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Introduction

Laboratory astrophysics is the study of astrophysical phenomena in the laboratory by use of advanced experimental facilities, diagnostics, as well as high performance computers. It is based upon the fact that laws governing physical processes on Earth apply throughout the Universe. This is a frontier of interdisciplinary research, which covers broad subjects in physics and astronomy. The Workshop on Laboratory Astrophysics will be held during 30th October – 1st November, 2019, Shanghai, China, supported by the Tsung-Dao Lee Institute (TDLI) (http://tdli.sjtu.edu.cn/web/yjxy/5130001.htm) and School of Physics and Astronomy, Shanghai Jiao Tong University. TDLI is a newly established national research center dedicated to fundamental research in the areas of astronomy and astrophysics, particle and nuclear physics, and fundamental quantum science. A few laboratories will be built in TDLI, including a research facility composed of a high energy PW laser and a multi-10 PW laser system dedicated to laboratory astrophysics studies.

This workshop aims to provide a forum to promote academic exchange and collaborations on the laboratory astrophysics. It will focus on astrophysical problems developed under extreme high energy density conditions, which could be modelled by high power lasers, high current particle beams, and other pulsed high energy drivers. The topics of the workshop include but not limited to: (1) Astrophysical jets, high-Mach-number flows, magnetic reconnection; (2) Supernovae, gamma-ray bursts, strong shocks, turbulent dynamo and transonic turbulence; (3) Ultrastrong fields, particle acceleration, relativistic plasmas, electron-positron pair plasma generation, and collisionless shocks; (4) High-pressure EOS, strongly-coupled degenerate plasmas, planetary interiors.

Organizing Committee:
Gianluca Gregori (Univ. Oxford)
Michel Koenig (Ecole Polytech.)
Hui Li (LANL)
Zhengming Sheng (SJTU & Univ. Strath.)
Hideaki Takabe (HZDR & Osaka Univ.)
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International Workshop on Laboratory Astrophysics

Wednesday 30 October 2019 - Friday 01 November 2019

Academic Activity Center, Minhang Campus, SJTU

Programme

Wednesday 30 October 2019

Wednesday morning session - Lecture Hall (09:00-11:00)

- Conveners: Mima, Kunioki

time	title	presenter
09:00	Introduction (00h10')	LIU, Chuan Sheng
09:10	On the radiation loss effects on charged particle acceleration during magnetic reconnection and in turbulent plasmas and on their modelling with high power lasers (00h30')	BULANOV, Sergei (ELI–Beamlines, Institute of Physics, Czech Academy of Sciences, Dolni Brezany, Czech Republic)
09:40	Collisionless Shock Acceleration Driven by Circularly Polarized Laser Pulses (00h30')	SHEN, Baifei (Shanghai Normal Univ)
10:10	Turbulent Megagauss Magnetic Fields generated in Ultra-Intense Laser-produced Plasmas and their Astrophysical Relevance (00h30')	LAD, AMIT DATTATRAYA (TATA INSTITUTE OF FUNDAMENTAL RESEARCH)
10:40	Tea break/Group photo (00h20')	

Wednesday morning session - Lecture Hall (11:00-12:00)

- Conveners: Wang, Xin

time	title	presenter
11:00	Particle Acceleration in Astrophysics (00h30')	LIU, Siming (Purple Mountain Observatory)
11:30	Flares from the supermassive black hole in the Galactic center (00h30')	YUAN, Feng (Shanghai Astronomy Observatory)

Lunch break - (12:00-13:30)

Wednesday afternoon session - Lecture Hall (13:30-15:20)

- Conveners: Ren, Chuang

time	title	presenter
13:30	Power law acceleration of charged particle by relativistic lasers relating to the physics of cosmic-ray acceleration (00h30')	TAKABE, Hideaki (HZDR)
14:00	Particle acceleration in the cosmos (00h30')	PALMER, Charlotte (Oxford)
14:30	Laboratory exploration of astrophysical outflow morphology regulated by magnetized disk wind (00h30')	HU, Guangyue (USTC)
15:00	Tea break (00h20')	

Wednesday afternoon session - Lecture Hall (15:20-17:20)

- Conveners: Yang, Dong

time	title	presenter
15:20	Experimental Observation of Ion-ion Acoustic Instability Associated with Collisionless Shocks in Laser Produced Plasmas (00h30')	ZHUO, Hongbin (Nat. Univ. Defense Technology)

15:50	Intense attosecond pulses carrying orbital angular momentum (00h20')	WANG, Jingwei (Shanghai Institute of Optics and Fine mechanics, CAS)
16:10	A new optical manipulation of relativistic vortex cutter (00h20')	WANG, Wenpeng (Shanghai Institute of Optics and Fine Mechanics, CAS)
16:30	Particle-in-Cell Simulation Method for Solid density Plasmas (00h20')	WU, Dong (Zhejiang Univ)

Dinner - Liuyuan Restaurant (17:00-19:00)

Thursday 31 October 2019

Thursday morning session - Lecture Hall (09:00-10:50)

- Conveners: Liu, Chuan Sheng

time	title	presenter
09:00	Hyperaccreting black hole as gamma-ray burst central engine (00h30')	LEI, Weihua (Huazhong University of Science and Technology)
09:30	Modelling of High-Mach Number Astrophysical Radiative Flows (00h30')	MICHAUT, Claire (Observatoire de la Côte d'Azur)
10:00	Particles Acceleration at Pileup Collision of the Twin Shock (00h30')	WANG, Xin (Xinjiang Observatory)
10:30	Tea break (00h20')	

Thursday morning session - Lecture Hall (10:50-12:00)

- Conveners: Sakawa, Youichi

time	title	presenter
10:50	Magnetic Reconnection in KLMP device (00h30')	LU, Quanming (USTC)
11:20	Laser Driven Magnetic Reconnection (00h30')	ZHONG, Jiayong (Beijing Normal Univ)

Lunch break - (12:00-13:30)

Thursday afternoon session - Lecture Hall (13:30-15:00)

- Conveners: Chen, Liming

time	title	presenter
13:30	Recent investigations on radiative shocks interacting with an obstacle (00h30')	KOENIG, Michel (Ecole Polytechnique)
14:00	Low-Mach-Number Collisionless Shocks in Solar Flares and Laboratory (00h30')	REN, Chuang (Univ Rochester)
14:30	Studies of High-Energy-Density Hydrodynamics at Laser Fusion Research Center (00h30')	PU, Yudong (Laser Fusion Research Center, CAEP)

Visit T.D.Lee Library &T.D.Lee Institute - (15:00-17:00)

Bus for Banquet (Shanghai City Center) - (17:00-21:00)

Friday 01 November 2019

Friday morning session - Lecture Hall (09:00-10:50)

- Conveners: Bulanov, Sergei

time	title	presenter
09:00	Raman Scattering and Electrons acceleration (00h30')	LIU, Chuan Sheng (Univ Maryland)
09:30	Transport dynamo (00h30')	RYU, Chang-Mo (POSTECH & IBS)
10:00	Relativistic laser plasma interaction in long scale pre-plasma and electron acceleration (00h30')	MIMA, Kunioki (GPI & Osaka)
10:30	Tea break (00h20')	

Friday morning session - Lecture Hall (10:50-12:00)

- Conveners: Shen, Baifei

time	title	presenter
10:50	Self-consistent hydrodynamic-kinetic hybrid simulation for laboratory astrophysics studies (00h30')	QIAO, Bin (Peking Univ)
11:20	Magnetohydrodynamic-Particle-in-Cell Method and its Applications (00h30')	BAI, Xuening (Tsinghua Univ)

Lunch Break - (12:00-13:30)

Friday afternoon session - Lecture Hall (13:30-15:20)

- Conveners: Koenig, Michel

time	title	presenter
13:30	Power-laser driven collisionles shock generation and particle acceleration (00h30')	SAKAWA, Youichi (Osaka University)
14:00	Dynamics of Stars Death and Birth: from the cosmos to the laboratory (00h30')	ALBERTAZZI, Bruno (Ecole Polytechnique)
14:30	Ultra-high Charge Electron Acceleration from Solid Target (00h30')	CHEN, Liming (SJTU)
15:00	Tea break (00h20')	

Friday afternoon session - Lecture Hall (15:20-16:30)

- Conveners: Chen, Min

time	title	presenter
15:20	Generation of Ultrahigh Fields by Micro-Bubble Implosion (00h30')	MURAKAMI, Masa (Osaka Univ)
15:50	Polarized Light from the Transportation of a Matter- Antimatter Beam in a Plasma (00h30')	KUMAR, Naveen (MPI-HD)
16:20	Conclusion remark (00h10')	ZHANG, Jie (SJTU/CAS)

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Book of Abstracts

Wednesday morning session

Introduction

On the radiation loss effects on charged particle acceleration during magnetic reconnection and in turbulent plasmas and on their modelling with high power lasers

Prof. BULANOV, Sergei[1]

[1] *ELI–Beamlines, Institute of Physics, Czech Academy of Sciences, Dolni Brezany, Czech Republic*

The talk is devoted to the prospects of using the laser radiation interaction with plasmas in the laboratory relativistic astrophysics context. We discuss basic features of charged particle acceleration during magnetic field line reconnection and at the shock wave front when the radiation friction effects become dominant and their modelling with super power lasers.

1. V. S. Berezinskii, S. V. Bulanov, V. L. Ginzburg, V. A. Dogiel, V. S. Ptuskin, Astrophysics of cosmic rays. (North Holland Publ. Co. Elsevier Sci. Publ. Amsterdam, 1990)
2. S. V. Bulanov, T. Zh. Esirkepov, D. Habs, F. Pegoraro and T. Tajima, "Relativistic Laser-Matter Interaction and Relativistic Laboratory Astrophysics", Eur. Phys. J. D 55, 483 (2009)
3. S. V. Bulanov, T. Zh. Esirkepov, M. Kando, J. Koga, K. Kondo, and G. Korn, "On the Problems of Relativistic Laboratory Astrophysics and Fundamental Physics with Super Powerful Lasers", Plasma Phys. Rep. 41, 1 (2015)
4. S. V. Bulanov, "Magnetic Reconnection: from MHD to QED", Plasma Physics and Controlled Fusion 59, 014029 (2017)
5. Y. J. Gu, F. Pegoraro, P. V. Sasorov, D. Golovin, A. Yogo, G. Korn, S. V. Bulanov, "Electromagnetic Burst Generation during Annihilation of Magnetic Field in Relativistic Laser-Plasma Interaction" arXiv:1903.09438v1 [physics.plasm-ph]

Collisionless Shock Acceleration Driven by Circularly Polarized Laser Pulses

SHEN, Baifei[1]

[1] *Shanghai Normal University*

Experiments for laser driven proton acceleration were carried out by using the femtosecond petawatt laser system. With an overdense plasma produced by the laser prepulse ionizing an initially ultrathin plastic foil, proton beams with narrow spectral peaks at energies up to 9 MeV, and with fluxes of as high as ˜3 10ˆ(12) protons/MeV/sr which is increased by two orders of magnitude compared with previous experimental results, were observed. Two-dimensional particle-in-cell simulations reveal that collisionless shocks are efficiently launched by circularly polarized lasers in exploded plasmas, resulting in a narrow energy spectrum. [1] Laser acceleration with 100 PW laser [2] and Laser-driven ultrafast antiproton beam [3] are also discussed. Vacuum birefringence and four wave mixing in vacuum using both optical laser and XFEL are discussed.

Turbulent Megagauss Magnetic Fields generated in Ultra-Intense Laser-produced Plasmas and their Astrophysical Relevance

Author(s): Dr. LAD, AMIT DATTATRAYA[1]
Co-author(s): Dr. SHAIKH, MONIRUZZAMAN [1] ; Dr. JANA, KAMALESH [1] ; Prof. DAS, AMITA [2] ; Prof. KUMAR, G. RAVINDRA [1]

[1] *TATA INSTITUTE OF FUNDAMENTAL RESEARCH*

[2] *The Indian Institute of Technology Delhi*

Ultra-intense laser-plasma interactions provide a novel and fascinating platform to simulate astrophysical scenarios [1]. Such ultra-intense laser pulses can launch mega-ampere transient currents of relativistic electrons inside the target [1-6], producing mega-gauss magnetic fields. The transport of such huge currents through solid is under severe investigation [1-7] A multitude of plasma instabilities [1-3,7], often of astrophysical significance, manifest in these megagauss magnetic fields.
To understand such a complex transport of electron currents, we measured the spatio-temporal evolution of the magnetic fields [2-5] at the front as well rear side of the dielectric, plastic, and metal targets. The p-polarized interaction laser pulse (˜ 5 × 10ˆ19 W/cmˆ2, 800 nm, 25 fs) was focused to a spot of 12 µm (FWHM). A linearly polarized, time-delayed and frequency-doubled (400 nm) probe pulse, extracted from the main interaction pulse, was suitably attenuated to low intensities (˜10ˆ10 W/cmˆ2) and focused to a 75 µm diameter spot on the target rear at near-normal incidence. The 400 nm probe pulses help to access 4 times the critical layer than that of the fundamental frequency of the plasma [4]. The magnetic fields induce a birefringence in the plasma at the target rear, resulting in a change in the polarization state of the incident probe, which was inferred from standard polarimetric measurements of the Stokes' parameters of the reflected probe [4].

Summary:
The magnetic field rises to 100's of mega-gauss during first few picoseconds and decreases thereby. We observed the higher and less filamentary magnetic field for the plastic (mylar) targets compared to dielectric (fused silica) or metal (aluminium) foil targets. This indicates that currents are less filamented in the plastic and the plastic is better conductor than the metal as well as dielectric targets at these ultra-intensities. We present snapshots of these megagauss magnetic fields, capturing their picosecond-scale evolution with micron-precision and delineating the evolution of filamentary instability mechanisms such as the Wiebel instability. The Fourier spectrum of these megagauss magnetic fields shows a power-law behaviour for the magnetic energy, which is a tell-tale signature of magnetic turbulence [2,3]. We will discuss the turbulence in such ultra-intense laser induced plasma and thereby their astrophysical relevance. Our results are fundamentally interesting in the context of fast ignition of laser fusion,1 laser-based acceleration of protons, ions and neutral particles [8], the feasibility of experimentally verifying such instability mechanisms in astrophysical magnetic fields [1] and simulating intra-planetary matter existing at ultrahigh pressures [9].
References:
[1] R. P. Drake, High-energy-density Physics-fundamentals, inertial fusion and experimental astrophysics (Springer, Berlin, Heidelberg) (2006).
[2] G. Chatterjee, K. M. Schoeffler, P. K. Singh, A. Adak, A. D. Lad, S. Sengupta, P. Kaw, L. O. Silva, A. Das, and G. Ravindra Kumar, Magnetic turbulence in a table-top laser-plasma relevant to astrophysical scenarios, Nature Commun. 8, 15970 (2017).
[3] S. Mondal, V. Narayanan, W. J. Ding, A. D. Lad, B. Hao, S. Ahmad, W. M. Wang, Z. M. Sheng, S. Sengupta, P. Kaw, A. Das, and G. R. KumaraDirect observation of turbulent magnetic fields in hot, dense laser produced plasmas, Proc. Natl. Acad. Sci. USA 109, 8011 (2012).
[4] G. Chatterjee, P. K. Singh, A. Adak, A. D. Lad, and G. R. Kumar, High-resolution measurements of the spatial and temporal evolution of megagauss magnetic fields created in intense short-pulse laser-plasma interactions, Rev. Sci. Instrum. 85, 013505 (2014).
[5] G. Chatterjee, P. K. Singh, S. Ahmed, A. P. L. Robinson, A. D. Lad, S. Mondal, V. Narayanan, I. Srivastava, N. Koratkar, J. Pasley, A. K. Sood, and G. R. Kumar, Macroscopic transport of mega-ampere electron currents in aligned carbon-nanotube arrays, Phys. Rev. Lett. 108, 205005 (2012).
[6] M. Shaikh, A. D. Lad, G. Birindelli, K. Pepitone, J. Jha, D. Sarkar, S. Tata, G. Chatterjee, I. Dey, K. Jana, P. K. Singh, V. T. Tikhonchuk, P. P. Rajeev, and G. R. Kumar, Mapping the damping dynamics of mega-ampere electron pulses inside a solid, Phys. Rev. Lett. 120, 065001 (2018).
[7] E. S. Weibel, Spontaneously growing transverse waves in a plasma due to an anisotropic velocity distribution, Phys. Rev. Lett. 2, 83–84 (1959).

[8] R. Rajeev, T. M. Trivikram, K. P. M. Rishad, V. Narayanan, E. Krishnakumar, and M. Krishnamurthy, A compact laser-driven plasma accelerator for megaelectronvolt-energy neutral atoms, Nature Phys. 9, 185-190 (2013).
[9] R. Jeanloz, Achieving high-density states through shock-wave loading of precompressed samples, Proc. Natl. Acad. Sci. USA 104, 9172–9177 (2007).

Particle Acceleration in Astrophysics

Prof. LIU, Siming[1]

[1] *PMO*

Varieties of mechanisms have been proposed for the acceleration of high-energy charged particles in different astrophysical environments, such as acceleration by parallel electric fields, betatron acceleration, magnetic curvature drift acceleration, magnetic gradient drift acceleration, current drift acceleration, ion pickups, resonant wave-particle interaction, stochastic particle acceleration, first-order Fermi acceleration, second-order Fermi acceleration, acceleration via magnetic reconnection, shock acceleration, turbulence acceleration etc. Some of these mechanisms deal with the microscopic processes, while others deal with statistical properties of particle acceleration and the related macroscopic energy conversion processes. Some deal with the instantaneous state of accelerated particles, others deal with the effects of particle acceleration accumulated over time. Clarification of relations among these mechanisms is essential to address the particle acceleration problem. I will discuss these relations and exploring the origin of complexity when dealing with specific acceleration phenomena. With the prominent enrichment of 3He in solar energetic particle events as an example, I will demonstrate how quantitative modeling may be carried out.

Flares from the supermassive black hole in the Galactic center

Prof. YUAN, Feng[1]

[1] *Shanghai Astronomy Observatory*

The supermassive black hole located at the center of our Galaxy, Sgr A*, is the best laboratory for studying the physical processes around black holes because of its proximity. Many observations therefore have been conducted. Especially, multiwaveband flares are observed in recent years, ranging from radio, infrared, to hard X-ray. In this talk, I will introduce our theoretical understanding of these flares. This is to invoke the magnetic field emergence from the accretion flow and the subsequent reconnection in the coronal region of the accretion flow. The light curves and spectrum have been calculated and compared with observations.

Wednesday afternoon session

Power law acceleration of charged particle by relativistic lasers relating to the physics of cosmic-ray acceleration

Prof. TAKABE, Hideaki[1]

[1] *HZDR*

In the past 20 years, the laser intensity has increased dramatically up to 1022 W/cm2 with the recently completed 10 PW laser at ELI-NP. In such ultra-intese laser field, electron oscillation energy is in relativistic regime. The average energy is about Lorentz factor 10,000 in GeV range. Further acceleration

is expected in stochastic interaction of the plasma waves and reflected laser. Most of the cases, relativistic Maxwell distribution is observed computationally and experimentally. In some case, the power spectrum is also predicted numerically. In my presentation, I will talk about the possibility to study the physics of cosmic-ray acceleration in ultra-intense laser and plasma interaction.

Particle acceleration in the cosmos

Prof. PALMER, Charlotte[1]

[1] *Oxford University*

Many mysteries surround the high energy particles, 'cosmic rays', arriving at Earth from space. They have been the subject of intense astronomical observations which continue to stimulate theoretical advances. Diffusive particle acceleration is the chief contender to explain the acceleration of these cosmic messengers. This relies on magnetic fields stronger than the mean interstellar field and the amplification of astrophysical magnetic fields is an area of active research. Terrestrial high-power lasers have been used to create analogs of astrophysical environments and I will present results from a series of experiments which have explored magnetic field amplification in shocks and turbulence, as well as preliminary results from an experiment to study magnetic field amplification due to the non-resonant hybrid instability using the Omega facility.

Laboratory exploration of astrophysical outflow morphology regulated by magnetized disk wind

HU, Guangyue[1]

[1] *University of Science and Technology of China*

Astrophysical outflows of Young Stellar Object (YSO) and Planetary Nebula (PN) exhibit abundant morphologies including collimated jet, blocked jet, and bipolar quasi-spherical winds (butterfly nebula) etc. The central outflow was surrounded by magnetized slow disk wind in YSO or PN. Wind-wind interaction was believed to generate the various outflows. Laboratory experiments have observed the magnetic field, inertial collimation in nested ambient outflow, and radiation cooling effects produced jets respectively in the past. Here we explored the astrophysical outflow surrounded by magnetized disk wind in laboratory via experiments and simulations. We represented almost all of the YSO and PN's outflow morphologies in our experiments. It shows that the outflow morphology was dominated by the Alfven Mach number of the outflow (Ma). When Ma<1, it presents as a collimated jet. When Ma>1 and Ma<2, the outflow exhibits as a blocked jet. While at Ma>2, the outflow shows as a quasi-spherical wind. We found that the morphology was caused by the different characters of the shock waves in the disk wind which transformed from sub-Alfven expansion without shock wave (jet), into switch-on shock wave (blocked jet), and final into single layer fast shock wave (butterfly nebula).

Experimental Observation of Ion-ion Acoustic Instability Associated with Collisionless Shocks in Laser Produced Plasmas

ZHUO, Hongbin[1]

[1] *Shenzhen Technology University*

In this workshop, we will report our recent experimental evidence of ion-ion acoustic instability in laser produced astrophysical relevant plasma. Irradiation of a copper foil with a short (2 ps) intense (10ˆ(17) W/cmˆ(2)) laser pulse generates dense hot plasma, whose expansion into the rarefied preplasma generates the electrostatic collisionless shock. A shock-reflected ion beam penetrates through the shock upstream excites the ion-ion acoustic instability. The shock oscillation electric field and the instability filamentary modulation are monitored by proton radiography. Particle-in-cell and particle tracing simulations reproduce the experimental observation.

Intense attosecond pulses carrying orbital angular momentum

Author(s): Dr. WANG, Jingwei[1]
Co-author(s): Prof. ZEPF, Matt [2] ; Dr. RYKOVANOV, Sergey [3]

[1] *Shanghai Institute of Optics and Fine mechanics*

[2] *Helmholtz Institute Jena*

[3] *Skolkovo Institute of Science and Technology*

Light beams with helical phase-fronts are known to carry orbital angular momentum (OAM) and provide an additional degree of freedom to beams of coherent light. While OAM beams can be readily derived from Gaussian laser beams with phase plates or gratings this is far more challenging in the extreme ultra-violet (XUV), especially for the case of high XUV intensity. Here, we theoretically and numerically demonstrate that intense surface harmonics carrying OAM are naturally produced by the intrinsic dynamics of a relativistically intense circularly-polarized Gaussian beam (i.e. non-vortex) interacting with a target at normal incidence. Relativistic surface oscillations convert the laser pulses to intense XUV harmonic radiation via the well-known Relativistic Oscillating Mirror mechanism. We show that the azimuthal and radial dependence of harmonic generation process converts the spin angular momentum of the laser beam to orbital angular momentum resulting in an intense attosecond pulse (or pulse train) with OAM.

A new optical manipulation of relativistic vortex cutter

Author(s): Dr. WANG, Wenpeng[1]
Co-author(s): Dr. JIANG, Cheng [1] ; Prof. BAIFEI, Shen [2] ; Prof. YUAN, Feng [3] ; Dr. GAN, Zhaoming [3] ; Dr. ZHANG, Hao [1] ; Dr. ZHAI, Shuhua [1] ; Prof. XU, Zhizhan [1]

[1] *Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences*

[2] *Shanghai Normal University*

[3] *Shanghai Astronomical Observatory, Chinese Academy of Sciences*

A new relativistic vortex cutter driven by the Laguerre-Gaussian (LG) mode is carried out for the first time in three-dimensional particle-in-cell simulations. Studies show that the electric fields periodically concentrate and emanate within every laser wavelength for the reflected circularly polarized LG ($p = 0$, $l = 1$, $\sigma z = -1$) laser, which works just like a vortex cutter, resulting in a relativistic ultrashort collimated electron cluster with a constant period in space. A single particle model is given and verifies that the cluster formation has a close relation with the parameters of orbital angular momentum (l) and spin angular momentum (σz). Such a relativistic vortex cutter potentially can be applied for the accelerator, generating high-flux particle and coherent radiation sources, astrophysical research and so on.

Particle-in-Cell Simulation Method for Solid density Plasmas

Dr. WU, Dong[1]

[1] *Zhejiang University*

A high-order implicit multidimensional particle-in-cell (PIC) method is developed for simulating plasmas at solid densities. The space-time arrangement is based on Yee and a leapfrog algorithm for electromagnetic fields and particle advancement. The field solver algorithm completely eliminates numerical instabilities found in explicit PIC methods with relaxed time step and grid resolution. Moreover, this algorithm eliminates the numerical cooling found in the standard implicit PIC methods by using a pseudo-electric-field method. The particle pusher algorithm combines the standard Boris particle pusher with the Newton-Krylov iteration method. This algorithm increases the precision accuracy by several orders of magnitude when compared with the standard Boris particle pusher and also significantly decreases the iteration time when compared with the pure Newton-Krylov method. The code is tested with several benchmarks, including Weibel instability, and relativistic laser plasma interactions at both low and solid densities.
This code had been extensively benchmarked with experiments, for example the laser driven ion acceleration experiment conducted at Peking University. This simulation framework can be directly applied to laser driven particle (electron, proton, neutron, and position, et al) sources, laser driven x/gamma ray sources, laser driven THz radiation, fast ignition inertial confinement fusion and many others. Based on this simulation framework, the future prospect is also discussed.

Summary:
[1] Dong Wu*, W. Yu, S. Fritzsche, and X. T. He, "A high-order implicit particle-in-cell method for plasma simulations at solid densities", Phys. Rev. E 100, 013207 (2019).
[2] Dong Wu*, W. Yu, Y. T. Zhao*, D. H. H. Hoffmann, S. Fritzsche, and X. T. He, "Particle-in-cell simulation of transport and energy deposition of intense proton beams in solid-state materials", Phys. Rev. E 100, 013208 (2019).

Thursday morning session

Hyperaccreting black hole as gamma-ray burst central engine

LEI, Weihua[1]

[1] *Huazhong University of Science and Technology*

A hyperaccreting stellar-mass black hole (BH) has been proposed as the candidate central engine of gamma-ray bursts (GRBs). The rich observations of GRBs by Fermi and Swift make it possible to constrain the central engine model by comparing the model predictions against data. We consider two jet-launching mechanisms, i.e., neutrino annihilations and the Blandford–Znajek (BZ) process. We study the data from GRB prompt emissions. Some correlations might be used to explore the activity of the central engine. We find that the empirical correlations are more consistent with the BZ mechanism, suggesting that at lease a good fraction of GRBs should have a magnetically dominated central engine. For the afterglow phase, we find that a BZ jet is more powerful and is likely responsible for the late-time central engine activities.

Modelling of High-Mach Number Astrophysical Radiative Flows

MICHAUT, Claire[1]

[1] *Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS*

Modelling high-Mach number flows requires sufficiently robust numerical solvers, because of the extremely fast propagation of the numerical informations in numerical mesh. In addition, very fast flows lead to high-Mach number flows which produce very strong compression. The kinetic energy is then transformed in thermal energy, material is ionized and consequently emits a flux of photons in a wide

range of wavelength. Therefore, complete and accurate modelling requires also to take into account the photon transport.
In the goal of wide broadening studies in astrophysics, we have developed the HADES code previously at the Observatory of Paris, and now at the Observatory of Côte d'Azur. Whereas physical assumptions and algorithms are verified and validated by laboratory experiments. Some of these experiments will be detailed in other talks (cf Michel Koenig and Bruno Albertazzi).
We will present the 2D numerical code HADES. Some realistic applications in the astrophysical context will be showed and discussed.
This work is done in a large collaboration because of the specific skill required. The following is a non-exhaustive list of collaborators.
In astrophysics: S.E. Bouquet, C. Busschaert, C. Cavet, A. Gintrand, J. Minière
In computation: L. Di Menza, M. Mancini, H.C. Nguyen, O. Saincir
In experiments: B. Albertazzi, E. Falize, M. Koenig…
This work was granted access to the HPC resources of MesoPSL financed by the

Particles Acceleration at Pileup Collision of the Twin Shock

WANG, Xin[1]

[1] *Xinjiang Astronomical Observatory, Chinese Academy of Sciences*

The ground-level enhancement (GLE) events are often associated with the large gradual solar events such as fast coronal mass ejections (CMEs), but not all fast CMEs lead to GLE events. Is there a type of coordinated CMEs that could produce GLEs with larger intensity and higher energies than those in the normal fast isolated CMEs? We propose a twin-shock scenario driven by the twin CME coordinately, in which the posterior shock catches up with the preceding shock and has a pileup collision. In the present study, we chose the first GLE event of the solar cycle 24 occurring on 2012 May 17 as an example to investigate the probable association with the "twin-shock" scenario. We use a dynamic Monte Carlo method to examine the energy spectrum with the relevance to the GLE event. In the twin-shock scenario, the seed energetic particles produced by the normal preceding shock can be injected into the posterior shock for reacceleration efficiently. As a result, we obtain the detailed energy spectrum of the solar energetic particles (SEPs) with different behaviors at the related episodes of the twin-shock evolution. Therefore, we predict that the pileup collision of the twin shock would dominate a "concave" energy spectral slope in the 2012 May 17 SEP event.

Magnetic Reconnection in KLMP device

Dr. LU, QuanMing[1]

[1] *USTC*

Magnetic reconnection converts magnetic energy into plasma kinetic energy, and it is generally accepted that magnetic reconnection is relevant to explosive phenomena in space and astrophysical environment, like solar flares and substorm in the earth's magnetosphere. Recently, with the development of plasma devices, magnetic reconnection experiments in plasma devices provides a. powerful tool to study magnetic reconnection. In this talk, we will report the recent results of magnetic reconnection in Keda Linear Magnetized Plasma(KLMP) device. Magnetic reconnection is driven by two strong plate current, and strong evidence of magnetic reconnection is obtained in this device. We also measure the abnormal resistivity in the vicinity of the X line, and its relation with the electron temperature. It is found that with the decrease of the electron temperature, the abnormal resistivity becomes smaller and smaller.

Laser Driven Magnetic Reconnection

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Laser driven magnetic reconnection (LDMR) occuring with self-generated B fields has been experimentally and theoretically studied extensively, where strong B fields of more than Mega-Gauss are spontaneously generated in high- power laser-plasma interactions, which are located on the target surface and produced by non-parallel temperature and density gradients of expanding plasmas. For properties of the short-lived and strong B fields in laser plasmas, LDMR opened up a new territory in a parameter regime that has never been exploited before. Here we review the recent results of LDMR taking place in both high and low plasma beta environments. We aim to understand the basic physics processes of magnetic reconnection, such as particle accelerations, scale of the diffusion region, guide field effects, and so on. Some applications of experimental results are also given especially for space and solar plasmas.

Thursday afternoon session

Recent investigations on radiative shocks interacting with an obstacle

Prof. KOENIG, Michel[1]

[1] *Ecole Polytechnique*

For more than a decade, we have performed laboratory experiments in connection with astrophysical phenomena, in order to improve our understanding in the field of radiation hydrodynamics, and to validate numerical schemes and assumptions in simulations. Here, recent experimental results on highly radiative shocks (RS) in interaction with solid obstacles (impact for molecular clouds physics) that play a major role in astrophysical fluid dynamics will be presented. Radiative shocks (RS) are phenomenon widely observed in astrophysics, for example in supernovae remnants or accretion processes. In this talk, we present experimental results on highly radiative shocks generated in a low-density gas filled cell obtained on the GEKKO XII laser facility. The RS was generated by using an ablator-pusher target (CH/Au/Ti), designed to limit as much as possible the preheating produced by the hot corona. The propagation media is Xe or He gas, with the aim to compare radiative effect in each medium. High velocity RS have been generated (100-140 km/s). We observed the interaction between the RS and a solid obstacle showing how radiation modifies the pure hydrodynamical case. Moreover, we also observed for the first time, shock deceleration due to radiation energy losses. Finally, we will present the LMJ experiment to be performed in 2020: the set-up, diagnostics and expected results.

Low-Mach-Number Collisionless Shocks in Solar Flares and Laboratory

REN, Chuang[1]

[1] *University of Rochester*

Low Mach number, high beta fast mode shocks can occur in the magnetic reconnection outflows of solar flares. These shocks, which occur above flare loop tops, may provide the electron energization responsible for some of the observed hard X-rays and contemporaneous radio emission. Here we present some two-dimensional particle-in-cell simulations of low-Mach-number/high beta quasi-perpendicular

shocks. The simulations show that electrons above a certain energy threshold experience shock-drift-acceleration [Park et al. ApJ. 765:147 (2013)]. We will also discuss a plan of creating such shocks using OMEGA-EP laser.

Studies of High-Energy-Density Hydrodynamics at Laser Fusion Research Center

Author(s): PU, Yudong[1]
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[1] *Laser Fusion Research Center, CAEP*

[2] *Laser Fusion Research Center*

Laser Fusion Research Center (LFRC) is mainly engaged in the research of inertial confinement fusion, with the largest laser facility in Asia, as well as experimental diagnostic systems and target fabrication capabilities that also benefit the research of laboratory astrophysics. This report reviewed the experiments of high-energy-density (HED) hydrodynamics carried out at LFRC in recent years. The evolutions of the interface perturbation under re-shocked condition and convergent geometry were investigated using the spherically bent crystal backlight imaging system and precisely fabricated and characterized samples. High spatial and energy resolution were achieved. As complementary to the backlight photography, the x-ray fluorescence imaging (XRFI) was demonstrated on the SGIII prototype laser facility. The XRFI was employed to study hydrodynamic instability and jet flow. All these experiments are relevant to laboratory astrophysics in many ways, such as physics regime, diagnostics and target fabrications. By sharing them with the community of laboratory astrophysics, we hope to promote cooperation between the two research area.

Friday morning session

Raman Scattering and Electrons acceleration

Transport dynamo

Prof. RYU, Chang-Mo[1]

[1] *POSTECH & IBS*

Random motions of particles have an interesting property to break the magnetic field lines, and can induce a net transport flow crossing the field lines. The transport flow deserves a special attention from the dynamo point of view, but has been neglected becasue of its smallness. By definition, the cross field transport-flow velocity describes a relative velocity to a field line, and has a capability to generate a magnetic field in nearly frozen-in plasmas, incurring a net magnetic flux change. I will talk about the peculiar charactereistics of this dynamo mechanism by transport flows , which is quite different from the conventional mean-field dynamos associated with the average of the coupling between turbulent flow velocities and magnetic fluctuations.

Relativistic laser plasma interaction in long scale pre-plasma and electron acceleration

KUMIOKI, Mima[1]

[1] *GPI&Osaka*

None

Self-consistent hydrodynamic-kinetic hybrid simulation for laboratory astrophysics studies

Author(s): QIAO, Bin[1]
Co-author(s): Dr. ZHAO, Z. H. [1] ; Dr. YAO, W. P. [1] ; Prof. HE, X. T. [1]

[1] *Peking University*

In the study of astrophysics and laboratory astrophysics, the macroscopic hydrodynamic simulation is used to understand the large-scale long-time dynamo, morphology and self-organization of plasma evolutions. However, the hydrodynamic simulation neglects important microscopic species of physics: the interactions that occur because of the effects of particle-particle interactions and the interactions of particles with the collective effects that accompany a fully or partially ionized ambient medium (i.e. a plasma), which generally needs the microscopic kinetic (particle-in-cell) simulations. On the other hand, many interesting astrophysical phenomena, for example, X/γ-ray radiations and flares, are generally connected with the explosive, discontinuous physical processes of energies in plasma and fields such as collisionless shocks and magnetic reconnections, which also requires microscopic kinetic simulations. However, so far, no self-consistent hydrodynamic-kinetic hybrid simulations have been successfully done, where the initial and boundary condition of the kinetic PIC simulation is always artificially assumed. This brings great difficulties to accurately interpret the astrophysical observations. In this talk, I shall report our recent progresses [1, 2, 3] on self-consistently combining the hydrodynamic and kinetic simulation for study of laboratory astrophysics. More specifically, we find a set of free parameters to achieve the self-similarity between hydrodynamic and kinetic PIC simulations so that they evolve identically. In other words, we, for the first time, provide a consistent and unabridged simulation result, connecting macroscopic and microscopic effects by applying the results of MHD as the initial condition in PIC simulations. Using this self-consistent hydrodynamic-kinetic hybrid simulation technique and proton radiography iterative inversion algorithm, we have successfully explained the experimental results of laser-driven asymmetric magnetic reconnection. The kinetic effects on relativistic astrophysical jet transport are also carefully studied using this hybrid simulation.

[1] W. P. Yao, B. Qiao*et al., Astrophys. J. 876, 2 (2019). [2] W. P. Yao, B. Qiao* et al., New. J. Phys. 20, 053060 (2018). [3] Z. H. Zhao, B. Qiao* et al., in preparation (2019).

Magnetohydrodynamic-Particle-in-Cell Method and its Applications

BAI, Xuening[None]

Energetic particles (cosmic-rays, CRs) play a dynamically important role in a variety of astrophysical and laboratory plasmas, yet the ability to study the mutual interaction between CRs and background plasmas at kinetic level is often limited by scale separation: conventional particle-in-cell (PIC) methods must resolve the microscopic scales of background plasmas, which can be orders of magnitude smaller than CR gyro radii. We develop a a magnetohydrodynamic-particle-in-cell (MHD-PIC) method, where we treat background thermal plasma as a fluid, obeying equations of ideal MHD, while CRs are treated as relativistic Lagrangian particles subject to the Lorentz force, with backreaction to gas in terms of momentum and energy feedback. This method retains the full kinetic physics of the CRs without much need to resolve scales much less than CR gyro radii, making it a promising tool for CR-related multi-scale problem. I will discuss initial applications of this method to the study of particle acceleration in collisionless shocks, mediated by the non-resonant Bell instability, as well as the growth and quasi-linear evolution of the gyro-resonant CR streaming instability, which is the underlying mechanism for CR self-confinement and CR-driven winds.

Friday afternoon session

Power-laser driven collisionles shock generation and particle acceleration

SAKAWA, Youichi[1]

[1] *Institute of Laser Engineering, Osaka University*

The collisionless shocks are common in the various astrophysical environments such as in supernova remnants, pulsar wind nebulae etc. These shocks are thought to be responsible for the generation of high-energy cosmic rays. Thanks to the development of high-energy and high-intensity lasers, it possible to study the formation/evolution of collisionless shocks and resultant particle acceleration in the laboratory. In this talk, we present experimental and computational studies of power-laser driven collisionles shock generation and particle acceleration. Nano-second laser driven Weibel instability mediated collisionless shock generation is investigated on Omega and NIF laser facilities. Pico- and femto-second laser driven electrostatic collisionless shock and particle acceleration are studied using two-dimensional EPOCH particle-in-cell simulations, and LFEX and J-KAREN-P laser facilities.

Dynamics of Stars Death and Birth: from the cosmos to the laboratory

Dr. ALBERTAZZI, Bruno[1]

[1] *Institute Polytechnique de Paris*

Astronomical observations reveals that interaction between shock waves, blast waves (BW) with astrophysical objects (molecular clouds, stars, jets winds, etc ..) and/or magnetic field is a common process which leads to the structuration of the Interstellar medium (ISM). It can also be responsible of high energy particles acceleration. In particular, when two isolate massive stars are relatively closed and exploded, the resulting Supernovae Remnants (SNR) can interact and lead to a more complex structure of the ISM. The impact zone presents a fascinating complex hydrodynamic physics which depends on the age of SNR and its relative evolution stage and the relative position of the two stars. On another side, the interaction of an SNR with a solid obstacle and/or a magnetic field is also interesting as it can modify the propagation of the blast wave and the structure of the astrophysical objects (for example to trigger the collapse of a molecular clouds). In this talk, we present a series of experiment made at LULI2000 modelling in the laboratory (i) the propagation of a BW under the influence of a external magnetic field, (ii) the interaction of two BWs and (iii) the interaction of BWs with a spherical object. To this end, one or two beams of LULI2000 are used and focused on 300 μm diameter carbon rods, located a part from the central axis of the chamber, producing the BW that will propagate in differents gases (N, Ar) and interact on the axis. Various optical diagnostics have been implemented to access to the relevant parameters (velocity, density, temperature, …). X-ray radiography have been also used to observe the compression of a sphere produced during its interaction with BWs. By changing the backlighter beam delay from shot to shot we have been able to follow the dynamic of the compression wave propagating inside the sphere.

Ultra-high Charge Electron Acceleration from Solid Target

CHEN, Liming[1]

[1] *IFSA Collaborative Innovation Center, School of Physics and Astronomy, Shanghai Jiao Tong University*

Collimated electron beams produced by intense laser pulses focused onto solid-density plasmas are studied intensively for many applications. Experiments and simulations have shown that the electron beams are emitted at an angle between laser specular and the target normal direction. In particular, an electron jet emitted along the target surface has been observed using large angles of incidence during laser irradiation of solid targets. However, the target surface electron energy spectrum shows a 100% energy spread in most cases, save for a few experiments [1] with low beam charge and large beam divergence angle (> 20ˆ0).
We systematically studied the relationship between the guiding of target surface electrons and *fs* laser parameters. When a nanosecond prepulse was added without picosecond ASE, the electron beam became concentrated and intense. We obtained a 0.8-MeV peaked electron beam with a charge of 100 pC in a single shot and a divergence angle as small as 3ˆ0 [2]. High-quality monoenergetic target surface accelerated electron beams with small normalized emittance (0.03π mm mrad) and large charge per shot have been observed from a 3 TW laser-solid interactions. The 2D PIC simulation reveals that a bubble-like structure as an accelerating cavity appears in the near critical density plasma region. A bunch of electrons is pinched transversely and accelerated longitudinally by the wake field in the bubble [3].
Besides these results obtained by using small size fs lasers, we also performed TSA experiment using sub-ps high power lasers such as PHELIX in GSI and TITAN in LLNL. Ten MeV monoenergetic and highly collimated (< 2ˆ0) electron beam with 8nC was observed on PHELIX. The Maximum beam charge of 100 nC are obtained on TITIAN [4]. The Direct Laser Acceleration might be the acceleration mechanism in ps-laser/solid interaction.
The good pointing stability and reproducibility of such a ultra-high charge electron beam makes it possible an ideal beam for fast ignition on ICF and drive the warm/hot dense matter. Based on this progress, a kJ and ps laser facility will be constructed at the laser laboratory in Tsung-Dao Lee institute, which will drive more powerful beam to explore Laboratory Astrophysics.

Generation of Ultrahigh Fields by Micro-Bubble Implosion

Prof. MURAKAMI, Masa[1]

[1] *Osaka Univ*

In the past quarter century, the chirped-pulse-amplification (CPA) technique has increased the laser intensity more than ten million times. Consequently, diverse research via laser-matter interactions has been pursued. To date, many studies have focused on increasing laser performance with regard to power and intensity to investigate even higher regimes towards the Schwinger field, which is the extreme intensity to quest for the ultimate fundamental phenomenon - vacuum physics. However, the current ”distance” in the laser intensity to the Schwinger field is still roughly seven orders of magnitude away. We propose a novel principle to make a substantial leap toward the Schwinger limit by using a new concept “micro-bubble implosions (MBI)” [1, 2]. In the previous work, we demonstrated the physical concept how to compress a micron-sized bubble contained in a solid target by an intense laser. By contrast, in this new submission, we reveal the unexplored core physics to achieve the ultrahigh electric field. In contrast with the spherical MBI, which is to generate ultrahigh electrostatic fields > 10ˆ15 − 10ˆ16 Vmˆ(-1) , one can use cylindrical MBI to produce ultrahigh magnetic fields > 10ˆ6 − 10ˆ7 Tesla. The details of these new concepts for both spherical and cylindrical MBI will be presented for generation of unprecedentedly ultrahigh fields.

Polarized Light from the Transportation of a Matter- Antimatter Beam in a Plasma

Dr. KUMAR, Naveen[1]

[1] *MPI-HD*

A relativistic electron-positron beam propagating through a magnetized electron-ion plasma is shown to generate both circularly and linearly polarized synchrotron radiations, which is intrinsically linked with asymmetric energy dissipation of the pair beam during the filamentation instability dynamics in the background plasma. Our results, for a wide range of beam-plasma parameters, can help in understanding the recent observation of circularly polarized radiation from gamma-ray bursts.

Conclusion remark

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General Information

Registration

Registration Time	Location
Oct. 30, 08:30 – 12:10	Conference Venue (At the lobby of the Academic Activity Center)

Meals

Time	Breakfast	Lunch	Dinner
Oct. 29	at Hotel	--------	Buffet at Courtyard by Marriott Minhang (18:30---)
Oct. 30	at Hotel	Buffet, 2nd floor, Academic Activity Center (12:00-13:30)	Reception Dinner at Liuyuan, Minhang Campus (17:00-19:00)
Oct. 31	at Hotel	Buffet, 2nd floor, Academic Activity Center (12:00-13:30)	Banquet at Shanghai City Center (17:00-21:00)
Nov. 01	at Hotel	Buffet, 2nd floor, Academic Activity Center (12:00-13:30)	----------

Accommodation

Hotel Name: Courtyard by Marriott Shanghai Minhang

Address: No.588 Zixing Road, Minhang District, Shanghai

Tel: 400-830-6666

酒店名称：上海紫竹万怡酒店

地址：闵行区紫星路 588 号 3 幢

电话：400-830-6666

Conference Venue

Lecture Hall, 2nd floor, Academic Activity Center, Minhang Campus, SJTU

Address: No.800 Dongchuan Road, Minhang District

Tel: (+86) 021 54740800

上海交大闵行校区学术活动中心二楼报告厅

地址：闵行区东川路 800 号

电话：(+86) 021 54740800

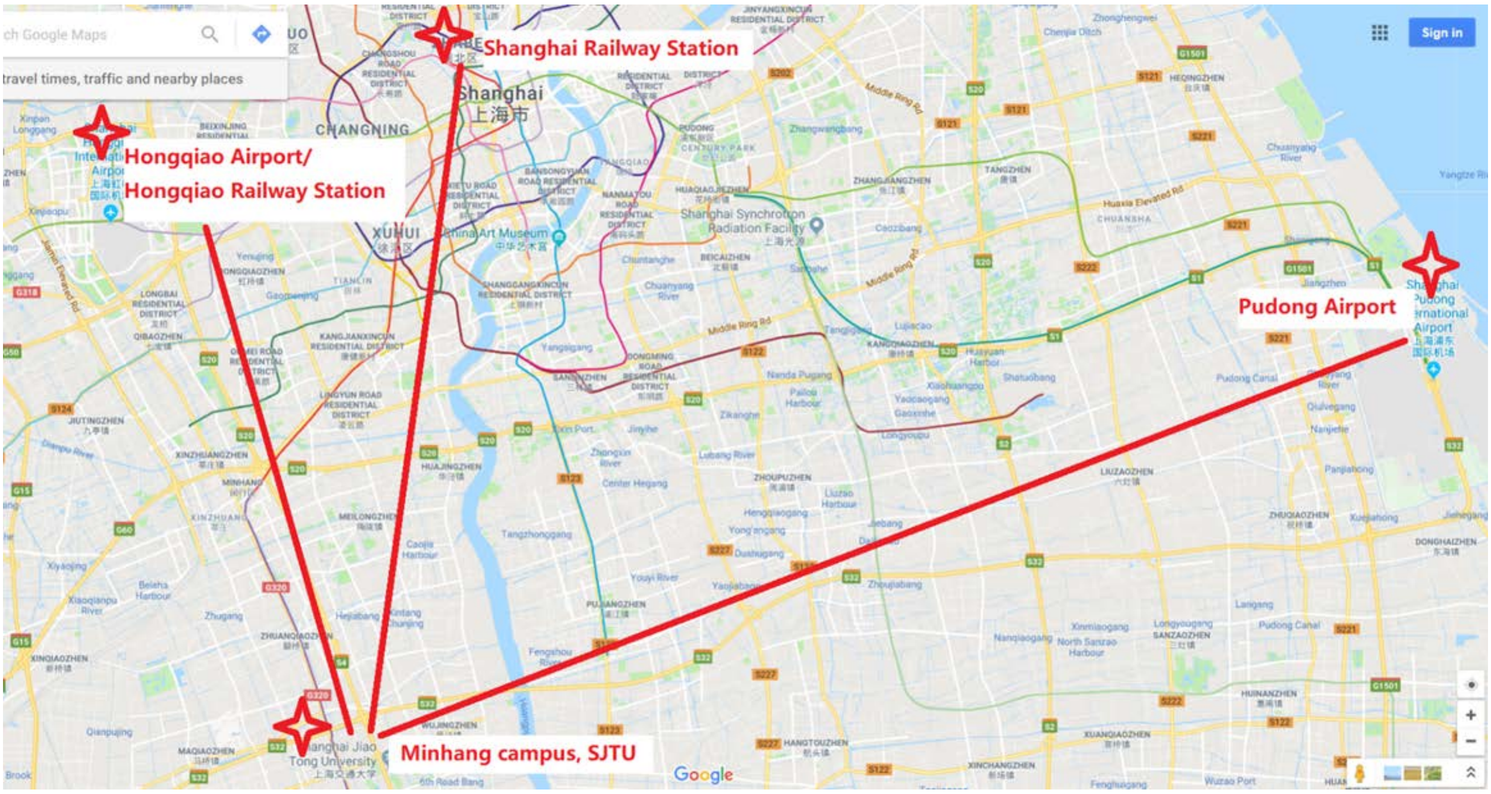
Wifi Information

Wireless network: **SJTU-guest**

Account: **IWLA2019**

Password: **astrophysics**

🚍 Local Transportation



- From airports/train station to the hotel/ conference venue

  From Pudong International Airport to the hotel:
  -- By taxi (suggested): taking around **70 minutes**, costing around **200 RMB**;

  From Hongqiao International Airport to the Hotel
  -- By taxi (suggested): taking around **50 minutes**, costing around **100 RMB**;

  From Hongqiao Railway Station to the Hotel
  -- By taxi (suggested): taking around **50 minutes**, costing around **100 RMB**;

From Shanghai Railway Station to the Hotel

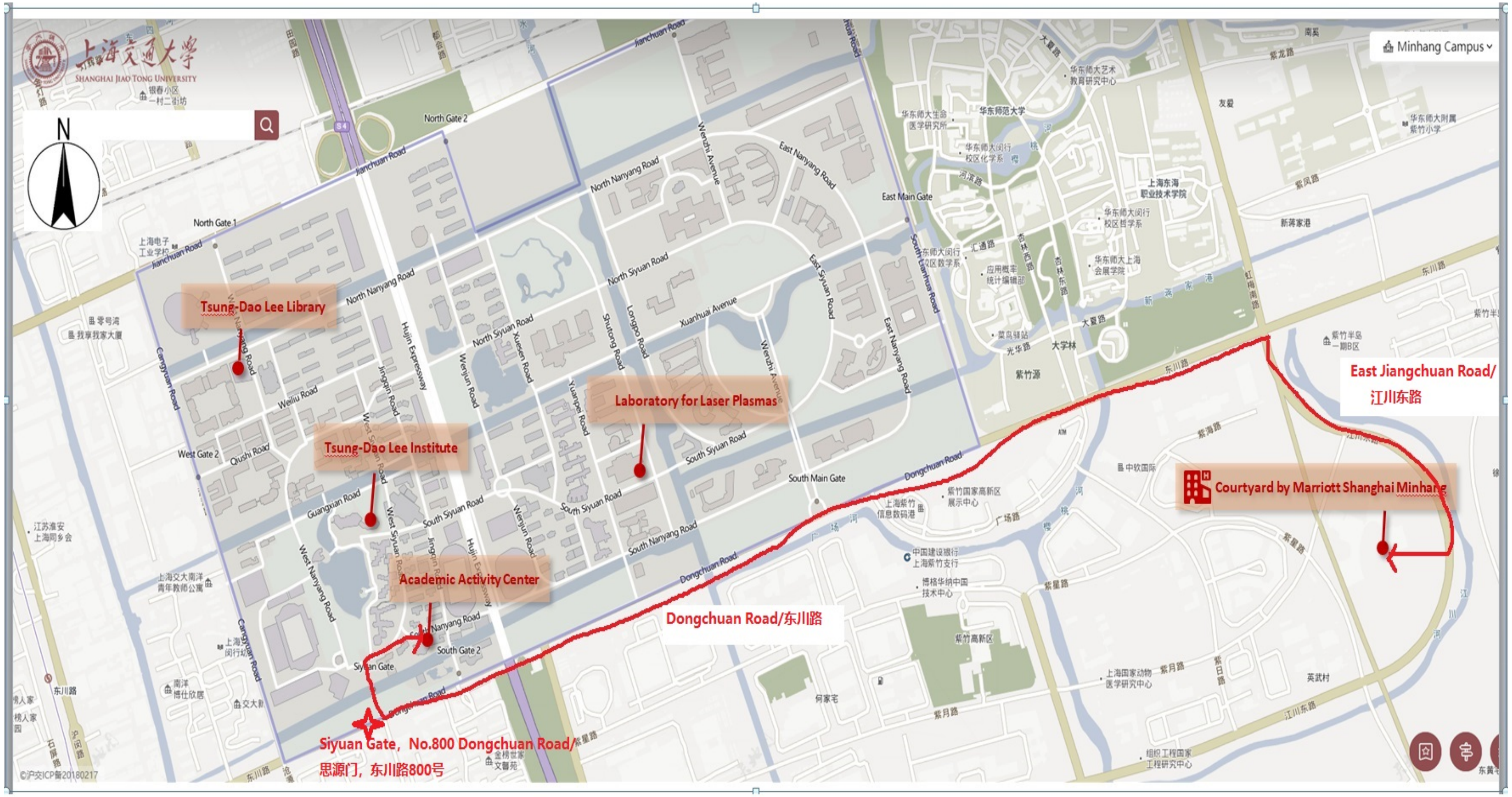
-- By taxi (suggested): taking around **70 minutes**, costing around **120 RMB**;

From Shanghai South Railway Station to the Hotel

-- By taxi (suggested): taking around **40 minutes**, costing around **70 RMB**.

- From the Hotel to the Venue:
  From the hotel to the venue is around 4km. **Shuttle buses** will commute between the hotel and the campus every day during the workshop. The detailed information is shown as follows:

Dates	Routines	Departure Time
Oct. 30	Hotel ---→ Venue	8:30 AM
	Liuyuan Restaurant---→ Hotel	7:00 PM
Oct. 31	Hotel ---→ Venue	8:40 AM
	Venue ---→ T. D. L. Library	3:00 PM
	T. D. L. Library-→T. D. L. Institute	3:45 PM
	T. D. L. Institute-→Hotel	4:15 PM
	Hotel-→ Downtown	4:40 PM
	Downtown-→Hotel	9:00 PM
Nov. 01	Hotel ---→ Venue	8:40 AM
	Venue-→Hotel	4:30 PM



From hotel to the venue is around 4 km.

🗣 If you have any problems to find the hotel or the conference venue, you may take a taxi and show the following information to the taxi driver.

To hotel:

请送我到闵行紫竹万怡酒店

地址：上海市闵行区紫星路 588 号 3 幢

联系人：石老师（13611947014）

Please take me to the Courtyard by Marriott Shanghai Minhang.

Address: No. 588 Zixing Road, Minhang District

In case of any problem, please contact Ms. Shi (13611947014).

To Venue:

请送我到上海交通大学闵行校区学术活动中心

地址：上海市闵行区东川路 800 号

联系人：石老师（13611947014）

Please take me to the Academic Activity Center, Minhang Campus, Shanghai Jiao Tong University.

In case of any problem, please contact Ms. Shi (13611947014).

About Shanghai

Shanghai, a vigorous and energetic international metro-polis, welcomes people from all over the world to enjoy its special atmosphere. This modern metropolis with its rich heritage of ancient Chinese culture has much to see and do. There're many attractions of Shanghai included Oriental Pearl TV Tower, the Bund, Nanjing Road, Jing'an temple, Yuyuan Garden, Disneyland Park and so on. Due to its rapid growth over the last two decades it has again become a global city, exerting influence over finance, commerce, fashion, technology and culture.

For more sightseeing information, please refer to the following

http://www.travelchinaguide.com/cityguides/shanghai.htm

http://www.chinatravel.com/china-guide/

Yuyuan Garden is a famous classical garden located in Anren Jie. It was finished in 1577 by a government officer of the Ming Dynasty (1368-1644) named Pan Yunduan. Yu in Chinese means pleasing and satisfying, and this garden was specially built for Pan's parents as a place for them to enjoy a tranquil and happy time in their old age.

The Bund, is a famous waterfront and regarded as the symbol of Shanghai for hundreds of years. It is on the west bank of Huangpu River from the Waibaidu Bridge to Nanpu Bridge and winds 0.93 mile in length. The most famous and attractive sight which is at the west side of the Bund are the various buildings of different architectural styles including Gothic, Baroque, Romanesque.