansion and damage of the pick-up coil during the pulsed shot.

In the magnetization measurement, two pulse shots with sample-in and sample-out are carried out to subtract the spurious dB/dt signals induced by the pulsed magnetic fields. The signals of dM/dt from the sample are then collected and integrated as a function of magnetic fields. A pulsed magnetic field up to 55T with a duration time of 10ms is generated by using a short pulsed magnet energized by 1.25 MJ capacitor bank. The high field magnetization data are calibrated by a comparison with the low field data measured by SQUID. Fourier transform of the data should be done finally to analyze the frequency information of the de Haas-van Alphen oscillations.

Project summary

This project focuses on a new experimental technique, i.e., de Haas-van Alphen measurement in pulsed magnetic fields using a high sensitivity pick-up coil. By utilizing this technique, we are able to measure the magnetic quantum oscillations of metallic sample at low temperatures and extend magnetic field range much higher than that by SQUID. This project includes two steps: (1) we first fabricate a high density (>1000 turns) pick-up coil and (2) then measure the de Haas-van Alphen quantum oscillations in pulsed high magnetic fields. Winding of the pick-up coil is challenging and needs special skills. When turns are less, the sensitivity is low; when turns are too much, new problem arises. For example, the inductance of coil increases and the measurement in millisecond time becomes difficult. Success of this kind of coil depends on whether we can detect the de Haas-van Alphen effect in subsequent magnetization measurements in pulsed fields. Through this project, the applicant will not only learn knowledge of quantum physics but also study the operation of measurement system in a large scale facility.

Assessment

Oral presentation within 30 minutes is required by the end of internship.

Applicant profile:

We are interested in the undergraduate and graduate interns. The interns should have an interest in the fields of condensed matter physics, low temperature physics, as well as experimental techniques. In addition, they should have studied the basic knowledge about the cryogenics and are able to operate liquid helium and liquid nitrogen. Skills of origin and LabVIEW software are also needed.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Position:1

Duration: from the end of June to the end of August，2023

#4 The pressure cell system for magnetization measurements under pulsed high magnetic field(Position: 1)

Techniques for physical measurements at extreme conditions of high pressure, low temperature and high magnetic fields are increasing required to explore the new properties and phenomena of materials. The magnetic measurements, such as the magnetization under high pressure is an important experiment method for the study of magnetic properties of materials. Pressure can be used as a control parameter in the same way as doping or electric and magnetic fields and can drive systems through phase transitions.

Nowadays, several types of high-pressure cells have been made for magnetic measurements at high pressure in a commercial superconducting quantum interference (SQUID) magnetometer where measurements can be done under automatic control of temperature and magnetic field. The magnetometer can resolve magnetic moment changes as small as 10^{-8}emu. The pressure cells for the magnetometer can be divided into two categories, piston-cylinder and miniature ceramic anvil high pressure cell (mCAC). Most of the cells for the SQUID magnetometer are of piston-cylinder type. Large sample volume is one of the key advantages of this cell. A precise magnetization measurement is possible. However, the pressure range is limited to at most 1.5 GPa since the inner bore diameter of the SQUID magnetometer is only 9 mm. The mCAC for the magnetometer can generate high pressures up to 15 GPa. However, the volume of the sample space in the mCAC is less than 0.01 mm^3. It can be used for the ferromagnetic or superconducting compounds with large absolute magnetization.

Under pulsed magnetic fields, the reduced resolution limits the application of the mCAC methods. As a result, the piston-cylinder method is the only routine available for the magnetization measurements under pulsed magnetic fields. A crucial point in all high pressure experiments are the pressure conditions in the cell. They need to be as hydrostatic as possible in order to get more than only qualitative results. In piston-cylinder cells, which cover a pressure region up to about 1.5 GPa, liquids such as oils or alcohols are used as pressure medium. These liquids still conserve good hydrostaticity when they solidify. The typical pulsed field high pressure cell was designed with a CuBe piston cylinder-type pressure cell and the pressure medium Daphne 7474 oil. A maximum pressure record of around 1.5 GPa was made by the group of Prof. Masayuki Hagiwara from the Osaka University. Figure 2 illustrates the design of the piston-cylinder pressure cell for the pulsed field measurements.

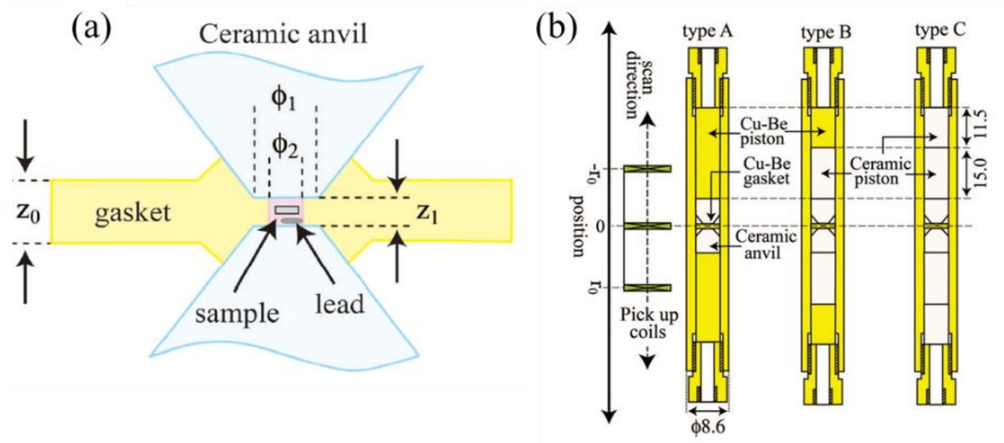

Fig.1 (a) Schematic illustration of the gasket and ceramic anvils. (b) Cross-sectional views of three typical designs of the miniature high pressure cell (mCAC) for the commercial SQUID magnetometer.

However, due to the multiple extreme conditions under pulsed magnetic fields: limited size of the magnet bore, strong electromagnetic noise, extreme short measurement durations and so on, several challenges are remained to be overcome to achieve higher pressures as well as precise measurements. This project aims to setup a new piston-cylinder pressure cell in Wuhan National High Magnetic Field Center.

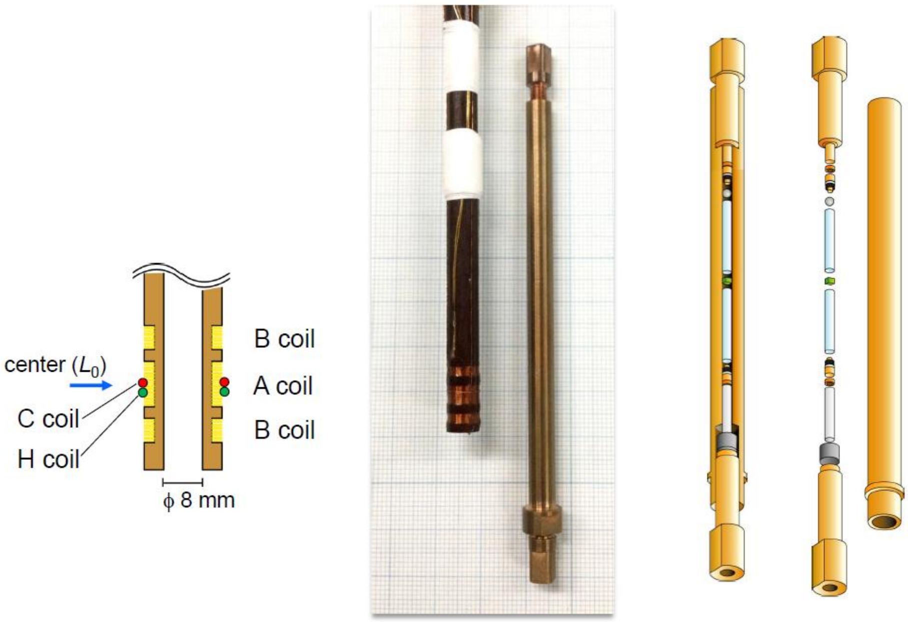

Fig.2. The design of the piston-cylinder pressure cell under pulsed magnetic field.

Project Aims:

Pressure and magnetic field are both powerful stimuli to tune the electronic structures of matters. The combination of several extreme conditions will significantly promote the exploration to novel quantum phenomenon and deepen our understandings on related mechanisms. The proposed work consists in setting up a hydrostatic pressure device, coupled to magnetization measurements under pulsed high magnetic field , in order to study the novel phenomenon related to the spin and orbital orderings in various systems.

Theinternwill help to design a piston-cylinder pressure cell, with a high-sensitive magnetization pock-up coil embedded. A prototype pressure cell should be made and the performance tests need to be performed to characterize the heating problem under pulsed magnetic fields. Through this project, we expect to set up a feasible pressure cell system for the precise magnetization measurement under pulsed fields.

Methods:

The piston-cylinder pressure cell system was proposed for the high pressure magnetization measurements under pulsed magnetic fields. The design of the pressure cell is a key factor to realize precise measurements under extreme conditions of low temperature and high pulsed magnetic fields.

The major challenge to overcome is to keep the heating effect within an acceptable value, which is mainly due to the eddy currents in the metallic part induced by pulsed magnetic fields. Ideally, a completely insulating pressure cell would be desired. This approach has been explored by using a diamond anvil cell (DAC) with a plastic body and a composite insulating gasket. However, as mentioned above, the extremely small sample space makes it impossible to generate enough magnetization signals which can be detected in pulsed fields. An alternative approach is to use a cell containing metallic elements, but which are sufficiently decoupled from the sample to ensure that most of the heat produced arrives at the sample after the end of the heat pulse, i.e., when the measurement is finished. Besides, some efforts can be made, such as opening some windows on the side of the cylinder to minimize the induction heating or manufacturing the cell and the gasket with some less conductive materials. The pressure will be monitored and calibrated by measuring the superconducting transitions of a Pb manometer located inside the gasket.

During the measurements, the heating effect should be evaluated by measuring the temperature change during the magnetic pulses. Furthermore, since the pressure strongly depends on the diameter and the compression strength of the gasket, it is also necessary to try different gaskets with different materials and diameters. All the parameters should be optimized to obtain a stable performance of the pressure cell with high pressure. After all are done, the intern will consider how to couple the pick-up coil with the pressure cell and perform magnetization measurements.

Project summary

The application of pressure to materials provides a powerful method of tuning various physical properties to search for new phase transitions in the strongly correlated electron systems. This project focuses on the design and test of a new experimental technique, i.e., high-pressure magnetization measurement in pulsed magnetic fields. A prototype piston-cylinder pressure cell is expected to be made and tested. The main challenge of this project is how to design the feasible pressure cell that can be used under pulsed field with minimized heating effect. Our group is specialized in the measurements under extreme conditions and have been working on transport measurements under high pressure and pulsed fields, as well as the magnetization measurements. The intern will have full access to all of the group’s facilities and obtain full support to finish this project. The intern will also be involved in experiments in high magnetic fields up to 60 T.

Assessment

Oral presentation within 30 mins is required by the end of internship.

Applicant profile:

We are interested in the undergraduate and graduate interns.

The intern should have an interest in the field of solid state physics, and should be highly motivated by experimental physics.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Position:1

Duration: from the end of June to the end of August, 2023

#5 Generation and Measurement of Attosecond Laser (Position: 1)

Attosecond science has emerged as an important research area of ultrafast phenomena within the past decade. Owing to its numerous successes, attosecond science has created important new knowledge of the fundamental science of the interaction between electrons and photons. Recently, some key research topics have been identified, which are expected to make major breakthroughs for the next attosecond frontiers, such as the MHz high-repetition high-order harmonic frequency combs for the joint frontier of precision spectroscopy and ultrafast science, attosecond-pump/attosecond-probe experiments for observing and controlling electronic processes in atomic and molecular physics, and nonlinear science occurring on the attosecond time scale.

To seriously tackle the above interesting research topics, one of the most important issues is the development of high-power isolated attosecond pulses (IAPs) and/or attosecond pulse trains (APTs). IAPs and APTs are produced using high-order harmonic generation (HHG) in gases. To date, high-power APTs have successfully been generated owing to research on high harmonic energy scaling using a loose-focusing geometry. APTs with sufficiently high energy in the microjoule range with a high conversion efficiency on the 10^{-4} level were generated, which are intense enough for implementing some applications, such as nonlinear attosecond optics without the assistance of laser pulses, single-shot femtosecond holography and an external injector for a seeded free-electron laser (FEL) in the extreme-ultraviolet (XUV) region. In contrast, the output energy of IAPs is still not sufficient for various applications, although the shortest pulse duration achieved is sub-100 as. The widespread application of IAPs has been limited because of the low photon flux and the complexity of the laser systems required to produce IAPs. At present, the production, characterization, and application of high-energy IAPs are still under active investigation.

Theoretically, synthesized sub-cycle driver pulses with a "perfect waveform" were proposed for optimized HHG and IAP production, and the enhancement of the HHG by using these synthesized waveforms was experimentally and theoretically studied. On the basis of the above results, synthesized few/multicycle driving pulses are expected to enable scaling up of the energy and efficiency of IAP generation. To obtain IAPs with pulse energies reaching the microjoule level, a Terawatt (TW)-class waveform synthesizer is necessary, which requires the use of high-energy femtosecond lasers that are all operated at low repetition rates (e.g., 10 Hz). In this project, we will set up a Terawatt (TW)-class two-color laser waveform synthesizer to generate a high-power IAP. We expect the pulse duration of the IAP to be about 200 as and the pulse energy can reach about 300 nJ.

1. Introduction of the Lab.

Ultrafast Optics (UFO) Lab in HUST mainly engages in the studies of strong field ultrafast optics. The research interests include attosecond pulse generation, atomic, molecular, and optical physics in strong-field, and ultrafast micronano optics. In the past twenty years, the UFO Lab has achieved many fruitful research results. The group members have published nearly 600 SCI papers in PRL, Nature Photonics, Nature Communications, Optics Letters, Optics Express, PRA, and other academic journals. The UFO Lab has 15 in-service teachers and good experimental conditions, which can guarantee the successful implementation of this project.

Visit UFO at: http://ufolab.phys.hust.edu.cn/

Wuhan National Laboratory for Optoelectronics (WNLO) is one of the six national research centers approved by the Ministry of Science and Technology of China in 2017. As an interdisciplinary research center, WNLO focuses on basic scientific and technological researches in the fields of optoelectronics for information, energy, and life science. In recent years, it has achieved fruitful results in fields including brain imaging, solar cells, ultrafast lasers, laser manufacturing, optoelectronic devices and integration, data storage etc.

Visit WNLO at: http://english.wnlo.hust.edu.cn/

Project Aims

In this project, we aim to produce a high-power IAP (200 as, 300 nJ) with a TW-class two-/three-color laser waveform synthesizer and measure its spatio-temporal profile with an all-optical method.

Methods

For the generation of high-power IAP, we will build a TW-class waveform synthesizer for two- or three-color laser fields. The synthesized laser field will interact with rare gases (e.g., Ar, Ne, Xe, and so on) to generate high-order harmonics. We will optimize the synthesized laser waveform to optimize the power and duration of the generated IAP.

To precisely manipulate the waveform of the synthesized laser, we will build a stability-control system for the synthesizer. In this system, we have to eliminate the relative timing and phase jitters as well as stabilizing carrier-envelope phases (CEPs) for each channel in the synthesizer.

For the measurement of the generated IAP, we will build an attosecond streaking camera equipment. Meanwhile, we will also develop an all-optical method to measure the pulse duration of the attosecond laser.

Project Summary

In this project, we intend to carry out experimental research on the generation and measurement of high-power attosecond laser. In this project, we will use a terawatt femtosecond laser in combination with a multi-channel laser coherent synthesis scheme to interact with rare gases to generate high-power attosecond pulses.

And the generated attosecond laser will be measured and characterized by the attosecond streaking camera technology or the all-optical method. The specific research contents include: (1) the construction of a multi-channel (two-color, three-color) femtosecond laser coherent synthesizer and its stability-control system; (2) the construction of attosecond streaking camera equipment; (3) the all-optical measurement of attosecond laser.

Assessment

An oral presentation is required by the end of the internship.

Applicant Profile

We are interested in undergraduate and graduate interns.

The interns should have studied basic knowledge about a range of fields in science and technology, particularly quantum mechanics, electrodynamics, optics, and signal processing.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our languages of instruction and work.

#6 Study on High Efficiency Tandem Perovskite Solar Cells (Positions: 2)

Extensive research on perovskite-based photovoltaics (PV) over the past decade led to rapid development, with power conversion efficiencies (PCEs) exceeding 25.2% being realized. Hybrid organic–inorganic metal halide perovskite semiconductors continue to attract enormous attention due to their exceptional optoelectronic properties, such as their high absorption coefficients, high carrier mobilities, and low recombination rates. The widely tunable band gap of these perovskites by compositional variations of the halide anion in the perovskite crystal structure allows strong light absorption in a broad spectral range. With their low material costs and a wide range of possible deposition techniques, perovskites qualify as promising candidates for next-generation multi-junction PV. Moreover, combined with established PV technologies, like wafer-based silicon or copper indium gallium selenide films, perovskite-based tandems are currently the most promising technology for terrestrial PV to enable PCEs exceeding the single-junction Shockley-Queisser limit.

The recent development in perovskite PV has been largely underpinned by advances in the composition and morphology of the perovskite absorber layer as well as progress in device architectures by employing passivation layers and optimizing hole and electron transport layers (HTLs and ETLs). Nevertheless, fundamental challenges, such as the toxicity of lead-based perovskites, the limited stabilities of the various layers-such as the perovskite absorber, charge trans-port layers (CTL), and combinations thereof-in terms of moisture, light, and heat stress remain to be solved. One promising route to cope the stability of the devices is via the replacement of organic CTLs with inorganic counterparts. In this regard, the HTLs, copper iodide (CuI), copper thiocyanate (CuSNC), and nickel oxide (NiOx) have been shown to promise good intrinsic chemical stability compared to the commonly used organic HTL spiro-OMeTAD. In addition, ETLs like zinc oxide (ZnO), tin oxide (SnO_2), and mesoporous titanium dioxide (TiO_2) are known to be intrinsically stable and have been demonstrated to result in highly efficient and stable perovskite solar cells.

However, conventional methods for layer deposition significantly limits the choice of materials, deposition techniques, and device architectures, due to solvent incompatibilities or process-induced damage of underlying layers during vacuum-based physical vapor deposition (PVD) and chemical vapor deposition (CVD) processes. Whereas the CTL under the perovskite must be robust against the perovskite deposition, many polar solvents have to be avoided for the layers, which are solution-processed on top of the perovskite to prevent decomposition or degradation. Similarly, high temperatures, radicals, and ion bombardment must be limited due to the possible damage of the underlying layers during PVD and CVD techniques such as sputtering, atomic layer deposition, or electron-beam evaporation. In this regard, metal-oxide or fullerene-based buffer layers are usually employed that protect the underlying absorber layer. Therefore, not every combination of ETL and HTL is accessible in a straightforward manner.

In this project, we will vigorously develop the technology of laminated perovskite solar cells.

2. Introduction of the Lab.

Our research group, Optoelectronic Devices and 3D Integration Team (ODTI), was founded in May 2012, mainly focusing on the research of new photoelectric conversion materials and devices, hoping to do the basic research with new ideas in science and promising technology, in order to live up to the taxpayers' money and the time of students and teachers. The research group attaches importance to students' basic scientific research skills, emphasizes all-round development, advocates student-oriented management philosophy, and strives to create a happy and comfortable environment for scientific research and experiment. We sincerely invite students with passion and pursuit for scientific research to join us. Those with photoelectric physics and materials chemistry background are welcome.

The leader of ODTI is Professor Tang Jiang, Dean of the School of Optics and Electronic Information, Huazhong University of Science and Technology, and Deputy Director of Wuhan National Laboratory for Optoelectronics. The team has 9 professors, 5 associate professors, and nearly 200 post-doctoral, doctoral and master students. Relying on advantageous scientific research platforms such as Wuhan National Laboratory for Optoelectronics, School of Optics and Electronic Information, and Hubei Optics Valley Laboratory, our team is mainly engaged in the application of optoelectronic materials, devices and chips. Some research achievements have been made in antimony selenide thin film solar cells, quantum dot near infrared detectors, perovskite X-ray detectors and light-emitting diodes. The related work is published in Nature, Nature Photonics, Nature Energy, Nature Electronics and other journals.

Visit ODTI at: http://tfsc.wnlo.hust.edu.cn/

Wuhan National Laboratory for Optoelectronics (WNLO) is one of the six national research centers approved by the Ministry of Science and Technology of China in 2017. As an interdisciplinary research center, WNLO focuses on basic scientific and technological researches in the fields of optoelectronics for information, energy, and life science. In recent years, it has achieved fruitful results in fields including brain imaging, solar cells, ultrafast lasers, laser manufacturing, optoelectronic devices and integration, data storage etc.

Visit WNLO at: http://english.wnlo.hust.edu.cn/

Project Aims

In this project, in view of the good photovoltaic performance of the perovskite, the perovskite thin films with narrow band gap (band gap width around 1.15 eV) and wide band gap (band gap width around 1.70 eV) are prepared by rotating coating method, thermal evaporation method and scraping method, respectively.

The open-circuit voltage and current of the laminated cell are increased by additive doping and energy level regulation. The intermediate interconnect layer ITO is prepared by Reactive Plasma Deposition (RPD) technology, which effectively achieves efficient carrier tunneling compound and improves the device's filling factor and efficiency. Strive to achieve efficiency over 30%, MPP of the T50 performance stability over 1000 hours of laminated solar cells.

Methods and Contents

1. Preparation of wide and narrow band gap perovskite thin films

Based on the structure of ABX_3, the band gap of the perovskite material can be adjusted to 1.15 eV and 1.70 eV, respectively, by adjusting the components of the A cation and the X halogen ion. Perovskite films with stable performance and suitable band gap can be prepared by means of spinning coating, thermal evaporation and scraping coating.

2. High efficiency and stability of single perovskite solar cell preparation

Efficient and stable single perovskite solar cells with band gaps of 1.15eV and 1.70eV are prepared respectively to obtain large short circuit current and open circuit voltage, and strive to achieve efficiency of more than 20%, laying a foundation for the preparation of laminate cells.

3. Preparation of perovskite and perovskite laminated cells

(1) Study on interconnect layer between perovskite cell and perovskite cell. RPD and ALD technologies are used to prepare the intermediate junction layer, and the charge loss and transmission process at the intermediate junction layer are studied to obtain the maximum efficiency.

(2) Preparation of perovskite battery and perovskite battery integrated device. Optimized structure design and device fabrication of laminated cells.

Project Summary

In this project, we regulate the band gap of perovskite materials by adjusting its A-site cation and X-site halogen based on theCH3NH3PbI3 perovskite ion respectively. Perovskite films with band gaps of 1.15 eV and 1.70 eV are prepared by rotating coating, thermal evaporation and scraping coating. Based on these thin films, a single perovskite solar cell with a band gap of 1.15eV and 1.70eV is prepared, respectively. The high short-circuit current and open-circuit voltage are obtained, and the efficiency is strived to exceed 20%, which lays a foundation for the preparation of laminated cells. RPD and ALD technologies are used to prepare the intermediate junction layer, and the two types of perovskite solar cells aree integrated to prepare the layered perovskite solar cells. The charge loss and charge transfer at the intermediate junction layer are studied, and the efficiency of the prepared integrated devices is more than 26%.

Assessment

Oral presentation is required by the end of internship.

Applicant Profile

We are interested in the undergraduate and graduate interns.

The interns should have an interest in the field of big data analysis, solar cell, optoelectronic device, and have already demonstrated strong research potential.

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly image and date processing, preparation and characterization of semiconductor materials, SEM, TEM, XRD measurement, etc.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

#7 Research on Silicon based Multi-Dimensional Multiplexing Optical Communication System (Positions: 2)

In recent years, with the rapid development of modern information technology, data communication traffic has also shown an explosive growth, which puts forward higher requirements for data storage, interconnect communication and signal processing. Using photons as information carriers in optical communications could take the unique advantages of high speed, large bandwidth and low latency, while silicon integrated photonics features the characteristics of high integration, low power consumption and low cost, providing a promising platform for the development of modern communication networks. Besides, photons could offer multiple physical resource dimensions such as frequency/wavelength, polarization, time, complex amplitude, and spatial structure as shown in Fig. 1, which could be developed into various multiplexing technologies as well as hybrid multi-dimensional multiplexing technology, providing the possibility for the further improvement of communication capacity. Therefore, the research on silicon integrated photonic chips for multi-dimensional multiplexing and processing has important strategic significance for the development of future high-speed and large-capacity communication networks.

Although multiple multiplexing technologies such as wavelength-division multiplexing (WDM), polarization-division multiplexing (PDM), mode-division multiplexing (MDM) and advanced modulation formats have developed rapidly in the past few decades, challenge remains to handle hybrid multi-dimensional multiplexing signals applied in fiber-to-chip optical processing systems. Not only the multi-dimensional signal processing puts forward higher requirements to the performance of on-chip integrated devices, including bandwidth limitation, polarization sensitivity and so on.

However, challenges remain to realize multidimensional hybrid multiplexing data transmission and signal processing between few-mode fiber transmission links and on-chip optical processing networks, since the optical coupling between fiber and chip almost exclusively in single mode regime.

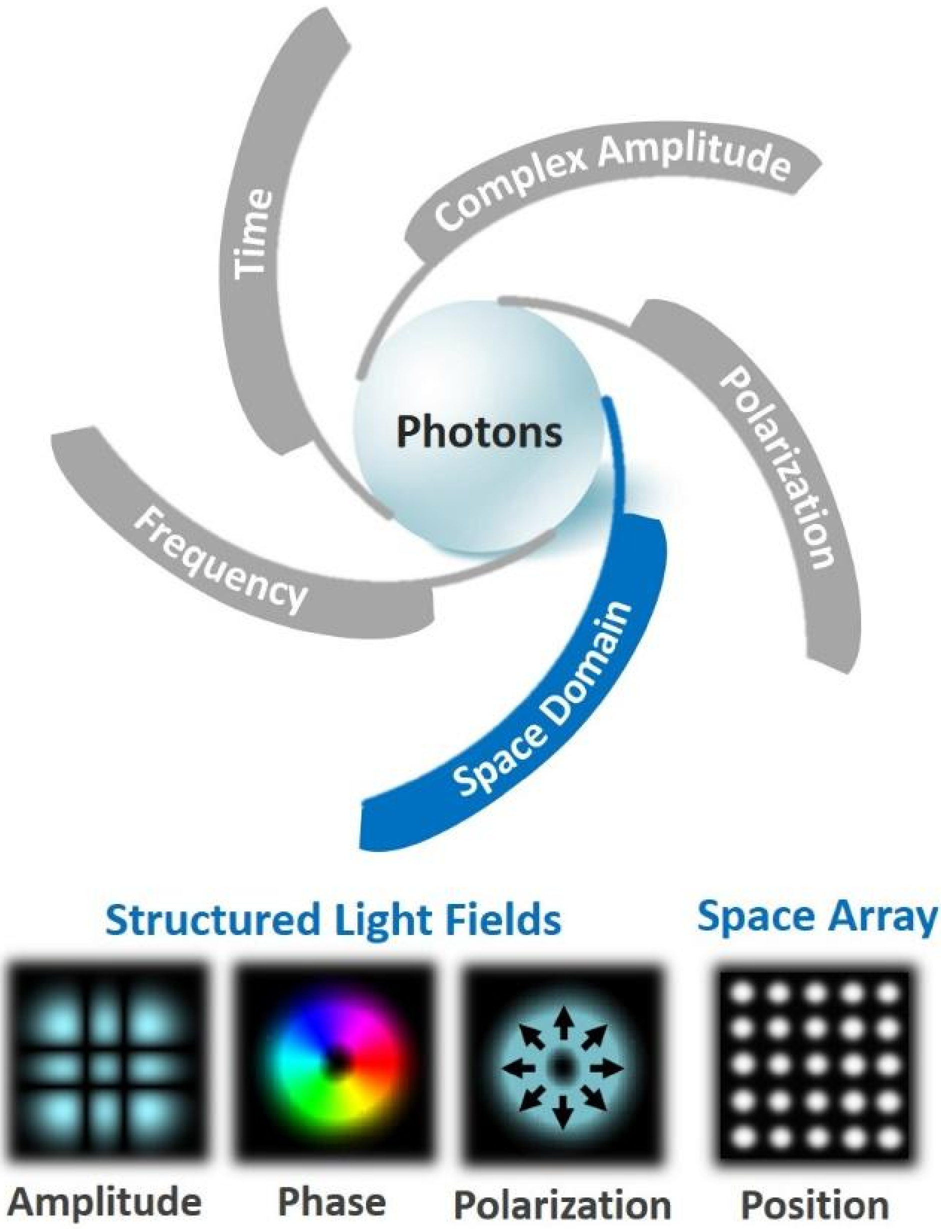

Fig. 1. Schematic illustration of physical dimension resources of photons (wavelength/frequency, time, complex amplitude, polarization, space domain). Manipulating the space domain of lightwaves for structured light field (spatial amplitude, spatial phase, spatial polarization) and space array (spatial position).

4. Introduction of the Lab.

The Multi-Dimensional Photonics Laboratory (MDPL) is led by Professor Wang Jian. The group is mainly focusing on the multiple physical resource dimensions of photons (frequency, time, polarization, complex amplitude, space), especially the new dimension, i.e. space dimension of photon. The research interests include: high-speed and large-capacity vortex beam/vector beam/structured light multi-dimensional optical communication, data center and high-performance optical interconnection, free space/underwater/optical fiber/chip optical communication and optical interconnection, high-speed and large-capacity intelligent multi-dimensional optical signal processing, space division multiplexing optical amplification technology, manipulation of multi-dimensional optical field on chip, silicon-based photonic integrated chip, optoelectronic integration chip, femtosecond laser direct writing photonic integrated chip, surface plasma/metamaterial/metasurface devices, special transmission fiber/active fiber/optical fiber devices.

Prof. Wang Jian's research interests include optical communications, optical signal processing, silicon photonics, photonic integration, orbital angular momentum, and structured light. He has been the Principal Investigator of >20 earmarked grants (NSFC, 973, etc.). He has published over 240 refereed international journal papers on Science, Science Advances, Nature Photonics, Nature Communications, Light: Science & Applications, Physical Review Letters, Optica, Laser & Photonics Reviews, ACS Photonics, Nanoscale, Nanophotonics, Photonics Research, Optics Express, Optics Letters, etc. He has authored and co-authored over 150 international conference papers on OFC, ECOC, CLEO, etc. He has also given over 110 tutorial/keynote/invited talks in international conferences including the invited talk at OFC2014 and tutorial talk at OFC2016.

Wang Jian has done pioneer works in twisted light communications employing orbital angular momentum

(OAM) multiplexing, which facilitates sustainable capacity increase of optical communications. Wang Jian and co-workers demonstrated terabit-scale free-space OAM communications (Nature Photonics, 6, 488, 2012, times cited: 2608; Science, 337, 655, 2012). Wang Jian has later played a leading role in twisted and structured light communications as well as multi-dimensional optical communications. He studied fundamental properties of spin angular momentum (SAM), OAM and vector beams (Nature Communications, 12, 4186, 2021; Physical Review Letters, 127, 233901, 2021; Laser & Photonics Reviews, 11, 1700183, 2017, Cover; Laser & Photonics Reviews, 14, 2000249, 2020, Cover), implemented outdoor free-space and adaptive underwater OAM communications, demonstrated OAM amplifier (Research, 2020, 7623751, 2020) and record 300-km fiber OAM communications. He realized structured light communications (Bessel, Airy, vector) and demonstrated the direct fiber vector eigenmode multiplexing transmission (Light: Science & Applications, 7, 17148, 2018, Cover). He authored/co-authored important review articles and comments on twisted (Photonics Research, 4, B14, 2016, times cited: 378; Advances in Optics and Photonics, 7, 66, 2015, times cited: 927) and structured light communications (Nature Photonics, 12, 249, 2018). These works were interviewed by the Nature Photonics editor (Dr. Rachel Won) (Nature Photonics, 11, 619, 2017).

Wang Jian and co-works have made an important breakthrough in multi-dimensional entanglement transport through single-mode fiber (SMF) (Science Advances, 6, eaay0837, 2020). By entangling spin-orbit degrees of freedom of a biphoton pair, passing the spin photon down the SMF while accessing multiple OAM subspaces with the other, multi-dimensional entanglement transport was realized, showing distinct advantages of deployment over legacy networks with conventional SMF.

Wang Jian has done innovative works in photonic integrated devices on different platforms for twisting and structuring light. Wang Jian demonstrated on-chip OAM generator (Optics Letters, 43, 3140, 2018, Editor's Pick), all-fiber OAM generator (Optics Letters, 40, 4376, 2015), metasurface for structuring light (Optics Letters, 38, 932, 2013), and integrated vector laser (ACS Photonics, 6, 3261, 2019, Cover). Very recently, he demonstrated ultra-compact broadband polarization diversity OAM generator with 3.6x3.6 μm2 footprint (Science Advances, 5, eaau9593, 2019).

Wang Jian has also done lots of works of great significance in chip-scale optical signal processing. Some representative contributions include terabit-scale on-chip optical interconnects, chiral silicon photonic circuits (Optica, 6, 61066, 2019), subwavelength slot waveguides (Physical Review Letters, 127, 233902, 2021), subwavelength grating slot microring resonators (Nanoscale, 12, 15620, 2020), reconfigurable multi-functional photonic signal processor (ACS Photonics, 7, 1235, 2020, Cover) and programmable multi-task photonic signal processor (ACS Photonics, 7, 2658, 2020, Cover) on a silicon chip.

Wuhan National Laboratory for Optoelectronics (WNLO) is one of the six national research centers approved by the Ministry of Science and Technology of China in 2017. As an interdisciplinary research center, WNLO focuses on basic scientific and technological researches in the fields of optoelectronics for information, energy, and life science. In recent years, it has achieved fruitful results in fields including brain imaging, solar cells, ultrafast lasers, laser manufacturing, optoelectronic devices and integration, data storage etc.

Visit WNLO at: http://english.wnlo.hust.edu.cn/

Project Aims

In this project, we will propose to use silicon-based integrated photonic devices to realize multi-dimensional fiber-to-chip optical processing system for hybrid wavelength-, mode- and polarization-division multiplexing signals.

First of all, in order to solve the few-mode fiber transmission link to the silicon integrated optical processing chip, the efficient mode coupling device between few-mode fiber and multi-mode photonic chip needs to be designed. We propose a multi-mode coupler based on heterogeneous waveguides, which enables the direct coupling for multiple guided modes between FMF and silicon integrated chip. The proposed multi-mode coupler consists of tapered FMF and silicon integrated multistage waveguide tapers buried in the polymer waveguide, where the tapered fiber acts as one transition optical waveguide to reduce the mode spot size as well as the coupling loss, while the silicon integrated multistage waveguide tapers are used to realize mode conversion.

Secondly, the multi-dimensional multiplexing processing on the silicon-based chip needs to be designed. The silicon multiple guided modes are demultiplexed into fundamental TE and TM modes based on the cascaded ADC structure, then PR structure is introduced to rotate the fundamental TM mode into fundamental TE mode. The silicon integrated chip takes advantages of parallel cascaded micro-ring resonator array to perform the signal processing function as reconfigurable optical add-drop multiplexer (ROADM). Finally, the chip can realize multi-dimensional fiber-to-chip optical processing system for hybrid wavelength-, mode- and polarization-division multiplexing signals.

Methods

This project mainly adopts FDTD and EME algorithms for simulation and design of silicon-based integrated photonic devices: the efficient mode coupling device between few-mode fiber and multi-mode photonic chip, mode (de)multiplexer, micro-ring (wavelength (de)multiplexer) and polarization (de)multiplexer so as to build the whole silicon based processing chip. For the fabrication of devices, we will use electron beam lithography (EBL) technology to fabricate silicon-based integrated photonic devices.

Project Summary

After decades of development, the traditional single-mode optical fiber communication has approached its Shannon capacity limit and have begun to have a new capacity crisis. Photons offer multiple physical resource dimensions such as polarization, frequency/wavelength, amplitude, phase, time, etc. The exploration of new dimensions and multi-dimensional integration of photonics is the key to the sustainable expansion of optical communications. Silicon-based integrated photonics has the characteristics of high integration, low power consumption and low cost, which provides a promising platform for the development of optical communication networks. This project studies the key technical issues in multi-dimension multiplexing processing, and realizes the hybrid wavelength-, mode- and polarization-division multiplexing on chip with photonic integrated devices, and realizes the multi-dimension signal processing system of fiber-to-chip- to-fiber.

Assessment

Oral presentation is required by the end of internship.

Applicant Profile

We are interested in the undergraduate and graduate interns.

The interns should have an interest in the field of optical communication, optical processing, and integrated optics.

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly optical communication, optical processing, and integrated optics.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

#8 Energy efficiency: HVAC (Positions: 3)

This project will focus on the hot issue of high energy consumption of building HVAC systems. In the building system, the energy consumption of Heating, Ventilation and Air Conditioning (HVAC) system accounts for 40%-60% of the energy consumption of the whole building system. Therefore, it is of great significance to construct an energy consumption prediction model for the internal air conditioning system of the building and realize high precision energy consumption prediction.

In recent years, with the development of technologies such as the Internet of Things, the measured data collection level of HVAC system is constantly improving, but there are still problems such as data quality that limit the development of energy consumption prediction. At the same time, in 2021, the Ministry of Housing and Urban-Rural Development issued a document pointing out that it is necessary to promote intelligent production, promote intelligent construction, develop digital design, build Internet platforms for the construction industry and accelerate the digital transformation and upgrading of the construction industry. Therefore, it is worth studying how to improve energy consumption prediction effect, promote energy conservation and carbon reduction of buildings and improve energy efficiency of buildings based on new digital technologies such as big data and artificial intelligence under existing deficiencies.

Therefore, this project will take building HVAC system as the research object, develop energy consumption prediction model, effectively analyze its energy performance and energy saving potential, and control building operation mode, improve energy utilization efficiency and reduce energy consumption and carbon emissions.

The content of project.

To develop building HVAC energy consumption prediction system, it is necessary to integrate geometeorological information and building operation information, collect the operation data of HVAC system, display the operating status of equipment in real time, and carry out automatic analysis and information feedback. The project needs to achieve two important functions:

Detect abnormal running state of HVAC system and provide warning.

Real-time collection and prediction of energy consumption data of building HVAC system.

An energy consumption forecasting system need to be established from four aspects: data acquisition, data calculation, data display and data application. Data acquisition is when sensors of HVAC systems and equipment send real-time data to computing servers via the Internet of Things according to specified communication protocols. Data calculation is to use big data analysis method and machine learning algorithm to analyze real-time data and give results, such as abnormal alarm information, energy consumption distribution information, energy consumption prediction results, optimization control signals, etc. For example, real-time monitoring of HVAC system, abnormal alarm and record, equipment asset information, energy consumption prediction results, energy saving and optimization control history, comprehensive statistical analysis report, etc. Data display is the display of all information from the system in the form of charts, tables and graphs, etc. Data application refers to the evaluation of future energy saving measures or other improvement plans by managers or decision makers based on available information.

To achieve above goal, the interns will be provided with real data collected form HVAC in commercial buildings. This internship also provides the opportunity to visit and learn from the cooling plant commercial buildings, and guidance about how to apply data-driven for application purpose in HVAC systems will be also provided.

The aimsof this project are to develop energy consumption prediction model of building HVAC system, realize data acquisition and transmission, and carry out real-time monitoring and control of system operation and energy consumption. At the same time, when system abnormalities and excessive energy consumption are found and demand side responds to demand, timely warning and control can be achieved, and real-time energy consumption prediction can be made to predict short-term energy consumption with high precision.

Methods:

The operation and maintenance system software of this project is mainly written as Python and R language.

The visual design of vehicle and subway station structures in this project can be done by using SketchUp, EnergyPlus and Autodesk Revit software.

The object of this project is building HVAC system, and the main method is big data analysis. Therefore, big data analysis and machine learning algorithm are used widely in this project.

The air conditioning equipment data and communication protocol will be provided. Energy consumption prediction methods will be trained and guided by our research group.

By the end of this project interns will gain:

Deep understanding of building HVAC system.

Learning the real cooling system of commercial building.

Deep understanding of how to apply big data analysis and artificial intelligence method into energy consumption prediction system.

An ability in programming based on python and R language.

An ability in designingenergy predictionmodel of building HVAC system based on Sketchup, EnergyPlus and Autodesk Revit software.

Applicant profile:

We are interested in the undergraduate and graduate interns.

The interns should have an interest in the field of big data analysis, machine learning, smart city, intelligent operation and maintenanceof HVAC systemsand have already demonstrated strong research potential.

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly mechanical equipment, heating, ventilation and air condition system, programming, big data analysis.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Positions:3

Duration: from the end of June to the end of August，2023

#9 Energy Efficiency:the research for volatile organic compounds (VOCs) abatement (Position: 1)

The VOCs are one of the main air pollutants in China and results in haze and high ozone level in the urban area. This project will offer the opportunity to understand the research for volatile organic compounds (VOCs) abatement by catalytic combustion. From the catalyst preparation, microstructure/surface property characterization to catalytic performance evaluation, the student can devote to the whole research process for the catalytic combustion abatement of VOCs. In addition, the site visit on the company can be offered depending on the situation in order to further understand the practical solution for VOCs abatement in China.

The aims of this project are to design and synthesize effective catalysts for VOCs abatement, including catalyst preparation, catalyst characterization and their catalytic activity evaluation.

Methods:

This project applies the methods including:

Catalyst preparation: Hydrothermal, Sol-gel and so on;

Catalyst characterization: XRD, H_2-TPR, O_2-TPD, SEM and so on;

Catalytic activity evaluation: the fixed-bed reactor.

By the end of this project interns should have gained:

A very good chance to understand the air pollution control in China

An ability in catalyst preparation.

An ability in catalyst characterization.

An ability in catalytic activity evaluation

Applicant profile:

We are interested intheundergraduate and graduate interns.

The interns should have an interest in the field of industrial catalysis, especially in air pollution control (undergraduate) and have already demonstrated strong research potential (graduate).

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly chemistry, nanomaterials and so on (undergraduate).

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Position:1

Duration: from the end of June to the end of August，2023

#10 Energy Efficiency: CO2 catalytic conversion (Position: 1)

This project provides a scheme of CO2 catalytic conversion. CO2 has attracted a lot of attention over the last 20 years due to the link between the increases in CO2 emissions with the rise in global temperatures and especially recently high motivation for carbon neutral society scenarios (2050 for EU and Japan; 2060 for China). Rather than viewing the CO2 as a waste material, the conversion of CO2 to value added products, such as methane, methanol, ethanol, olefin and other hydrocarbons, has attracted much attention.

The aims of this project are to catalyze CO2 to methanol. By the means of catalytic pathway design and catalysts synthesize to achieve the high activity and selectivity. Moreover, our lab also aims at better understanding CO2 activation and catalytic mechanism.

Method: This project applies the methods including:

catalyst preparation

catalyst characterization: XRD, SEM, TEM, In-Situ DRIFTS measurements etc.

catalytic activity measurements

By the end of this project interns will gain:

An ability in catalyst preparation.

An ability in catalyst characterization.
An ability in catalytic activity measurements.

Applicant profile:

We are interested intheundergraduate and graduate interns.

The interns should have an interest in the field of path plan and have already demonstrated strong research potential.

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly Control Science and Engineering.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Position: 1

Duration: from the end of June to the end of August, 2023

#11 Biomass technology +Solar technology (Positions: 3)

This project provides new ideas on the utilization of solar energy and treatment of waste fan blade. As is known to all, wind power has developed rapidly to effectively curb global warming, and its installed capacity has been obviously increased. The wind power machine is responsible for wind power, and fan blade is key in wind power machine. However, the expected service life of wind power machine is 20–25 years, and it would be destroyed when the life time is ended. The situation would bring out a large quantities of waste fan blades and great pressures to the environment, because 10 tons composite material is required to manufacture fan blades for each additional 1 MW capacity, which indicates the waste fan blades are also important resources. Therefore, it is urgent and promising to dispose waste fan blades with high resource recovery.

Pyrolysis is an advanced technology, and has been widely applied to treat waste and achieve resource recovery. However, the traditional pyrolysis commonly needs a lot of external heat source provide by combustion, which did not benefit to reduce carbon emission. Photothermal pyrolysis can produce a limited high-temperature zone and quickly separate volatile, would thus reduce complex secondary reactions in volatile and improve products quality. Besides, photothermal would use sun light in the practical applications, which is also clean, renewable, and can reduce CO_2 emission.

This project is supported by National Key R&D program of China (No. 2018YFE0127500) and National Natural Science Foundation of China (NSFC) (No. 52076097). Sufficient funds and measures can ensure the successful and safe promotion of the project. We are a very international team with 2 international exchange scholars and rich experience in guiding exchange students. We have received 8 Oxford students and 11 international students have been working in the research group. We sincerely welcome students interested in energy and waste treatment.

The aims of this project are to investigate the application prospect of the synergistic utilization of concentrating solar energy and waste fan blade in China based on the novel concentrating photothermal pyrolysis system, including experimental analysis, economic analysis and environment protection analysis. In other words, it is to match technology and market through research, data acquisition and computational analysis

Of course, we also provide technical research posts, and abundant scientific research instruments will be fully open to you. We can witness how waste fan blade is converted into gas, oil and char. Also, the useful chemicals and materials can be prepared and recovered by photothermal pyrolysis on waste fan blade.

We will cultivate the basic knowledge of energy and resources, the basic principles of new thermal conversion technology, and the basic process of technology transformation. At the same time, we will also organize the investigation of the resources and environment around Wuhan.

This project applies the methods of laboratory visit, experimental observation, data research, process model establishment, computer simulation, data analysis, etc.

By the end of this project interns should have gained:

An ability in experimental system operation and experiments conducting.

An ability in data acquisition, collation and analysis.

An ability in paper writing and oral presentation.

Applicant profile:

We are interested in the undergraduate and graduate interns.

The interns should have an interest in the field of energy utilization, waste treatment, thermal conversion technology and have already demonstrated strong research potential.

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly energy, chemistry, physics, mathematics and so on.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Positions:3

Duration: from the end of June to the end of August，2023

#12 Energy efficiency: capture and utilization of carbon dioxide (Positions: 2)

This project provides the opportunity to learn knowledge about capture and utilization of carbon dioxide, including adsorbent technology, chemical looping, oxygen-enriched combustion, CO_2 conversion and utilization, etc. Besides, we will have a visit to 3MW oxy-fuel combustion facility for CO_2 capture.

The aim of this project is to realize the issue of Global Warming and Greenhouse Effect by controlling carbon dioxide emissions.

Method: Experimental and simulation works in developing carbon capture and utilization technologies, including the design of CO2 sorbent, solvent, and oxygen carriers, operation of lab-scale bench tests.

By the end of this project interns should have gained:

Knowledge of carbon capture and utilization technologies.

A Preliminary acquaintance of the culture in Wuhan.

Applicant profile:

We are interested in the undergraduateand graduate interns.Students from Singapore, Malaysia, Thailand, China, as well as those who love Chinese cultures, are highly expected, and we will organize additional tours in or around Wuhan city during weekends.

The interns should have an interest in the field of capture and utilization of carbon dioxide (undergraduate) and have already demonstrated strong research potential (graduate).

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly chemical engineering, mechanical engineering, and so on.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Positions:2

Duration: from the end of June to the end of August，2023

#13 Energy efficiency:build a digital twin numerical model based on a simple thermal hydraulic and heat transfer device (Position: 1)

A digital twin is a virtual representation of the real system of device, including physical objects, processes, relationships, and behaviors. It is the virtual representation of a physical object or system across its life-cycle. It uses real-time data and other sources to enable learning, reasoning, and dynamically recalibrating for improved decision making. A digital twin is a vital tool to help engineers understand not only how products are performing, but how they will perform in the future. Analysis of the data from the connected sensors, combined with other sources of information, allows us to make these predictions.

This internship project aims toprovides an opportunity to build a digital twin numerical model based on a simple thermal hydraulic and heat transfer device.

Method:This project requires to establish a numerical model, with MATLAB or other programming language, to reflect the operation of a simple thermal hydraulic and heat transfer device. Visualizing the device in computer screen and realizing the numerical simulation.

By the end of this project interns should have gained:

Understanding the idea of digital twin and intelligent manufacturing.

An ability in using some three-dimensional software to do basic 3D design.

An ability in programming to perform fundamental heat transfer calculation.

Applicant profile:

We are interested in the undergraduate and graduate interns.

The interns should have an interest in the field of heat transfer theory (undergraduate) and have already demonstrated strong research potential (graduate).

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly physics, thermodynamics, heat transfer and so on (undergraduate)

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Position:1

Duration: from the end of June to the end of August，2023

#14 Energy efficiency + solar technology (Positions: 2)

We are ready to provide the interns with a challenging and versatile research projects over the summer. They will join the students and University professors to conduct research in CO_2 catalytic reduction using solar energy. The novel nanoscale catalysts will be prepared and used to convert the greenhouse gas CO_2 to valuable products under the radiation of solar energy.

The aims of this project are to develop an efficient photocatalyst for CO_2 photoreduction and understand the related mechanism.

Method: This project applies the methods of advanced characterization technology (HR-TEM, XPS, etc.) and in situ experimental analysis to understand the mechanism of CO_2 photoreduction.

By the end of this project interns should have gained:

An ability in preparing nano photocatalyst and doing photocatalytic reaction experiment.

An ability in writing research report.

Applicant profile:

We are interested in the undergraduate and graduate interns.

The interns should have an interest in the field of in science and technology, particularly nanomaterials science, chemistry or chemical engineering science, photocatalytic reaction science, etc. (undergraduate) and have already demonstrated strong research potential (graduate).

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly chemistry, nanomaterials, photocatalysis and so on (undergraduate).

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Positions:2

Duration: from the end of June to the end of August, 2023

#15 Energy efficiency +Life Cycle Assessment (Positions: 3)

The Energy and Economics lab mainly focuses on study of energy system, climate change, resources and environment, and their interactions. The lab has formed a multi-disciplinary talent team covering energy system modeling, Life Cycle Assessment (LCA), renewable energy potential evaluation, environmental impacts analysis, etc., and has accumulated sufficient experience and strength. The team has carried out a series of pioneering work in the field of carbon footprint calculation, energy system transformation pathway design, etc. The team has completed a number of national key scientific research projects and published more than 100 SCI papers in high-level academic journals, including PNAS and Nature Communication.

The project we are currently working on is the environmental impact assessment of renewable energy. We focus on the impacts of renewable energy development on the environment in China, and its feedback on climate change.

The aim of this project is to realize evaluation of renewable energy development impacts on the environment and climate change in China, mainly focusing on wind power and solar energy. The project may reveal the relationship between renewable energy development and environmental changes, and would provide suggestion for policy makers to rationally design the development pathway of renewable.

Method: This project applies the methods of Geographic Information System (GIS), Remote sensing (RS), Python programming, Life Cycle Assessment (LCA).

By the end of this project interns should have gained:

An ability in using GIS software

An ability in performing LCA analysis

An ability in reading Python programs

An ability in scientific paper writing

Applicant profile:

We are interested in the undergraduate and graduate interns.

The interns should have an interest in the field of renewables and environment interaction evaluation and have already demonstrated strong research potential.

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly renewable.

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Positions:3

Duration: from the end of June to the end of August，2023

<u>#16 Energy efficiency (Positions: 3)</u>

This lab is engaged in the frontier and cross fields of micro/nano manufacturing. The research direction mainly includes the study of nanomaterials, nano devices and their processes, as well as to use them to solve the challenges facing the energy and electronic industry in the future. The selective atomic layer deposition method has been developed and expanded to the fields of green energy catalysis, including the development of key catalysts in new energy technologies and environmental governance technologies. And a series of outstanding achievements have been made in key technologies such as hydrogen fuel cells, power lithium batteries, and solar cells.

The aim of this project is to realize atomic layer deposition coating technology for lithium ions batteries, composite catalysts of precious metals in hydrogen fuel cells, and preparation of perovskite quantum dot materials.

Method: These projects develop the stable coating of energetic particles and noble metal nanoparticles to improve the electrochemical performance and cycle stability of the cathode and anode materials of power lithium ion battery; the composite catalyst synthesis to reduce noble metals in hydrogen fuel cells; the fabrication of halide perovskite materials for optoelectronic applications.

By the end of this project interns should have gained:

An ability in the applications in power lithium ion batteries and hydrogen fuel cells.

An ability in atomic layer deposition of thin films in perovskite materials and their application in optoelectronics.

Applicant profile:

We are interested in the undergraduate and graduate interns.

The interns should have an interest in and study the basic knowledge about a range of fields, particularly in fuel cells, lithium ion battery, and solar cells.

No matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Positions:3

Duration: from the end of June to the end of August，2023

#17 Energy efficiency: smart sensor (Positions: 2)

This lab mainly focuses on the smart gas sensors and artificial olfactory, including the synthesis of the sensing material, fabrication of the sensor, design the algorithm and system, and application in the environment monitoring and breath analysis.

The aim of this project is to realize the smart artificial olfactory system, and its application in the environment monitoring and exhaled breath analysis.

Method: This project applies the methods of material synthesis (chemical synthesis), device fabrication (MEMS technology), algorithm design (Python) and data analysis (SPSS or Python).

By the end of this project interns should have gained:

An ability in logical thinking and systematic design;

An ability in material synthesis, device fabrication and data analysis.

Applicant profile:

We are interested in the undergraduate and graduate interns.

The interns should have an interest in the field of materials, semiconductor device, or algorithm and have already demonstrated strong research potential.

In addition, they should have studied the basic knowledge about a range of fields in science and technology, particularly (chemistry, semiconductor physics or computer science).

It is no matter whether the interns understand Chinese or not, English as well as Chinese are our language of instruction and work.

Positions:2

Duration: from the end of June to the end of August，2023