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ICTP-AP
INTERNATIONAL CENTRE FOR
THEORETICAL PHYSICS ASIA-PACIFIC

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University of Chinese Academy of Sciences

ICTP-AP
International Centre
for Theoretical Physics Asia-Pacific
国际理论物理中心-亚太地区

PROGRESS REPORT
ICTP-AP
2023-2024

国际理论物理中心（亚太地区）
INTERNATIONAL CENTRE FOR THEORETICAL
PHYSICS ASIA-PACIFIC

CONTENTS

FOREWORD

2024年即将结束，ICTP-AP积极响应教科文组织“国际科学促进可持续发展十年”这一项全球性的协调倡议，进一步加强自身人才和机构的必要能力建设，不断完善开放科学必要基础服务，扩大了我们的朋友圈，促进了国际科学合作。

2024年是ICTP-AP启动建设的第五个年头，我们努力推动科教平台建设和学科领域发展，应对当今和未来的挑战，致力于为亚太地区的科学家和学生们提供基础科学前沿领域交流平台，多措并举吸引他们参与我们的活动和项目。在这一年中，我们的女性参与比例也在不断上升，显示出我们在促进性别平等方面的努力和成效。

与可持续发展相关的科学面临诸多挑战，包括对基础科学重要性的认识有限和投入不足，不同可持续发展目标之间的互补和权衡等。因此，要通过支持开放科学等方式，来加强知识共享，提高机构和人员在基础科学、技术、研究、创新和工程学等方面的能力，让科学造福人民。ICTP-AP正努力打造这样一个公共“生态系统”，致力于使高性能计算、机器学习等资源逐步开放，为来自不同机构的研究人员提供了平等的研究学习机会。

在国际合作方面，我们于2024年参加了多个重要的国际活动。我们与多个国内外的研究机构携手，共同推动理论物理前沿领域的知识发展。值得强调的是，ICTP-AP始终保持对创新的开放态度，尤其是在机器学习和量子计算领域。我们理解，这些新兴技术与我们的基础科学和理论物理并不矛盾，而是相辅相成的。我们希望通过在科学界、决策者、私营部门和公众之间架起桥梁，提升公众科学素养，推动国际科技合作，加强对基础科学支持。

展望未来，ICTP-AP将继续致力于推动科学研究的开放性与合作性，强化我们在亚太地区的影响力。我们期待与各位共同努力，探索科学的未知领域，迎接更多的挑战与机遇。

在此，我要感谢每一位为ICTP-AP发展贡献力量的同事和伙伴。让我们携手共进，创造更美好的未来！

吴岳良
ICTP-AP主任
2024年12月

As 2024 comes to a close, ICTP-AP actively responds to UNESCO’s “International Decade of Science for Sustainable Development,” a global coordination initiative. We are further strengthening our necessary capacity building for talents and institutions while continuously improving our open science infrastructure. We have expanded our network and promoted international scientific collaboration.

2024 marks the fifth year since the establishment of ICTP-AP. We are committed to advancing the development of scientific education platforms and disciplinary fields to meet current and future challenges, dedicated to providing a communication platform for scientists and students in the Asia-Pacific region in the forefront of basic science. We have taken multiple measures to attract their participation in our activities and projects. This year, we have also seen a continuous increase in the proportion of female participants, demonstrating our efforts and achievements in promoting gender equality.

Science related to sustainable development faces numerous challenges, including limited recognition of the importance of basic science and inadequate investment, as well as the complementarity and trade-offs among different sustainable development goals. Therefore, we aim to strengthen knowledge sharing through support for open science, enhancing the capabilities of institutions and personnel in basic science, technology, research, innovation, and engineering, so that science can benefit humanity. ICTP-AP is working to create a public “ecosystem” that gradually opens up resources such as high-performance computing and machine learning, providing equal research and learning opportunities for researchers from various institutions.

In terms of international collaboration, we participated in several important international events in 2024. We have partnered with various domestic and international research institutions to promote knowledge development in the forefront of theoretical physics. It is worth emphasizing that ICTP-AP maintains an open attitude towards innovation, especially in the fields of machine learning and quantum computing. We understand that these emerging technologies are not in conflict with our basic science and theoretical physics; rather, they complement each other. We hope to bridge the gap between the scientific community, policymakers, the private sector, and the public to enhance public scientific literacy, promote international scientific cooperation, and strengthen support for basic science.

Looking ahead, ICTP-AP will continue to promote the openness and cooperativeness of scientific research, reinforcing our influence in the Asia-Pacific region. We look forward to working with all of you to explore the unknown fields of science and embrace more challenges and opportunities.

I would like to thank every colleague and partner who has contributed to the development of ICTP-AP. Let us work hand in hand to create a better future!

Wu Yueliang
Director, ICTP-AP
December 2024

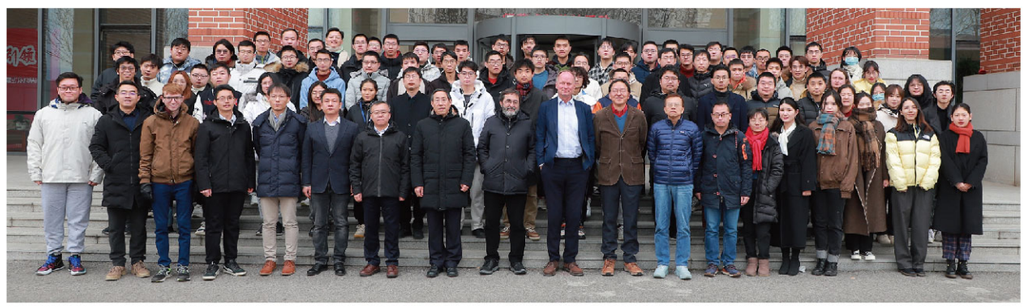
ICTP-AP RESEARCH

The International Centre for Theoretical Physics Asia Pacific (ICTP-AP) offers an excellent academic environment to facilitate the advancement of physical sciences, gathering a team of distinguished young scientists who conduct rigorous, cooperative, innovative research in frontier and interdisciplinary science ranging from quantum field theory, string theory, cosmology, black holes, gravitational wave detection, particle physics to machine learning.

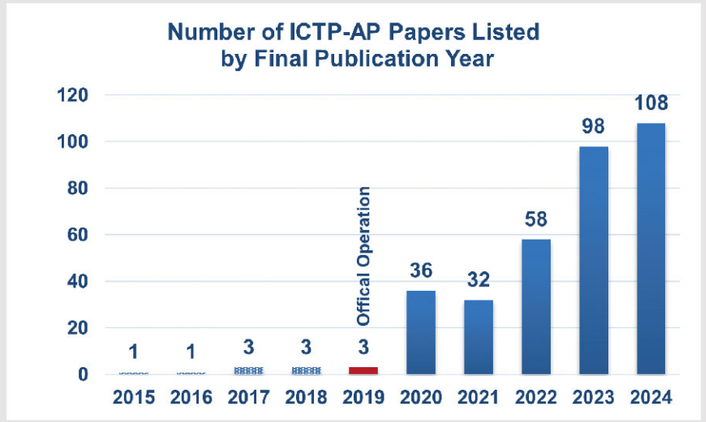
Today, ICTP-AP supports cutting-edge research on wide-ranging topics in physical science, organized under the following main groups: Astrophysics and Cosmology, Phenomenology of Particle Physics, String Theory and Quantum Gravity, Gravitational Wave Experimental Physics, and Computational Physics and Cosmology, Gravitational Quantum Field Theory and Unification Theory. Read more about these research lines on the following pages.

国际理论物理中心（亚太地区），简称ICTP-AP，致力于营造一个促进物理科学发展的学术环境。这里汇集了一批才华横溢的青年科学家，他们在量子场论、弦理论、宇宙学、黑洞、引力波探测、粒子物理和机器学习等前沿和交叉科学领域进行严谨、协作、和创新的研究工作。

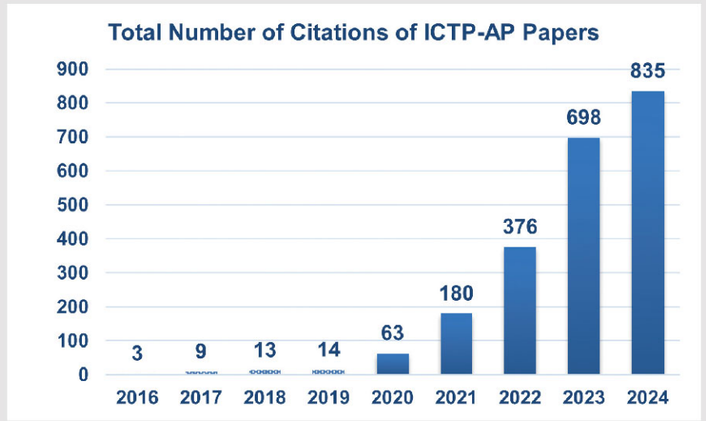
ICTP-AP在物理学领域开展了许多前沿研究，这些研究主要分为以下几个方向：天体物理学和宇宙学，粒子物理唯象，弦理论和量子引力，引力波实验物理学，计算物理和计算宇宙，引力量子场论和统一理论。在接下来的几页里，可以阅读更多关于这些研究的内容。



NUMBER OF ICTP-AP PAPERS LISTED BY FINAL PUBLICATION YEAR
2015-2024 ICTP-AP每年发表文章的数量



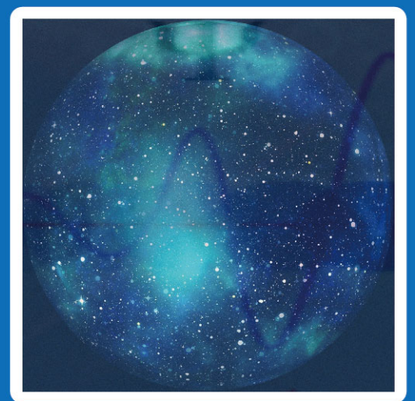
TOTAL NUMBER OF CITATIONS OF ICTP-AP PAPERS
2016-2024 ICTP-AP每年文章的引用量



Research Direction:

Astrophysics and Cosmology

天体物理学和宇宙学



The research direction of astrophysics and cosmology at ICTP-AP focuses on the early Universe, black holes, general properties of gravitational effective field theories, and dark matter particle astrophysics.

ICTP-AP的天体物理和宇宙学研究方向主要聚焦于早期宇宙、黑洞、引力有效场论的一般性质以及暗物质粒子天体物理学。

Researchers at this direction study the formation mechanisms of primordial black holes and their implications in gravitational wave detections and JWST observations. The researchers investigate ultralight dark matter, focusing on their roles in compact object binary mergers and in multi-band gravitational wave observations. The researchers also consider more general candidates of dark matter, to explore their possible production processes at early Universe and observational signatures across a wide range of experiments. Taking such a multi-messenger approach not only enhances the reliability of potential discoveries, but also opens up new avenues for scientific research.

该研究方向的研究人员主要研究原始黑洞的形成机制及其在引力波探测和詹姆斯·韦伯太空望远镜（JWST）观测中的影响。他们还研究了超轻暗物质，特别关注它们在紧密天体双星并合以及多波段引力波观测中的作用。研究人员还考虑了更广泛的暗物质候选者，以探索它们在早期宇宙中可能的生产过程以及在一系列实验中的观测特征。采用这种多信使方法不仅增强了潜在发现的可靠性，而且还为科学研究开辟了新的途径。

Future research interest at this direction involves exploring new approaches of probing dark matter and gravitational theories beyond GR with current and upcoming experiments, such as gravitational wave observations and sky survey. Given the rapid advancements in astronomical observations and deep-space missions, it is crucial to maintain a comprehensive perspective on the broader landscape of fundamental physics.

该方向的未来研究兴趣涉及探索暗物质和超越广义相对论的引力理论的新方法，这将通过当前和即将进行的实验来实现，例如引力波观测和巡天项目。鉴于天文观测和深空任务的快速发展，保持对基础物理学更广泛领域的全面视角至关重要。

Publication Highlights

1 X. Y. Chu, M. Nikolic, and J. Pradler, Successful Freeze-Out of Strongly Interacting Dark Matter with Even-Numbered Interactions. Phys. Rev. Lett. 133 (2024), 021003.
DOI: 10.1103/PhysRevLett.133.021003

2 M. C. Chen, H. Y. Liu, Q. Y. Zhang, J. Zhang, Probing massive fields with multiband gravitational-wave observations. Phys. Rev. D 110 (2024), 064018.
DOI: 10.1103/PhysRevD.110.064018

3 A. Guo, J. Zhang, H. Yang, Superradiant clouds may be relevant for close compact object binaries. Phys. Rev. D 110 (2024), 023022.
DOI: 10.1103/PhysRevD.110.023022

4 H. L. Huang, Y. Cai, J. Q. Jiang, J. Zhang, and Y. S. Piao, Supermassive Primordial Black Holes for Nano-Hertz Gravitational Waves and High-redshift JWST Galaxies. Res. Astron. Astrophys. 24 (2024), 091001.
DOI: 10.1088/1674-4527/ad683d

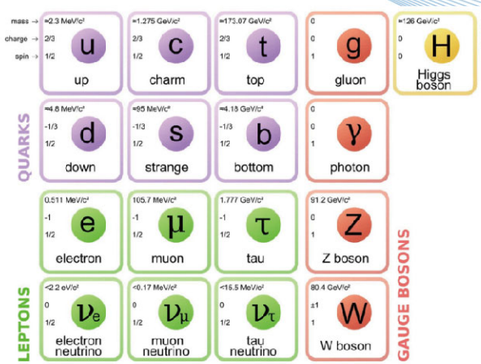
5 J. B. He, H. L. Deng, Y. S. Piao, and J. Zhang, Implications of GWTC-3 on primordial black holes from vacuum bubbles. Phys. Rev. D 109 (2024), 044035
DOI: 10.1103/PhysRevD.109.044035

6 H. Y. Liu, Y. S. Piao, and J. Zhang, Probing higher-spin particles with gravitational waves from compact binary inspirals. Phys. Rev. D 109 (2024), 024030
DOI: 10.1103/PhysRevD.109.024030

Research Direction:

Phenomenology of Particle Physics

粒子物理唯象



Phenomenology of particle physics is an important research direction of theoretical physics that bridges the gap between fundamental theories and experimental observations. This research direction at ICTP-AP focuses on the study of collider phenomena, new physics beyond the Standard Model, effective field theories, and innovative frameworks S-matrix bootstrap to explore the fundamental nature of particle interactions.

While the Standard Model has been highly successful in explaining particle physics at lower energy scale, it leaves several fundamental questions unanswered, such as the nature of dark matter and the hierarchy problem. Currently, there is no signal of new physics, indicating the energy scales of new physics maybe be much higher than current collider energies. Effective Field Theory (EFT) provides a powerful framework to describe their effects at lower energy scale.

粒子物理唯象是理论物理的一个重要研究方向，它架起了基本理论与实验观测之间的桥梁。ICTP-AP的这个研究方向专注于研究对撞机现象、标准模型之外的新物理、有效场理论，以及S矩阵自举这一创新框架，以探索粒子相互作用的基本性质。

虽然标准模型在解释低能量尺度下的粒子物理学方面非常成功，但仍有一些基本问题未得到解答，例如暗物质的性质和层级问题。目前，尚未观测到新物理现象的迹象，这可能意味着新物理现象可能发生在比现有对撞机所能提供的能量更高的能区。在这种情况下，有效场论（EFT）提供了一个强有力的工具，它允许我们在低能量尺度上探讨新物理效应。

The researchers in this direction are trying to explore the other new physics theories to understand these puzzles in a better way. Additionally, the group is exploring how to use on-shell amplitude method to simplify the EFT calculations. The group also implements novel method, such as S-matrix bootstrap, to explore the space of possible quantum field theories, to understand strong dynamics and gravity scattering amplitudes, and to investigate the properties of both known and hypothetical particles.

这个方向的研究人员正在努力研究除现有理论以外的新物理理论，以便更深入地解开物理学中的未解之谜。此外，该小组还研究如何使用在壳振幅方法来简化有效场论（EFT）的计算。该小组也在使用S矩阵自举等创新方法，以探索可能的量子场论参数空间，理解强相互作用和引力散射振幅，以及分析真实和假想粒子的特性。

Publication Highlights

1 C. Csaki, T. Ma, J. Shu, Trigonometric Parity for Composite Higgs Models. Phys. Rev. Lett. 121 (2018), 231801.
https://doi.org/10.1103/PhysRevLett.121.231801

2 C. Csaki, C.-S. Guan, T. Ma, J. Shu, Twin Higgs with exact Z2. JHEP 12 (2020) 005.
https://doi.org/10.1007/JHEP12(2020)005

3 T. Ma, J. Shu, M.-L. Xiao, Standard model effective field theory from on-shell amplitudes. Chin. Phys. C 47 (2023), 023105.
https://doi.org/10.1088/1674-1137/aca200

4 H. K. Liu, T. Ma, Y. Shadmi, M. Waterbury, An EFT hunter's guide to two-to-two scattering: HEFT and SMEFT on-shell amplitudes. JHEP 05 (2023), 241.
https://doi.org/10.1007/JHEP05(2023)241

5 T. Ma, A. Pomarol, F. Sciotti, Bootstrapping the chiral anomaly at large Nc. JHEP 11 (2023), 176.
https://doi.org/10.1007/JHEP11(2023)176

Research Direction:

String Theory and Quantum Gravity

弦理论和量子引力

String theory, which aims to unify general relativity and quantum mechanics, could be used to describe spacetime in extreme conditions, such as near a black hole or the big bang singularity, where quantum gravitational effects are significant. The researchers in String Theory and Quantum Gravity group study the physics of quantum black holes, strongly coupled quantum field theories, and the fundamental principles of holographic correspondence.

In recent years, the researchers in this direction have tried to resolve some long-standing problems in theoretical physics. For instance, they applied the conformal field theory technique to the Navier-Stokes equation in hydrodynamics and successfully derived the famous scaling laws of 2D turbulence, which generalized Prof. Polyakov's previous study from Princeton University. Moreover, they proposed a new approach to Hawking's celebrated black hole information paradox. This new method provides a more physical picture for rotating black holes, which differs from the island formula currently in the literature.

弦理论旨在统一广义相对论和量子力学，可以用来描述极端条件下的时空，比如黑洞附近或大爆炸奇点，这些地方的量子引力效应非常重要。弦论和量子引力小组的人员研究量子黑洞的物理、强耦合量子场论，以及全息对应的基本原理。

近年来，该研究方向的研究人员致力于解决一些理论物理学领域长期存在的难题，例如，他们将共形场论技术应用于流体力学中的纳维尔-斯托克斯方程，并成功推导出著名的二维湍流标度定律，推广了普林斯顿大学Polyakov教授的研究成果。此外，他们还提出了一种解决霍金著名的黑洞信息悖论的新方法。这种新方法为旋转黑洞提供了更物理的图像，不同于目前文献中的孤岛公式。

The researchers in this direction broadly studied the formal theory side of high energy physics and gravity theory, emphasizing the quantum effects of black holes. In particular, they try to apply advanced techniques from quantum field theory and string theory to some physical problems that can be performed and observed in experiments and laboratories.

Besides, the researchers in this direction studied quantum gravity effects in the near-horizon region of black holes and their implications for the AdS/CFT correspondence. Surprisingly, they have found that the long-standing problems of Yang-Mills confinement and mass gap can possibly be resolved by the near-horizon quantum effects. The results will be published in some upcoming papers.

该方向研究人员广泛研究高能物理和引力理论的形式理论方面，尤其关注黑洞的量子效应。特别是，他们尝试将量子场论和弦论中的先进技术应用于可以在实验和实验室中进行和观察的一些物理问题。

此外，该方向研究人员还研究黑洞近视界区域的量子引力效应及其对AdS/CFT对应的启示。令人惊讶的是，他们发现长期存在的杨-米尔斯禁闭问题和能隙问题可能通过近视界的量子效应得到解决。这些结果即将发表在后续的论文中。

The researchers in this direction also used conformal field theory to calculate gravitational waves generated by non-extremal rotating black holes. This extended the previous results by Prof. Strominger's team from Harvard University on near-extremal rotating black holes. The paper has been published in the journal Physical Review D. The student's thesis work based on this paper has been awarded as the 2023 best undergraduate thesis of universities in Beijing. Currently, we are further studying how to calculate possible quantum gravitational signals in gravitational waves.

该研究方向的研究人员还利用共形场论计算了非极端旋转黑洞产生的引力波。这项工作扩展了哈佛大学Strominger教授团队之前关于近极端旋转黑洞的结果。这篇论文已经发表在《物理评论D》期刊上。基于这篇论文的学生毕业论文获得了2023年北京市高校最佳本科生毕业论文奖。目前，该研究小组正在进一步研究如何在引力波中计算可能的量子引力信号。

Publication Highlights

1. J. Nian, Kerr Black Hole Evaporation and Page Curve. Int. J. Mod. Phys. D, 33 (2024), 2450030. https://doi.org/10.48550/arXiv.1912.13474

2. J. Nian, W. J. Tian, Gravitational Waves of Non-Extremal Kerr Black Holes from Conformal Symmetry. Phys. Rev. D 110 (2024), 104006. https://doi.org/10.1103/PhysRevD.110.104006

3. J. Nian, X. Q. Yu, and J. W. Ye, A Non-Unitary Conformal Field Theory Approach to Two-Dimensional Turbulence, arXiv:2210.06762.

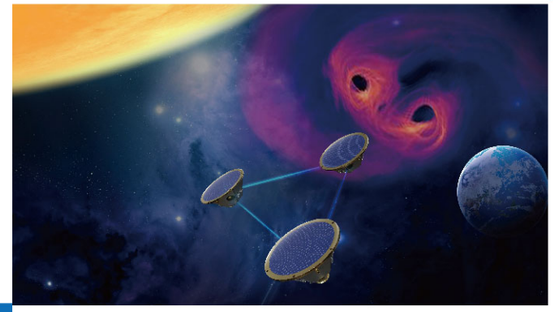
4. J. Nian, Hawking Radiation, Entanglement Entropy, and Information Paradox of Kerr Black Holes, arXiv:2312.14287.

5. X. L. Liu, J. Nian. And L. A. P. Zayas, Quantum Corrections to Holographic Strange Metal at Low Temperature, arXiv:2410.11487.

Research Direction:

Gravitational Wave Experimental Physics

引力波实验物理



People in the direction of gravitational wave experimental physics at ICTP-AP conduct experimental research on the detection of gravitational waves, with affiliations to two major experimental collaborations in the world: Taiji and LIGO, which target relatively low and high frequency range respectively.

该研究方向的研究成员开展了引力波探测的实验研究，并参与了世界上两个主要的实验合作项目：太极计划和LIGO。这两个项目分别针对相对较低和较高频率范围的引力波探测。

The Taiji team conducts R&D in preparation for gravitational wave detection in space, which targets the millihertz frequency range. Their work includes developing hardwares such as high precision propulsion technologies operating at the micro-Newton level. They also work on data analysis techniques and build pipelines to detect various important targets such as supermassive black hole mergers, extreme mass ratio inspirals, stochastic background of gravitational waves, etc.

太极团队正在进行空间引力波探测的技术研发，目标是探测毫赫兹频段的引力波。他们的工作包括开发硬件，如在微牛顿级水平上运行高精度的推进技术。此外，他们还致力于数据分析技术的研究，并构建用于探测各种重要目标的软件系统，例如超大质量黑洞并合、极端质量比旋进、随机引力波背景等。

The LIGO group works on data analysis techniques, and develops specialized algorithms and pipelines to extract key information regarding the nature of our universe from LIGO's data. They try to answer fundamental questions such as: what is the nature of dark matter? why is there more matter than anti-matter in our universe?

LIGO团队致力于数据分析技术的研究，并开发专门的算法和软件，以从LIGO的数据中提取关于宇宙本质的关键信息。他们试图回答一些基本的问题，例如：暗物质的本质是什么，宇宙中为何正物质比反物质多。

Publication Highlights

1 H. K. Guo; K. Sinha, D. Vagie; G. White, Phase transitions in an expanding universe: stochastic gravitational waves in standard and non-standard histories. J. Cosmol. Astropart. P. 1 (2021). https://doi.org/10.1088/1475-7516/2021/01/001

2 A. Romero, K. Martinovic, T. A. Calliste, H. K. Guo, M. Martinez, M. Sakellariadou, F. W. Yang; Y. Zhao, Implications for First-Order Cosmological Phase Transitions from the Third LIGO-Virgo Observing Run. Phys. Rev. Lett. 126 (2021), 151301. https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.126.151301

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4 H. K. Guo, K. Riles, F. W. Yang, Yue Zhao, Searching for Dark Photon Dark Matter in LIGO O1 Data. Commun. Phys., 155 (2019) https://www.nature.com/articles/s42005-019-0255-0

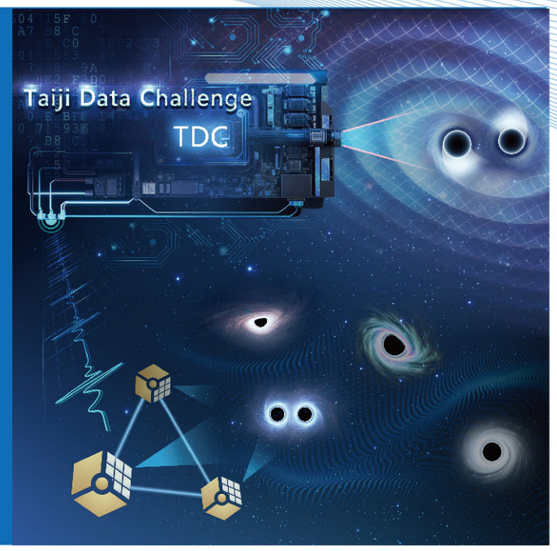
5 H. K. Guo, J. H. Hu, Y. Xiao, J. M. Yang, Y. Zhang, Growth of Gravitational Wave Spectrum from Sound Waves in a Universe with Generic Expansion Rate. arxiv:gr-qc/2410.23666 https://arxiv.org/abs/2410.23666

6 H. K. Guo, S. Li, Y. Xiao, J. M. Yang, and Y. Zhang, Estimating the uncertainty of cosmological first order phase transitions with numerical simulations of bubble nucleation. Phys. Rev. D 110 (2024), 063541. https://journals.aps.org/prd/abstract/10.1103/PhysRevD.110.063541

Research Direction:

Computational Physics and Cosmology

计算物理和计算宇宙



Advanced data analysis and machine learning have become indispensable in gravitational wave research. Transformer-based models and deep neural networks have been developed to denoise data and extract gravitational wave signals from complex, non-stationary noise environments. These methods significantly enhance the precision of signal detection, opening new avenues for extracting meaningful physical insights and improving the reliability of astrophysical findings. The integration of machine learning aids in overcoming challenges in space-based gravitational wave data analysis, making the extraction and interpretation of weak signals more robust.

Recent research in this direction has focused on developing advanced AI techniques for space-based gravitational wave detection and analysis, addressing several key challenges: non-stationary noise handling, signal denoising, parameter estimation. These advancements are particularly important for future space-based gravitational wave observatories like LISA, Taiji, and TianQin, where complex noise environments and computational efficiency are critical challenges.

在引力波研究中，先进的数据分析和机器学习已成为不可或缺的工具。基于Transformer的模型和深度神经网络已被开发出来，用于从复杂、非平稳的噪声环境中去噪数据和提取引力波信号。这些方法显著提高了信号检测的精度，为挖掘深刻的物理见解和增强天体物理学成果的可靠性开辟了新的途径。机器学习的整合有助于克服空间引力波探测数据分析中的挑战，使弱信号的提取和解释更加稳健。

近期，该研究方向的研究致力于开发先进的人工智能技术，用于空间引力波探测和分析，解决了非平稳噪声处理、信号去噪、参数评估这几个关键挑战。这些进展对未来的空间引力波观测项目，如LISA、太极和天琴等，具有重要意义，因为它们面临的主要挑战包括复杂的噪声环境和计算效率问题。

Future research is set to delve into novel approaches for probing dark matter and testing gravitational theories beyond general relativity. This work is crucial for leveraging current and upcoming experimental data from gravitational wave observations and sky surveys. By combining multi-messenger approaches and advanced computational tools, researchers can push the boundaries of fundamental physics, fostering new discoveries in the dynamic field of cosmology and astrophysics.

未来研究将深入探索新的方法来探测暗物质以及测试超越广义相对论的引力理论。这项工作对于利用当前和即将到来的引力波探测和巡天项目的实验数据至关重要。通过结合多信使方法和先进的计算工具，研究人员可以突破基础物理学的边界，推动宇宙学和天体物理学领域中的新发现。

Publication Highlights

1 H. Wang, M. H. Du, P. Xu, and Y. F. Zhou, Challenges in Space-Based Gravitational Wave Data Analysis and Applications of Artificial Intelligence. Sci. Sin.-Phys. Mech. As. 54 (2024): 270403.
DOI: 10.1360/SSPMA-2024-0087

2 H. Wang, Y. Zhou, Z. J. Cao, Z. K. Guo, and Z. X. Ren, WaveFormer: Transformer-Based Denoising Method for Gravitational-Wave Data. Mach. Learn.: Sci. Technol. 5 (2024).
DOI: 10.1088/2632-2153/ad2f54

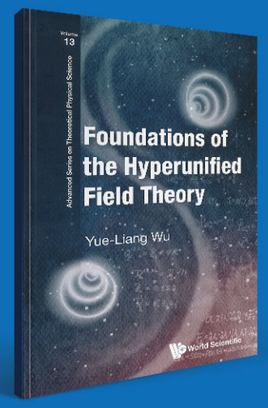
3 Y. X. Xu. M. H. Du, P. Xu, B. Liang, and H. Wang, Gravitational Wave Signal Extraction against Non-Stationary Instrumental Noises with Deep Neural Network. Phys. Lett. B 858 (2024), 139016.
DOI: 10.1016/j.physletb.2024.139016

4 B. Liang, M. H. Du, H. wang, et al., Rapid Parameter Estimation for Merging Massive Black Hole Binaries Using Continuous Normalizing Flows, Mach. Learn.: Sci. Technol.5 (2024), 045040.
DOI:10.1088/2632-2153/ad8da9

Research Direction:

Gravitational Quantum Field Theory and Unification Theory

引力量子场论和统一理论



Based on the gravitational quantum field theory (GQFT), the new physics phenomena of gravidynamics governed by the inhomogeneous spin gauge symmetry were explored. In GQFT, the fundamental gravitational field is a spin-related gravigauge field rather than a metric field in general relativity (GR). The gravidynamics of gravigauge field enables us to derive the generalized Einstein equation (symmetric tensor) and the new equation(antisymmetric). To simplify the analyses, the dynamic equations of gravitational interaction are linearized by keeping terms up to the leading order in the dual gravigauge field. Such linearized dynamic equations were applied into two particular gravitational phenomena. Firstly, we consider the linearized equations in the absence of source fields, which is shown to have five physical propagating polarizations as gravitational waves, i.e., two tensor modes, two vector modes, and one scalar, instead of two polarizations in the general relativity. Secondly, we examine the Newtonian limit in which the gravitational fields and the matter source distribution are weak and static. We analyze the motion of a photon in this weak and static gravitational background, and investigate three classical tests: (i) the deflection of light, (ii) the time delay of light, and (iii) the gravitational redshift. It turns out that the GQFT gives exactly the same prediction of the gravitational redshift effect as in the GR, so that this kind of experiments cannot be used to distinguish these two theories. On the other hand, the light deflection and the Shapiro time delay do predict differently in the GQFT than in the GR, due to the dependence of the parameter, which reflects the breaking down of equivalence principle. Thus, we can probe and constrain the GQFT with the associated experiments. As a consequence, the most stringent constraint is provided by the radar time-delay experiment carried out by the Cassini spacecraft with $Yw = 10^{-5}$.

基于引力量子场论(GQFT)研究了由自旋规范对称性支配的引力动力学的新物理现象。在引力量子场论中，基本引力场是自旋相关的引力规范场，不再是几何度规场。对引力动力学导出的广义引力场方程（对称的广义爱因斯坦方程和反对称的广义引力方程）进行了研究。为简化分析，通过展开对偶引力规范场的领头阶来线性化引力相互作用的广义动力学方程，并将线性化动力学方程应用于相关引力现象。一是考虑在没有源场的情况下的线性化方程，结果表明引力规范场具有五个物理传播极化模式作为引力波：两个张量极化、两个矢量极化和一个标量极化模式，而不是通常广义相对论中的两个张量极化模式。二是研究牛顿极限在引力场和物质源分布为弱的和静态情况下的新现象。通过推导相关的引力场方程，得到了引力动力学中基本相互作用耦合与实验测量的牛顿常数的精确关系。利用非相对论性物体和相对论性光子来探测牛顿场构型。主要考虑光子在弱静态引力背景下的运动，研究了三个经典测试：（i）光的偏转，（ii）光的时间延迟，（iii）引力红移。结果表明，引力量子场论对引力红移效应的预测与广义相对论相同，无法用来区分这两种理论。由于等效原理在引力量子场论中不再成立，对光线的引力偏转和Shapiro 时间延迟，两者的预言不同，由此可对引力量子场论中的线性化引力动力学给出严格的约束。Shapiro时间延迟实验对偏离广义相对论的参数 w 给出的限制为：$Yw = 10^{-5}$。

Publication Highlights

1 Y. K. Gao, et.al., Linear dynamics and classical tests of the gravitational quantum field theory. Phys. Rev. D 109 (2024), 064072
https://doi.org/10.1103/PhysRevD.109.064072

2 Y.-L. Wu, Gravidynamics, Spinodynamics and electrodynamics within the framework of gravitational quantum field theory. Sci. China Phys. Mech. Astron. 66 (2023), 260411.
https://doi.org/10.1007/s11433-022-2052-6

3 Y.-L. Wu, Foundations of the Hyperunified Field Theory. World Scientific: 2022; Vol. 13, p 396.
https://doi.org/10.1142/12868

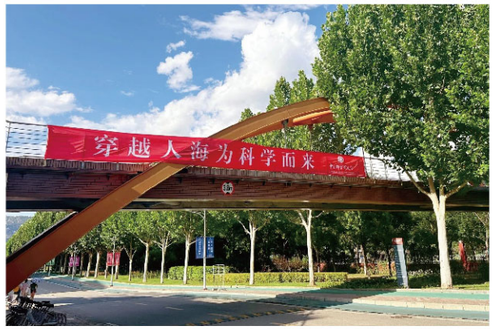
TALENT DEVELOPMENT

ICTP-AP will introduce and cultivate relevant researchers in alignment with the Centre's strategic development plan, to enhance its research capacity and achieve its research objectives. This year, one new tenured-track assistant professor, three research associate, and ten postdocs (including three foreign postdocs) have joined us.

ICTP-AP has attached great importance to the cultivation of young scientists and worked to create a favorable academic environment for young talents while providing support for them to apply for talent programs. In 2024, three members of ICTP-AP received the support of the General Program of the National Natural Science Foundation of China (NSFC), the Young Scientists Fund of the NSFC, and the Fund of National Talent Program.

ICTP-AP就中心发展规划引进和培养相关科研人员，提升中心的科研能力，实现科研目标。今年，中心新加入一位长轨助理教授，三名E系列副研究员和10名博士后（包括三名外籍博后）。

中心高度重视青年科学家的培养，着力打造良好的氛围和环境，支持青年科学家的发展，助力人才项目申请。2024年，中心三位老师分别获得了国家自然科学基金委面上项目、国家自然科学基金委青年科学基金项目、国家级人才项目的支持。



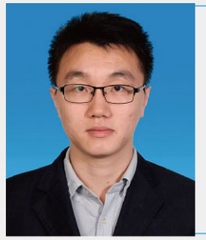
Our New Member
新成员

Xiaoyong Chu: Tenure-track assistant professor

储晓勇：长轨助理教授

Research Interests(研究兴趣):

Models and Detections of Dark Matter and Dark Sector Physics, Particle Physics beyond the Standard Model.

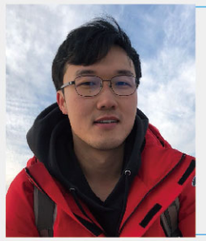


Linxiao Cong: Research Associate

丛麟骁：E系列副研究员

Research Interests(研究兴趣):

Micro thrust calibration, vibration isolation, weak signal detection

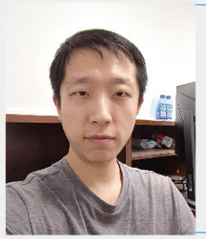


He Wang: Research Associate

王赫：E系列副研究员

Research Interests(研究兴趣):

Application of machine learning to gravitational wave data processing



Jing Liu: Research Associate

刘京：E系列副研究员

Research Interests(研究兴趣):

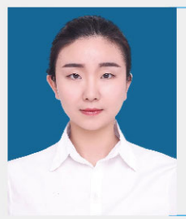
The early Universe and stochastic gravitational-wave backgrounds

2024 Joined Postdocs
博士后

Alessia Segati
Graduation School: Physics Department, University of Milan
Research Area:
AdS/CFT Correspondence, Gauged Supergravity, Black Holes, Supersymmetric Localization

Federico Faedo
Graduation School: Physics Department, University of Milan
Research Area:
Gauged Supergravity, Black Hole Solutions, Orbifold Geometries, AdS/CFT Correspondence

Nilanjandev Bhaumik
Graduation School: Indian Institute of Science, Bengaluru
Research Area:
Inflation, Primordial Black Holes, Stochastic Gravitational Wave Background

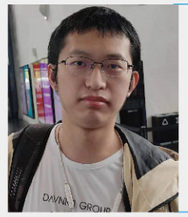


Pan Guo（郭盼）
Graduation School: University of Chinese Academy of Sciences (UCAS)
Research Area:
Data Processing in Space Gravitational Wave Detection, such as Sky Location and Parameter Estimation of Double White Dwarf Sources and Massive Black Hole Binaries

Pin Gao（高品）
Graduation School: Beijing Normal University
Research Area:
Gravitational Wave Data Processing

2024 Joined Postdocs
博士后

Jianchao Mu（穆建超）
Graduation School: UCAS
Research Area:
Plasma Physics, Fluid Mechanics, Engineering Thermophysics



Mai Qiao（乔迈）
Graduation School: Institute of Theoretical Physics, Chinese Academy of Sciences (CAS)
Research Area:
Stochastics Gravitational Wave Backgrounds, Cosmological Phase Transition, Dark Matter Direct Detection.

Jun-Shuai Wang（王俊帅）
Graduation School: Jilin University
Research Area:
Vector Meson Effects on Multi-Skyrmion States from the Rational Map Ansatz, Multi-skyrmion States in the Skyrme Model with a False Vacuum Potential

Chengjie Yang（杨成杰）
Graduation School: Institute of High Energy Physics, CAS
Research Area:
SMEFT, Positivity bound, Scattering Amplitude

Fu-Guo Yang（杨富国）
Graduation School: Institute of Theoretical Physics, CAS
Research Area:
Black Hole Physics and AdS/CFT Duality

Visiting Scientists
访问学者

To enhance the international development of the Centre and foster a more robust international academic atmosphere, ICTP-AP warmly welcomes visiting scholars from all over the world to conduct academic exchange and cooperation.

为加强中心国际化建设，提高中心国际化科研氛围，中心长期欢迎访问学者来中心开展学术交流与合作。

Prof. Danny Marfatia from the University of Hawaii visited the Centre in April, and gave a seminar with the title "High-energy Physics with Gravitational Waves". With a high interest now in gravitational waves, which is also a focus of study for the Centre, he had extensive discussions with people here.

夏威夷大学的Danny Marfatia教授于2024年4月访问了ICTP-AP，并作了一场学术报告“高能物理基于引力波的研究”。他目前的兴趣为将引力波应用到粒子物理的研究中，而引力波也是中心的研究重点，Marfatia因此与大家进行了广泛充分的探讨。

Prof. Leopoldo A. Pando Zayas from the University of Michigan visited ICTP-AP in May 2024. During this period, he gave a seminar talk and participated in two frontier forums organized by ICTP-AP ("Black Holes and Wormholes" and "Supersymmetry in Physics and Mathematics"). He highly praised the Centre's fast development and research environment.

密歇根大学的Leopoldo A. Pando Zayas教授于2024年5月访问ICTP-AP。在他访问期间，他发表了一场研讨会演讲，并参与了由ICTP-AP组织的两个前沿论坛（“黑洞与虫洞”和“物理学和数学中的超对称性”）。他对ICTP-AP 的快速发展和研究环境给予了高度评价。

Visiting Scientists
访问学者

Prof. Yue Zhao from the University of Utah visited the Centre during May and June. He gave a seminar with the title "Searching for New Physics Beyond the Standard Model of Particle Physics". He also participated in the summer school organized by the Centre and shared his research experience with the students. He has close collaboration with people in the Centre, and enjoyed very much the stay here.

犹他大学赵悦老师于2024年5月到6月访问ICTP-AP，并给了一场学术报告“寻找超越粒子物理模型的新物理学”。他还参加了中心组织的夏令营，并向同学们分享了他的科研经历。他和中心的老师有紧密的合作，并在中心有一段愉快的访问经历。

Visiting Scientists
访问学者

Prof. Jun'ichi Yokoyama from the Kavli IPMU, Tokyo University visited ICTP-AP in November 2024. During his visit, he gave a colloquium titled “Quantum aspects of inflationary cosmology”, which was open to all teachers and students, and exchanged views on questions from the teachers and students. He said that it was a pleasant experience when interacting with the scientists here on various topics.

东京大学卡弗里研究所的Jun'ichi Yokoyama教授于2024年11月访问了ICTP-AP。在他访问期间，他发表了一场对全体师生开放的学术讨论会，并针对师生提出的问题进行了详尽的解答。他表示，能够和中心的科研人员就多个议题进行深入的探讨和交流，对他来说是一次愉快的经历。

Visiting Scholars

- Dr. Rui Sun, from Korea Advanced Institute of Science and Technology
- Dr. Fengwei Yang, from University of Florida
- Dr. Anna Tokareva, from Hangzhou Institute for Advanced Study (HIAS), UCAS
- Prof. Wei-Tou Ni, from National Tsing Hua University
- Dr. Jahed Abedi, from UCAS
- Prof. Yue Zhao, from University of Utah
- Prof. Leopoldo A. Pando Zayas, from University of Michigan
- Dr. Hong-Kai Liu, from Israel Institute of Technology
- Prof. Ignazio Ciufolini, from University of Salento
- Dr. Yong Xu, from MITP, Mainz University
- Post Doctor Andrew Miller, from Utrecht University
- Dr. Ziyu Dong, from IFAE, Barcelona
- Dr. Gen-Liang Li, from Putian University
- Prof. Poul H. Damgaard, from Niels Bohr International Academy
- Prof. Jian-Xin Lu, from University of Science and Technology of China
- Prof. Hong Lü, from Tianjin University
- Prof. Bo Feng, from Beijing Computational Science Research Centre
- Prof. Laurent Baulieu, from Sorbonne University
- Prof. Bin Chen, from Ningbo University/Peking University
- Prof. Yue-Liang Wu, from International Centre for Theoretical Physics Asia-Pacific UCAS
- Prof. Kimyeong Lee, from Beijing Institute of Mathematical Sciences and Applications
- Prof. Jinwu Ye, from Great Bay University
- Prof. Wen-Li Yang, from Northwest University
- Prof. Jun’ichi Yokoyama, from Kavli IPMU, Tokyo University

Exchange Students

- Mu-Chun Chen, from Wuhan University
- Dian Jiao, from Nanjing Normal University
- Xuanye Fan, from University of Malaya
- Fangzhou Guo, from HIAS, UCAS
- Zhonghao Luo, from HIAS, UCAS
- Jingrui Zhang, from HIAS, UCAS
- Hong Su, from HIAS, UCAS
- Xu Li, from Institute of High Energy Physic, CAS

ICTP-AP ACTIVITIES

Scientific Activities
学术活动

Campus Events

ICTP-AP's Professors invite experts and scholars from distinguished universities and institutes globally to deliver reports on Seminars and the ICTP-AP Winter School on Theoretical Physics, aiming at carrying out academic exchange and teaching students the cutting-edge hot spots and research methods in fields around theoretical physics

中心的教授们邀请来自全球知名大学和研究所的专家学者到ICTP-AP冬季学校和研讨会上做报告，旨在向学生介绍理论物理领域的最新热点和研究方法，并促进学术上的交流和合作。

ICTP-AP Winter School on Theoretical Physics

From November 25-29, 2024, the first ICTP-AP Winter School on Theoretical Physics was successfully held in Beijing. This Winter School brought together seventeen top experts from both local and international backgrounds and taught students the cutting-edge hot spots and research methods in fields around theoretical physics, mainly involving disciplines such as quantum field theory, string theory, gravitational theory, particle physics, and cosmology. During the five-day school, 60 students had in-depth exchanges and interactions with top international experts in the field of theoretical physics.

2024年11月25日至29日，ICTP-AP首届理论物理冬季学校在北京成功举办。本次冬季学校汇集了17位来自国内外的顶尖专家，向学生讲授了理论物理领域的前沿热点和研究方法，主要涉及量子场论、弦理论、引力理论、粒子物理、宇宙学等学科。在为期五天的学习中，60名学生与理论物理领域的国际顶尖专家进行了深入的交流与互动。

Seminars

To broaden students' scientific perspectives and master the latest advancements in frontier science, the ICTP-AP's professors invite experts and scholars from distinguished universities and institutes globally for academic sharing and discussions on a weekly basis.

为拓展学生科学视野和了解前沿科学动态，中心的教授每周邀请来自世界各地知名学府和研究所的报告人进行学术分享和讨论。

Jan 3 2024

Title: Partial entanglement network and geometry reconstruction in AdS/CFT
Speaker: Associate Prof. Qiang Wen
Affiliation: Southeast University

Jan 4, 2024

Title: Non-Gaussianities in the primordial black hole formation
Speaker: Prof. Shi Pi
Affiliation: Institute of Theoretical Physics, CAS

Jan 8, 2024

Title: Gauged global strings
Speaker: Dr. Fengwei Yang
Affiliation: University of Florida

Jan 11, 2024

Title: UV-IR connections in scattering amplitudes: power of unitarity and causality
Speaker: Associate Prof. Anna Tokareva
Affiliation: Hangzhou Institute for Advanced Study, UCAS

Jan 18, 2024

Title: Fundamental questions in black hole theory
Speaker: Prof. Yi Ling
Affiliation: Institute of High Energy Physics, CAS

Jan 19, 2024

Title: Dancing with the stars: next-generation models of binary star systems
Speaker: Dr. Meng Sun
Affiliation: Northwestern University

Feb. 29, 2024

Title: Combinatorial origins of scattering amplitudes: from toy models to the real world
Speaker: Prof. Song He
Affiliation: Institute of Theoretical Physics, CAS

Mar. 07, 2024

Title: Exact solution of quantum integrable systems without U(1) symmetry
Speaker: Prof. Junpeng Cao
Affiliation: Institute of Physics, CAS

Mar. 14, 2024

Title: Primordial black holes and non-Gaussianity in the gravitational-wave era
Speaker: Associate Prof. Sai Wang
Affiliation: Institute of High Energy Physics, CAS

Mar. 21, 2024

Title: Family tree decomposition of cosmological correlators
Speaker: Associate Prof. Zhong-Zhi Xianyu
Affiliation: Tsinghua University

Mar. 22, 2024

Title: Spectroscopy for asymmetric binary black hole mergers
Speaker: Dr. Jahed Abedi
Affiliation: University of Stavanger

Mar. 27, 2024

Title: Large volume scenario from Schoen manifold with de sitter under swampland conjecture
Speaker: Dr. Rui Sun
Affiliation: Korea Advanced Institute of Science and Technology

Mar. 28, 2024

Title: Applying on-shell amplitude methods to the convex geometric positivity bounds of SMEFT dim-8 operator
Speaker: Dr. Chengjie Yang
Affiliation: Institute of High Energy Physics, CAS

Mar. 29, 2024

Title: Search for echoes on the edge of quantum black holes
Speaker: Dr. Jahed Abedi
Affiliation: University of Stavanger

Apr. 08, 2024

Title: Effective Field Theory of black hole perturbations with a timelike scalar profile
Speaker: Prof. Shinji Mukohyama
Affiliation: University of Tokyo

Apr. 11, 2024

Title: Understanding fermionic symmetries
Speaker: Assistant Prof. Yinan Wang
Affiliation: Peking University

Apr. 18, 2024

Title: High-energy physics with gravitational waves
Speaker: Prof. Danny Marfatia
Affiliation: University of Hawaii

Apr. 24, 2024

Title: Grand Unified Theories in light of upcoming neutrino and gravitational wave measurements
Speaker: Associate Prof. Ye-ling Zhou
Affiliation: Hangzhou Institute for Advanced Study, UCAS

May 9, 2024

Title: Exploring the internal structure of black holes
Speaker: Dr. Fu-Guo Yang
Affiliation: Hangzhou Institute for Advanced Study, UCAS

May 15, 2024

Title: Quantum aspects of AdS black holes from lower dimensional gravity theories
Speaker: Prof. Leopoldo A. Pando Zaya
Affiliation: University of Michigan

May 16, 2024

Title: Gravitational waves and gravitational tests
Speaker: Prof. Wen Zhao
Affiliation: University of Science and Technology of China

May 23, 2024

Title: Tetrahedron equation, cluster algebra and supersymmetric field theories
Speaker: Xiaoyue Sun
Affiliation: Tsinghua University

May 24, 2024

Title: Dark matter search with a strongly-coupled hybrid spin system
Speaker: Prof. Jia Liu
Affiliation: Peking University

Jun. 3, 2024

Title: Constraining the black hole interior with energy condition
Speaker: Associate Prof. Run-Qiu Yang
Affiliation: Tianjin University

Jun. 6, 2024

Title: Magnetic stars, black holes, and pulsar wind: A few frontier problems in theoretical astrophysics
Speaker: Prof. Yuqing Lou
Affiliation: Tsinghua University

Jun. 21, 2024

Title: Cosmological Neff and related BSM scenarios: a pedagogical introduction
Speaker: Associate Prof. Xunjie Xu
Affiliation: Institute of High Energy Physics, CAS

Jun. 25, 2024

Title: Searching for new physics beyond the Standard Model
Speaker: Associate Prof. Yue Zhao
Affiliation: University of Utah

Jun. 27, 2024

Title: Classification of neutrinoless double beta decay mechanisms
Speaker: Associate Prof. Gui-Jun Ding
Affiliation: University of Science and Technology of China

Jun. 28, 2024

Title: Tests of the general theory of relativity and of gravitational physics with the LARES and LARES 2 space experiments

Speaker: Prof. Ignazio Ciufolini

Affiliation: University of Salento

Jul. 8, 2024

Title: Testing the Kerr hypothesis: universality, imitators and dynamical signatures

Speaker: Prof. Carlos A.R. Herdeiro

Affiliation: University of Aveiro

Jul. 17, 2024

Title: Gravitons, BRST-BMS4 symmetry and its cocycles from horizontality conditions

Speaker: Prof. Laurent Baulieu

Affiliation: University of Paris

Jul. 22, 2024

Title: Neutrino-Dark matter interactions: new constraints and opportunities

Speaker: Associate Prof. Bhupal Dev

Affiliation: Washington University

Aug. 1, 2024

Title: Probing reheating with graviton bremsstrahlung

Speaker: Dr. Yong Xu

Affiliation: Mainz Institute for Theoretical Physics (MITP) JGU Mainz

Aug. 7, 2024

Title: Mono- and oligochromatic extreme-mass ratio inspirals

Speaker: Prof. P. Amaro Seoane

Affiliation: Technical University of València

Aug. 27, 2024

Title: Gravitational collapse and black holes in general relativity and beyond

Speaker: Dr. Hongguang Liu

Affiliation: University of Nuremberg

Aug. 29, 2024

Title: An Overview of Extra Dimensions and Brane Worlds

Speaker: Prof. Yuxiao Liu

Affiliation: Lanzhou University

Sep. 5, 2024

Title: Inside black holes, singularity and complementarity?

Speaker: Associate Prof. Dingfang Zeng

Affiliation: Beijing University of Technology

Sep. 12, 2024

Title: The holographic dual of correlation functions

Speaker: Jia Tian

Affiliation: Shanxi University

Oct. 17, 2024

Title: No-go and yes-go theorems for partially massless spin-2 fields
Speaker: Assistant Prof. Sebastian Garcia-Saenz
Affiliation: Southern University of Science and Technology

Oct. 24, 2024

Title: Gravitational wave probes of cosmology and gravity
Speaker: Dr. An Chen
Affiliation: Queen Mary University of London

Oct. 31, 2024

Title: Nanohertz gravitational waves and primordial quark nuggets from dense QCD matter
Speaker: Prof. Mei Huang
Affiliation: University of Chinese Academy of Sciences

Nov. 5, 2024

Title: Quantum Black holes and the conundrum of cosmic causality
Speaker: Prof. Niayesh Afshordi
Affiliation: University of waterloo

Nov. 7, 2024

Title: From WIMPs to FIMPs with low reheating temperatures
Speaker: Prof. Nicolás Bernal
Affiliation: New York University Abu Dhabi

Nov. 21, 2024

Title: Listen to the universe with the aid of Tian Qin project
Speaker: Associate Prof. Yi-Ming Hu
Affiliation: Sun Yat-sen University

Nov. 25, 2024

Title: Thermodynamic equation of state for gravitational systems
Speaker: Prof. Ya-Peng Hu
Affiliation: Nanjing University of Aeronautics and Astronautics

Nov. 28, 2024

Title: Post-Hubble-tension cosmology
Speaker: Associate Prof. Shao-Jiang Wang
Affiliation: Institute of Theoretical Physics, CAS

Dec. 5, 2024

Title: Axion-like dark matter and black hole superradiance
Speaker: Associate Prof. Shou-Shan Bao
Affiliation: Shandong University

Dec. 19, 2024

Title: Irregular KZ-equations from Liouville conformal blocks
Speaker: Dr. Babak Haghighat
Affiliation: Tsinghua University

Dec. 20, 2024

Title: Probing fundamental physics via supermassive black hole observations
Speaker: Dr. Yifan Chen
Affiliation: Noels Bohr Institute, University of Copenhagen

Dec. 26, 2024

Title: Changing states in holography: From modular Berry curvature to the bulk symplectic form
Speaker: Dr. Ricardo Espindola
Affiliation: Tsinghua University

Off-Campus Events

In 2024, ICTP-AP organized a series of academic conferences aimed at promoting academic exchange, collaboration, and research development.

2024年，ICTP-AP举办了多次学术会议，旨在促进学术交流、学术合作和研究发展。

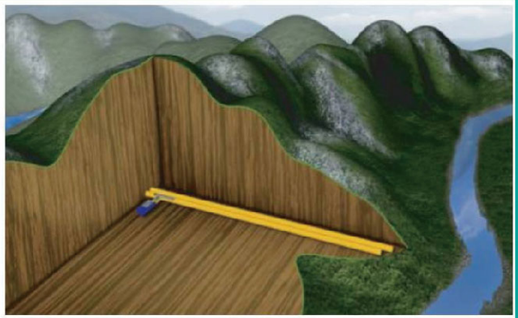
01

The 2nd Symposium on Cutting-edge Science and Forward-looking Technologies in the Era of Gravitational Waves

第二届引力波时代前沿科学与前瞻技术研讨会

The Symposium was held at Nanjing University from April 26 to April 30, 2024. The objective is to find out fundamental physics problems that may lead to major breakthroughs, share major cutting-edge technological advances related to gravitational wave detection, and facilitate substantive cooperation among peers.

会议于2024年4月26日至4月30日在南京大学举办。旨在凝练出可能取得重大突破的基础物理问题、交流与引力波探测相关的重大前沿技术进展、并促进同行间实质性的合作。



02

Conference on frontiers of underground and space particle physics and Cosmo physics, COUSP2024

第三届地下和空间粒子物理与宇宙物理前沿问题研讨会

The conference was held in Xichang, Sichuan Province, from May 7 to May 11, 2024. It intensively focused on the cutting-edge basic physics topics concerning the theory and experiment of deep earth and space physics both domestic and overseas, and initiated a warm, extensive and in-depth exchange and discussion on the latest advancements of relevant disciplines and frontier hot issues.

本次会议于2024年5月7日-11日在四川西昌召开。会议深度聚焦国内外深地和空间物理理论与实验相关的基础物理前沿课题，就相关学科最新进展和前沿热点问题展开了热烈、广泛和深入的交流讨论。

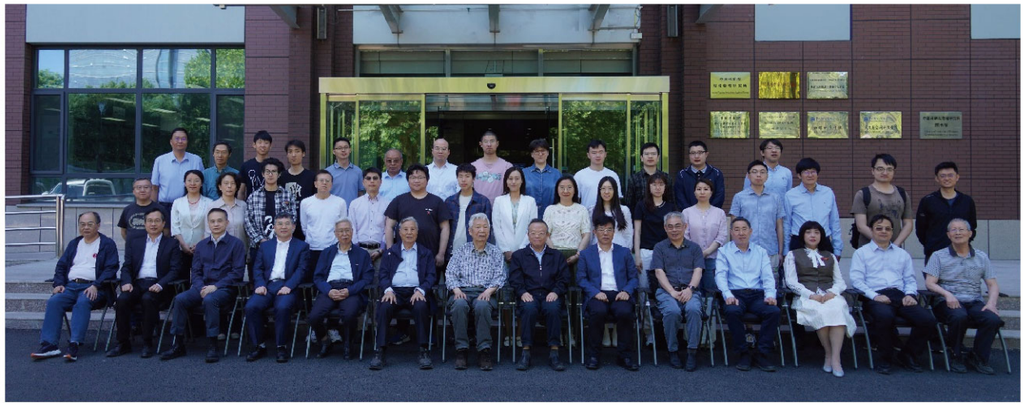
03

Frontier Forum on Quantum-cosmology Physics

量子-宇宙物理前沿论坛

The forum was held on May 16, 2024, in Beijing, gathering theoretical physics experts from ICTP-AP, Hangzhou Institute for Advanced Study, UCAS, Zhejiang University, and Nanjing University. They came together to discuss the latest advancements and cutting-edge dynamics in quantum physics and cosmological research. The forum not only facilitated academic exchange but also laid the foundation for future close cooperation.

本次论坛于2024年5月16日在北京召开，来自ICTP-AP、国科大杭州高等研究院、浙江大学和南京大学的理论物理专家齐聚一堂，共同探讨了量子物理和宇宙学研究中的最新进展和前沿动态。此次论坛不仅促进了知识的交流，也为未来的紧密合作奠定了基础。



04

Frontier Forums on the “Black Holes and Wormholes” and “Supersymmetry in Physics and Mathematics”

“黑洞和虫洞”和“物理和数学中的超对称”前沿论坛

The "Black Holes and Wormholes" and "Supersymmetry in Physics and Mathematics" forums were held in Qiandao Lake from May 21 to May 24, 2024, and from May 26 to May 30, 2024, respectively. The former focused on searching for the microstates of black holes and resolving the associated black hole information paradox, while the latter concentrated on supersymmetric localization and the AdS/CFT correspondence, and their applications to black hole microstates and entropies. Renowned experts and scholars in the relevant fields were invited to give academic reports and engage in in-depth discussions on the black hole information paradox, a long-standing challenging issue in theoretical physics.

“黑洞和虫洞”和“物理和数学中的超对称”前沿论坛分别于2024年5月21日至24日和2024年5月26日至30日在千岛湖举行。前者聚焦于寻找黑洞的微观态并解决相关的黑洞信息悖论，后者关注于将超对称中的局域化方法和AdS/CFT对应相结合，通过边界量子场论来计算黑洞微观态和黑洞熵。相关领域的知名专家学者被邀请来做学术报告，并就理论物理中长期存在的黑洞信息悖论这一挑战性问题进行深入讨论。

05

Embracing the International Year of Quantum Science and Technology: Symposium on the History of Modern Physics

迎接 2025 国际量子科学技术年：现代物理学史国际研讨会

The symposium was held from September 21 to September 23, 2024, in Beijing. Nearly 30 experts and scholars from China, Germany, the United States, Canada, Italy, Russia, Japan, Brazil, and other countries attended the symposium and conducted reports. It focused on topics such as the evolution of fundamental concepts in modern physics, philosophical thoughts of quantum physics, the quantum revolution and its impact on society and culture, individual and collective studies of physicists, the relationship between physics and political diplomacy as well as international exchange and cooperation, the Copenhagen interpretation, cutting-edge developments in quantum field theory of gravity, and the history of unified theory research. The meeting also discussed the preparations for the International Year of Quantum Science and Technology in 2025 by the international physics history community, with scholars from Italy, Germany, Brazil, and the United States introducing the preparations for relevant international conferences and academic organizations.

研讨会于2024年9月21日-23日在北京举办。来自中国、德国、美国、加拿大、意大利、俄罗斯、日本、巴西等国的近30位专家学者出席研讨会并作报告。会议围绕现代物理学的基本概念演化、量子物理哲学思想、量子革命与社会文化、物理学家个体及群体研究、物理学与政治外交及国际交流合作、哥本哈根诠释、引力量子场论前沿发展以及统一理论研究历史等主题展开。并讨论了国际物理学史界有关2025年国际量子科学技术年的筹备活动，来自意大利、德国、巴西和美国的学者分别介绍了相关国际会议与学术组织筹备的活动。

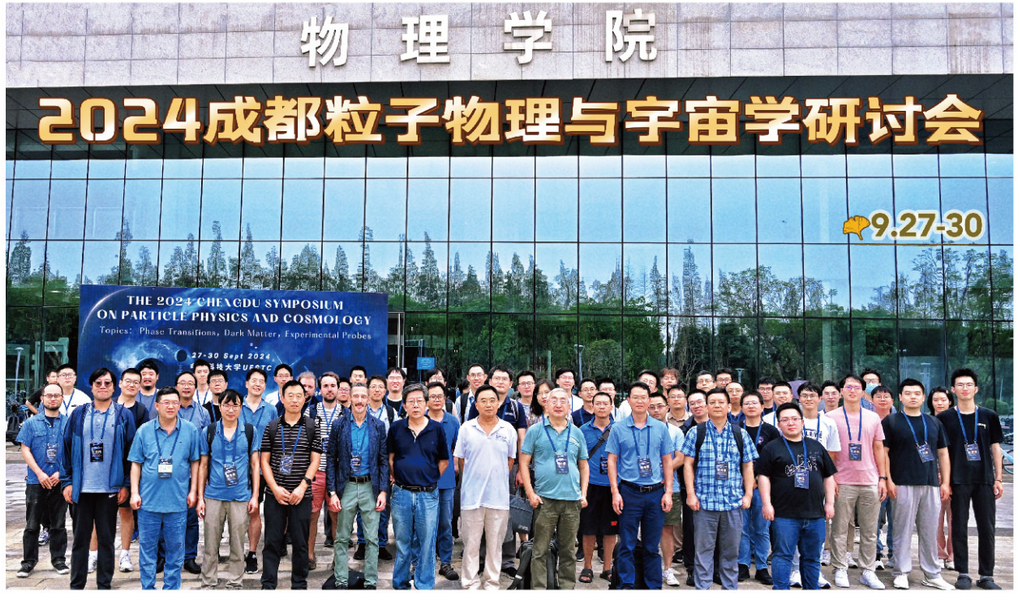
06

The 2024 Chengdu Symposium on Particle Physics and Cosmology: Phase Transitions, Dark Matter, and Experimental Probes (CPCS 2024)

2024年成都粒子物理与宇宙学：相变，暗物质与实验探测研讨会

During September 27-30, 2024, the CPCS 2024 symposium was held in Chengdu, Sichuan Province. It focused on the possibility of phase transitions in the early universe, potential signals from next-generation gravitational wave detectors, and the direct and indirect detection of dark matter and its correlation, as well as related theories and phenomenology, aiming at providing a platform for participants to exchange and discuss the latest research findings in these fields, as well as to stimulate new ideas and foster collaboration.

研讨会于2024年9月27日-30日在四川成都举办，主要关注早期宇宙中的相变可能性（包括但不限于电弱相变），下一代引力波探测器的潜在信号，以及暗物质的直接和间接探测及其相关关联，以及相关的理论和现象学。此次会议旨在提供一个平台，让与会者交流和探讨这些领域内的最新研究成果，并激发新思想和促进合作。



07

The 2nd Annual Conference on Quantum-Cosmology

第二届量子-宇宙物理年会

The annual conference was held in Hangzhou, Zhejiang Province from December 29 to December 31, 2024. During this conference, researchers from ICTP-AP, Institute of Theoretical Physics, CAS, and HIAS presented and discussed the latest advancements in their respective fields over the past year. The research topics encompass a wide range of cutting-edge fields, including particle physics and the origin of matter, dark universe and black hole physics, gravitational waves and precision measurement physics, as well as the application of machine learning in gravitational wave data processing. This annual conference serves as a platform for researchers to showcase their findings, exchange ideas, and collaborate on research. It promotes interdisciplinary integration among these institutions and lays a solid foundation for the further development of quantum-cosmology.

年会于2024年12月29日-31日在浙江杭州召开。来自中心、中国科学院理论物理研究所、国科大杭高院数理学院的科研人员在会上分享并讨论了过去一年里在各自研究领域取得的最新成果。研究内容涵盖多个前沿科学领域，包括粒子物理与物质起源、暗宇宙与黑洞物理、引力波与精密测量物理、机器学习在引力波数据处理中的应用等。此次年会为科研人员提供了一个展示成果、交流思想、合作研究的平台，促进了各单位之间不同学科的交叉与融合，为量子-宇宙物理进一步发展奠定了坚实的基础。

Public Outreach

科普活动

Throughout the year, ICTP-AP engages with the public through numerous outreach activities aimed at spreading the joy of science to the young and old.

在这一年中，ICTP-AP通过很多外展活动直接与公众接触，旨在向各年龄段的人群传播科学的乐趣。

Public Science Day

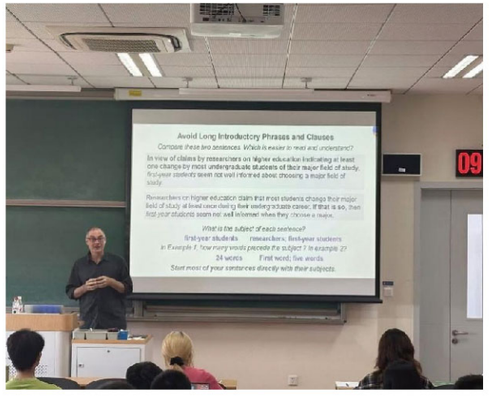
In response to the call of the “Public Science Day of the Chinese Academy of Sciences”, ICTP-AP engaged in various science popularization activities, explaining the working principle of micro-Newton Hall thrusters to the public, especially primary and secondary school students. The aim was to stimulate the curiosity and desire to explore space among young people, and sow the seeds for cultivating future scientific research talents.

ICTP-AP响应“中国科学院公众科学日”号召，参与丰富多彩的科普活动，向公众尤其是中小学生科普了微牛级霍尔推力器的工作原理，以激发青少年对太空的好奇心和探索欲，为培养未来的科研人才播下种子。

Academic Writing Training

On June 15, 2024, ICTP-AP and the Academic Writing Training of Department of Foreign Languages, UCAS, co-organized the "Academic English Writing Training" at the Yanqihu Campus of UCAS, with the aim of improving students' academic English writing skills and international communication abilities. The training featured seasoned experts in writing and pedagogy: Raymond Porter, Prof. Yanli Meng, and Associate Prof. Zhuxuan Zhao. They provided comprehensive insights into English linguistic expression and the intricacies of academic writing. The event attracted more than 70 students from various departments to participate.

ICTP-AP联合中国科学院大学外语系学术写作中心于2024年6月15日在国科大雁栖湖校区举办了“学术英语写作培训”，旨在提升学生的学术英语写作能力和国际交流能力。本次培训邀请了写作实验和教学经验丰富的外籍讲师Raymond Porter、孟艳丽教授和赵竹轩副教授。他们围绕英语语言表达技能和学术论文写作等主题进行了深入讲解。此次活动吸引了来自不同院系的70余名学生参与。



The Spirit of the Older Generation of Scientists

On October 16, 2024, the ICTP-AP Director, Prof. Yue-Liang Wu, delivered a report on promoting the spirit of the older generation of scientists for undergraduates at Yuquanlu Campus of UCAS. He inspired students to learn the spirit of the older generation of scientists—loving the motherland, selfless dedication, self-reliance, and the courage to explore, and encouraged them to continue to work hard, be down-to-earth, and strive for the goal of achieving self-reliance in science and technology.

2024年10月16日，中心主任吴岳良院士在国科大玉泉路校区为本科生作关于弘扬老一辈科学家精神的报告。他激励学生们学习老一辈科学家精神--热爱祖国、无私奉献、自力更生、勇于探索，并鼓励他们继续勤奋工作，脚踏实地，为实现科技自立自强的目标而奋斗。

2024 TIMELINE

January

国际学生前沿与交叉科学冬季学校于2024年1月14日-20日在云南成功举办，来自21个国家的留学生参加。

The Winter School on Frontier and Interdisciplinary Sciences was held successfully at Yunnan Province from January 14 to January 20, 2024, with 34 international students from 21 countries participating.

ICTP-AP参与编辑的物理学领域的科普词条，已累计影响14,011,777人，被评选为2023年科学百科知识影响力机构。

ICTP-AP was selected as the 2023 Scientific Encyclopedia Knowledge Influence Institution for editing popular science entries in the field of physics, with a cumulative influence reaching 14,011,777 people.

February~March

2024年3月，获得国家自然科学基金理论物理专款第二期经费资助。

In March 2024, “Joint Center for Quanta-to-Cosmos Physics” received the second phase of funding from the Special Fund for Theoretical Physics of the NSFC.

2024年3月20日，中国科学院国际合作局国际组织处调研ICTP-AP.

On March 20, 2024, a delegation from the International Organizations Office of the Bureau of International Cooperation, CAS, conducted an inspection of ICTP-AP.

April

第二届引力波时代前沿科学与前瞻技术研讨会于2024年4月26日至4月30日在南京大学举办。

The Symposium on Cutting-edge Science and Forward-looking Technologies in the Era of Gravitational Waves was held at Nanjing University from April 26 to April 30, 2024.

2024年4月21日-26日， 在广东东莞，34名来自8个国家的留学生参加了前沿与交叉科学春季学校。

The 2024 Spring School on Frontier and Interdisciplinary Sciences was held at Dongguan, Guangdong Province during April 21 to April 26, 2024, with 34 international students from 8 countries participating.

May

2024年5月16日，量子-宇宙物理前沿论坛在北京召开。

The Frontier Forum on Quantum-cosmology Physics was held in Beijing on May 16, 2024。

2024年5月15日至17日，ICTP-AP代表团参加了在马来西亚吉隆坡举办的自然科学领域的联合国教科文组织二类中心国际研讨会。

During May 15-17, 2024, delegations from ICTP-AP participated the International Symposium of Category 2 Centre under the auspice of UNESCO in the field of Natural Sciences in Kuala Lumpur, Malaysia.

June

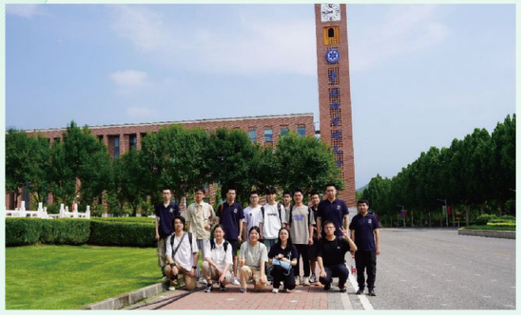
2024年6月，LIGO科学合作组委员会投票通过了ICTP-AP加入LIGO科学合作组织的申请，郭怀珂副教授为该合作项目的负责人。

In June 2024, the LIGO Scientific Collaboration Committee voted to approve the application of ICTP-AP to join it, with Prof. Huaike Guo serving as the director of the cooperation project.

2024年6月27日，ICTP-AP主任吴岳良院士和UNESCO东亚多部门地区办事处主任Shahbaz Khan教授进行了接洽，就中心国际评估和续约工作进行了充分交流。

On June 27, 2024, Prof. Yue-Liang Wu, the Director of ICTP-AP, and Prof. Shahbaz Khan, the Director of the UNESCO Multisectoral Regional Office for East Asia, had a meeting to fully exchange views on ICTP-AP’s international evaluation and the renewal work.

July



ICTP-AP 2024年优秀大学生夏令营于6月27日-7月2日在中国科学院大学中关村校区举办。

From June 27 to July 2, 2024, the ICTP-AP 2024 Summer School was held in the Zhongguancun Campus, UCAS.

2024年 7月7日至12日，第十七届马塞尔·格罗斯曼会议在意大利东部城市佩斯卡拉举办。中心主任吴岳良院士率团参会，并受邀做大会报告。

From July 7 to July 12, 2024, the Seventeen Marcel Grossmann Meeting was held in Pescara, a city on the eastern coast of Italy. The Centre's director, Prof. Yue-Liang Wu, led a delegation to the conference and was invited to give a keynote speech.

August

2024年8月，《中国科学：物理学 力学 天文学》出版了一期关于空间引力波探测相关技术和科学应用系统的专题。

In August 2024, "SCIENTIA SINICA Physica, Mechanica & Astronomica" published a special topic: Technologies and scientific applications of space-based gravitational-wave detection.

2024年8月4日至8月9日，39名留学生参加了在中国科学院大学雁栖湖校区举办的前沿与交叉科学暑期学校。

During August 4 to August 9, 2024, the 2024 Summer School on Frontier and Interdisciplinary Sciences was held at the Yanqihu Campus, UCAS, with 39 international students participating.

September

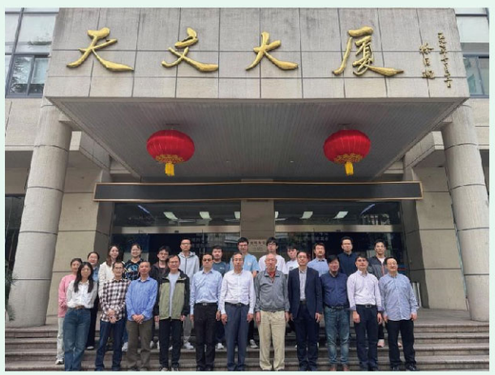
2024年9月21日-23日，“迎接 2025 国际量子科学技术年：现代物理学史国际研讨会”在北京成功举办。

During September 21 to September 23, 2024, the Embracing the International Year of Quantum Science and Technology: Symposium on the History of Modern Physics was held successfully in Beijing.

October

2024年10月12日，中心联合中国科学院上海天文台在上海组织召开了“星载激光锁臂稳频技术与时间延迟技术研究”项目专题研讨会。

On October 12, 2024, ICTP-AP co-organized a special symposium in Shanghai for the Project “Research on Spaceborne Laser Lock-in Frequency Stabilization Technology and Time Delay Interferometry Technology” with Shanghai Astronomical Observatory, CAS.



November

2024年11月15日，中心主任吴岳良院士出席ICTP 60周年庆祝活动

On November 15, 2024, ICTP-AP Director Prof. Yue-Liang Wu attended the ICTP 60th anniversary.

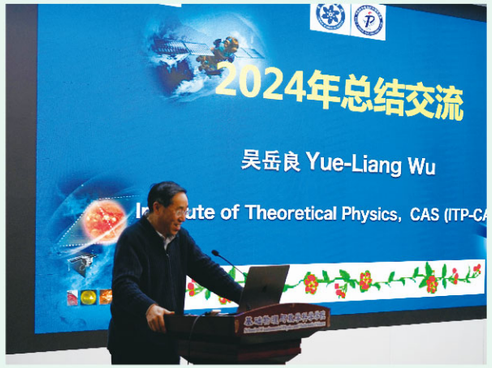
本次冬季学校于2024年11月25-29日在中国科学院大学雁栖湖校区举办。作为庆祝意大利国际理论物理中心（ICTP）成立六十周年活动之一，重点围绕量子场论、弦论、引力理论、粒子物理、宇宙学等主题展开，吸引了60名学员参与。

The 2024 ICTP-AP Winter School on theoretical physics was held at Yanqihu Campus, UCAS, from November 25 to 29, 2024. As a part of the celebration of the 60th anniversary of the International Centre for Theoretical Physics (ICTP) in Italy, the Winter School mainly focuses on quantum field theory, string theory, gravitational theory, particle physics, cosmology and other topics, with 60 students participating.

December

2024年12月29日-31日，第二届量子-宇宙物理年会在浙江杭州举办。中心主任吴岳良院士在会上发表了开幕致辞。

The 2nd Annual Conference on Quantum-Cosmology was held in Hangzhou, Zhejiang Province from December 29 to December 31, 2024. The Director of the Centre, Prof. Yue-Liang Wu, delivered the opening address at the conference.

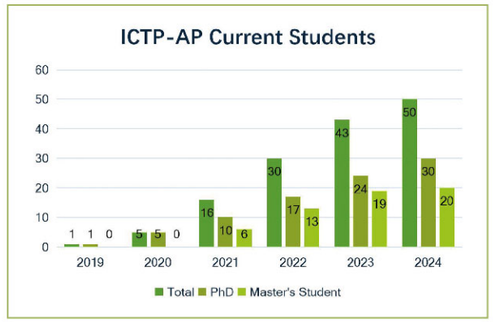


STUDENT CULTIVATION

Student Admission
招生情况

The scale of students has increased year by year and the total number has reached 50. In 2024, ICTP-AP has enrolled 16 students, including 10 PhD students and 6 master's students. During their study in UCAS, students could apply for the following scholarships: National grants, Nation scholarships, scholarships of Chinese Academy of Sciences, academic scholarships of UCAS, scholarships of research institutes and allowances for "Research Assistants/ Teaching Assistants/Management Assistants".

目前，中心的在校生人数已达到50人。2024年，中心共招收16名研究生，其中包括10名博士生，6名硕士生。在学期间，学生可以申请国科大设置的各类奖助学金：国家助学金、国家奖学金、中国科学院奖学金、国科大学业奖学金、研究所奖学金、“助研/助教/助管”岗位津贴，共计六个类别。



As a Category 2 Centre of UNESCO, ICTP-AP has been actively playing its role in the cultivation of talents from developing countries, and engaged in the recruitment promotion of UCAS for international students and the training and teaching work of the International College of the UCAS. In 2024, a total of 321 international students were admitted. These students come from various regions including Asia, Africa, Europe, and North America, with 98% overseas students coming from developing countries. During their study in UCAS, international students could apply for the UCAS President Scholarship and the Alliance of National and International Science Organizations Scholarship, etc.

作为联合国教科文的二类机构，中心一直支持和推动发展中国家科学人才的培养，积极参与国科大国际学生的招生宣传和国际学院的培训教学工作。2024年，共招生321名国际学生。他们来自亚洲、非洲、欧洲和北美洲等多个地区；其中，来自发展中国家的学生占留学生总人数98%。在学期间，国际学生可以申请中国科学院大学校长奖学金和ANSO奖学金等。

Student Education

科教融合的培养体制

ICTP-AP is promoting a high-quality education model characterized by the fusion of scientific research and education. The Centre's professors engage in graduate teaching by integrating state-of-the-art research findings and additional methodologies into their course, which make students have access to cutting-edge scientific knowledge, aiming to cultivate a new generation of talents who possess both creativity and practical skills.

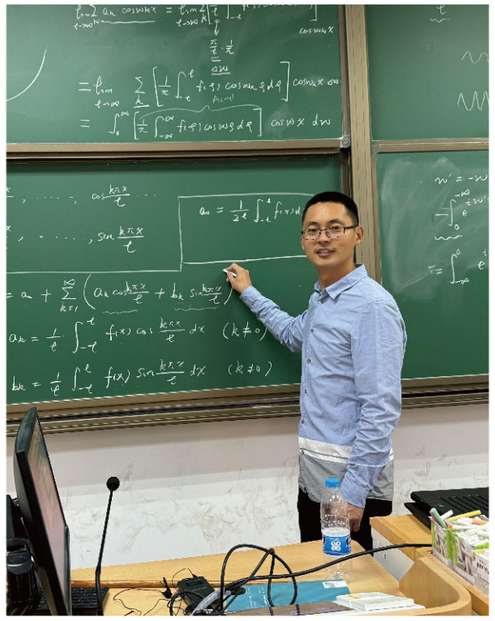
ICTP-AP正高质量推进科教融合的教学理念。中心的教授积极参与到研究生教学中，将最新的科研成果和方法融入教学内容，使学生能够接触到前沿科学知识，旨在培养兼具创造力和实践技能的新一代人才。

ICTP-AP annually organizes an Outstanding Undergraduate Summer Camp aimed at discovering and enrolling excellent undergraduates. Through this program, students are given the opportunity to learn about the cutting-edge topics in theoretical physics. The Centre also uses this platform to select students who have a strong interest in scientific research and let them experience the academic atmosphere of graduate students.

The ICTP-AP 2024 Summer School was held in the Zhongguancun Campus, UCAS, from June 27 to July 2, 2024. The Centre's office and the graduate supervisors introduced the Centre's faculty, the situations of talent cultivation, and the frontiers research of theoretical physics science to the students in detail. Students had in-depth communication with graduate supervisors on their research interests, research plans, and future plans.

中心每年举办优秀大学生夏令营，致力于发掘和招募具有优秀潜力的本科生，通过这一项目，学生们有机会深入了解理论物理领域的前沿热点课题。中心也借此平台选拔那些对科研有浓厚兴趣的学生，并让他们亲身体验研究生的学术氛围。

夏令营于6月27日-7月2日在中国科学院大学中关村校区举办。ICTP-AP中心办公室和研究生导师向大家详细介绍了中心师资力量、学生培养情况和理论物理科学前沿研究。学生们就研究兴趣、研究计划和未来规划与研究生导师进行了深入的沟通交流。



Besides, ICTP-AP jointly funds the International Students Frontier and Interdisciplinary Science School, an international student education and training innovation program project, with the International College of UCAS. The program focuses on the highlight and cross-disciplinary nature of cutting-edge fields, as well as the deep integration of science research and education. Its goal is to break down the boundaries between traditional disciplines, foster the integration of knowledge and technology across various fields, address complex scientific challenges, and cultivate innovative talents.

In 2024, ICTP-AP held three International Frontier and Interdisciplinary Science Schools, with themes focusing on biodiversity, materials science and engineering, and basic sciences for sustainable development, attracting over 100 international students. As of this year, the Frontier and Interdisciplinary School has been carried out for ten years, making positive contributions to promoting the development of science and cultural exchange.

中心与中国科学院大学国际学院（IC-UCAS）共同资助了国际学生前沿与交叉科学学校。这是一项教育和培养国际学生的创新计划项目，着重突出专业方向的针对性和交叉性以及科教深度融合性。旨在打破传统学科之间的界限，促进不同领域知识和技术的整合，解决复杂的科学问题，并培养创新人才。

2024年，中心共举办了三次国际学生前沿与交叉科学学校，主题分别围绕生物多样性、材料科学与工程以及基础科学促进可持续发展等相关学科展开，超过100余名国际留学生参加。前沿与交叉学校已开展了十年，为推动国际科学发展和文化交流做出积极贡献。

(January 14-20, 2024)


(April 26-30, 2024)


(August 4-9, 2024)

Student Activities
学生活动

The Centre organizes sports competitions and provides career guidance services to enrich students' campus life and improve their comprehensive abilities.

中心积极组织体育竞赛活动和提供就业指导服务，丰富学生的校园生活，并提升学生的综合素质。

On March 30, 2024, the men's basketball league of the University of Chinese Academy of Sciences officially commenced. ICTP-AP, in collaboration with the International College and the Kavli Institute for Theoretical Physics, jointly formed an international physics team composed of 12 students to participate in the competition.

2024年3月30日，中国科学院大学2024年“科苑杯”男子篮球联赛正式开赛。中心携手国际学院、卡弗里理论科学研究所，共同组建了一支由12名学生组成的国际物理联队参加比赛。

On July 15, 2024, the Centre organized a farewell party for the graduates to celebrate successful completion of academic studies and the beginning of a new life stage. Seven graduates shared their learning experiences and daily life moments. The teachers at the Center provided career planning guidance based on their major and future goals. This activity not only enhanced the graduates' sense of belonging but also marked a perfect ending to their campus life.

2024年7月15日，中心举办了毕业生欢送会，以庆祝毕业生顺利完成学业并迈向新生活阶段。7名毕业生分享了自己的学习经历和生活点滴。中心的老师们针对他们的专业和未来规划提供了职业规划指导。这一活动不仅增强了毕业生的归属感，也为他们的校园生活画上了圆满的句号。

ICTP-AP PLATFORM

Taiji Laboratory for Gravitational Wave Universe

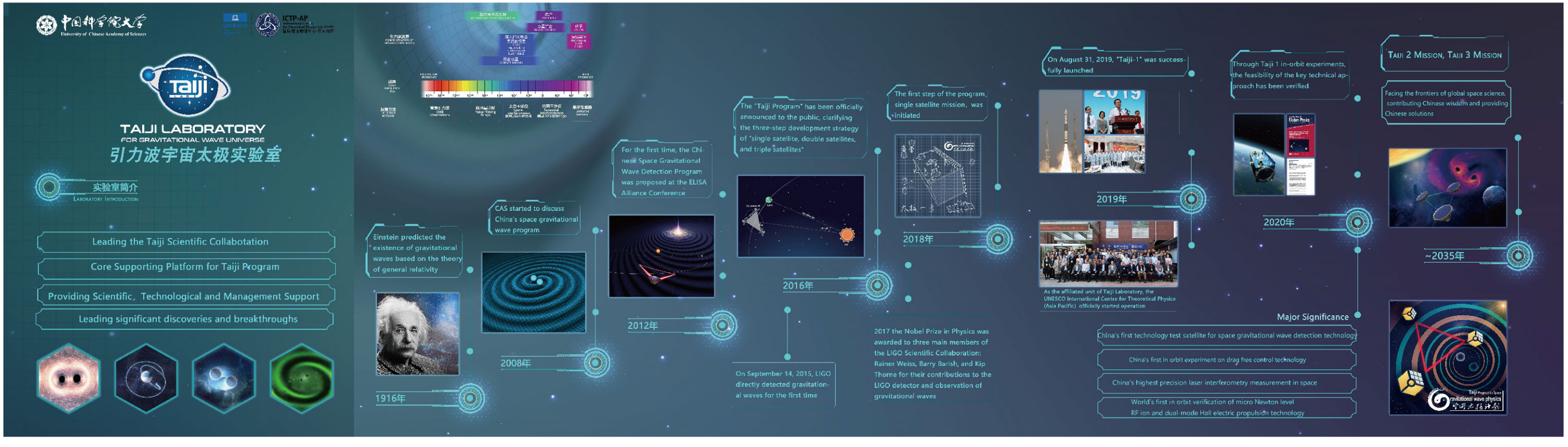
引力波宇宙太极实验室

The Taiji Laboratory for Gravitational Wave (Taiji Laboratory), which is the core support platform of the "Taiji Program", operates under the support of ICTP-AP. The laboratory is located in both Beijing and Hangzhou.

引力波宇宙太极实验室依托国际理论物理中心建设运行，是空间引力波探测“太极计划”的核心支撑平台，实验室分布在北京和杭州两地。

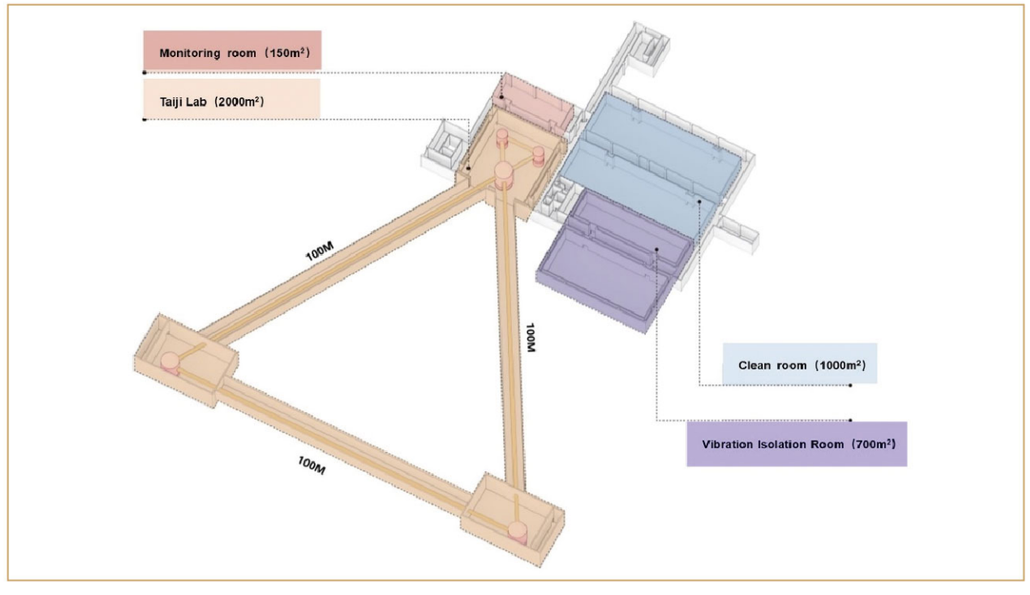
Taiji Laboratory (Beijing) provides comprehensive scientific, technical and management support, and undertakes the construction of the scientific application system of Taiji Program. In 2024, Taiji Laboratory (Beijing) deployed five subsystems: Scientific operation and data management, Preprocessing of detection data, Scientific data processing, Scientific users, and Semi-physical simulation for scientific measurement. Taiji Laboratory (Beijing) will be effectively linked with the engineering master, satellite and ground branch systems, supervising and evaluating each subsystem, coordinating the development of each subsystem, and forming an integrated scientific application system.

太极实验室（北京）为空间太极计划的项目推进提供科学、技术和管理的全面支撑，同时承担“太极计划”科学应用系统建设。2024年，太极实验室（北京）论证部署科学运行和数据管理、探测数据预处理、科学数据处理、科学用户和科学测量半物理仿真五大分系统，与工程大总体和卫星、地支等系统有效衔接，对各分系统进行监督和评估、协调各分系统研制，形成科学应用系统的有机整体。



Taiji Laboratory (Hangzhou), in response to the requirements of key technologies for the ground verification of Taiji Program in space gravitational wave detection, has proposed the construction of physical experimental device for ultra-precision measurement of gravitational wave in HIAS (Shuangpu Campus). Focusing on the needs of high-precision and high-sensitivity cutting-edge physics experiments, it will utilize the stable and superior geological conditions of underground to build a world-class laser interferometer measurement device based on the ultra-high precision (picometer-level) laser interferometer. In 2024, the design schemes of physical experiment equipment for ultra-high precision measurement of gravitational waves, as well as the structure of the laboratory infrastructure, including HVAC, electrical, low-voltage systems, etc., were completed, and the approval process of these schemes was successfully passed. In September, the bidding for construction units was completed, officially entering the stage of basic environmental construction.

太极实验室（杭州）针对空间引力波探测太极计划开展地面关键技术攻关及实验验证需求，提出在杭高院双浦园区实施引力波超高精密测量物理实验装置建设项目，将围绕开展高精度、高灵敏度前沿物理实验需求，利用地下稳定优越的地质条件，基于超高精度（皮米量级）的激光干涉仪，建设国际一流的激光干涉极限测量装置。2024年完成了引力波超高精密测量物理实验装置以及实验室基础建设的结构、暖通、电气、弱电等专项设计方案，并通过了报审工作。9月份完成了施工建设单位招标，正式进入基础环境建设阶段。



In August 2024, "SCIENTIA SINICA Physica, Mechanica & Astronomica" published a special topic: Technologies and scientific applications of space-based gravitational-wave detection. This issue invited many experts to write reviews and research papers on space gravitational wave detection related technologies and scientific application systems, aiming at presenting the latest progress and future prospects in this field. These articles cover many aspects from detection technology to scientific application, and show the diversity and complexity of space gravitational wave detection.

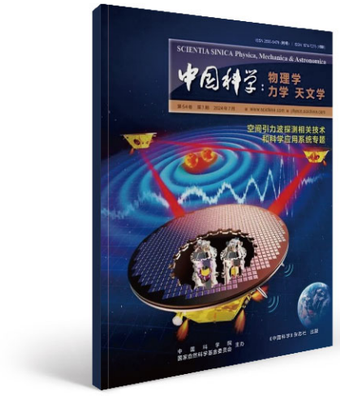
It includes the status and prospect of space gravitational wave detection, the challenges of scientific data processing and the application of artificial intelligence technology, laser interferometry, inertial sensors and their key technologies, ground testing, calibration and testing methods of multi-degree-of-freedom capacitive sensors, and the new physical generation mechanism of millihertz gravitational wave background.

Through these articles, we hope to show readers the latest research results and development trends in the field of space gravitational wave detection, and show the current technical level and challenges. It is believed that with the continuous progress of science and technology and the deepening of international cooperation, space gravitational wave detection will play an increasingly important role in exploring the mysteries of the universe and testing basic physical theories, and promote the deepening of human understanding of the universe.

2024年8月，《中国科学：物理学 力学 天文学》出版了空间引力波探测相关技术和科学应用系统专题。本期专题邀请多位专家撰写关于空间引力波探测相关技术与科学应用系统的综述和研究论文，旨在呈现这一领域的最新进展与未来展望。

这些文章涵盖了从探测技术到科学应用的多个方面，展示了空间引力波探测领域的多样性与复杂性，包括：空间引力波探测的现状与展望、科学数据处理的挑战和人工智能技术的应用、激光干涉技术、惯性传感器及其关键技术、地面测试、多自由度电容传感标定测试方法，以及毫赫兹引力波背景的新物理产生机制。

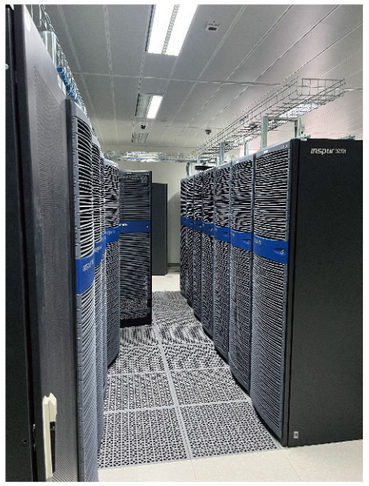
通过这些文章， 希望为读者展示空间引力波探测领域的最新研究成果和发展趋势，展示当前的技术水平和面临的挑战。相信随着科学技术的不断进步和国际合作的深化，空间引力波探测将在探索宇宙奥秘、检验基本物理理论等方面发挥越来越重要的作用，推动人类对宇宙的认识不断深入。



Computing Platform
计算平台

ICTP-AP is equipped with 207 computing nodes for C++, Fortran, and python programming operations. The servers are mainly distributed in Yanqihu Campus and Zhongguancun Campus of UCAS. In 2024, the Centre purchased two new storage servers serving as landing nodes of the cluster for connecting the computing cluster and storing scientific data.

目前，中心配有207个计算节点，用于C++、Fortran以及python的编程运算。服务器主要分布于中国科学院大学雁栖湖校区和中关村校区。2024年，中心新购置两台存储服务器用作集群的登陆节点，用于连接计算集群和存储科学数据。



The School of Fundamental Physical and Mathematics Science, HIAS
国科大杭高院数理学院

The School of Fundamental Physical and Mathematics Science, HIAS was jointed by ICTP-AP and ICP, CAS in 2019. The school currently has 34 teaching and research staff, 28 postdoctoral researchers, 1 experimental technician, and 10 contracted staff. There are 126 master's degree candidates and 29 doctoral degree candidates.

In 2024, the school is deeply committed to improving the research layout of the Department of Basic Physics and actively introduces outstanding teams in the field of astronomy and astrophysics research, promoting the establishment of professorial studios. Additionally, the school is actively preparing for the establishment of the Department of Mathematical Sciences, planning to set up the First Division of Mathematical Sciences (Pure Mathematics) and the Second Division of Mathematical Sciences (Applied Mathematics). The main research directions include analysis, probability and statistics, differential equations, dynamical systems, mathematical physics, and computer science. In terms of academic activities, this year the school has successfully hosted the "Workshop on Grand Unified Theories: Phenomenology and Cosmology," the First Neutrino Scattering: Theory, Experiment, and Phenomenology Symposium, the 2024 BESIII New Physics Symposium, and the 2024 Hangzhou Gravitation and Cosmology Symposium.

国科大杭州高等研究院基础物理与数学科学学院（简称“数理学院”）成立于2019年12月28日，由中国科学院理论物理研究所和联合国教科文组织国际理论物理中心（亚太地区）共同建设。学院现有教学科研人员34人，在站博士后28人，实验技术人员1人，聘用人员10人。在校硕士生126人，博士生29人。

2024年，在学科建设方面，学院深入完善基础物理学部科研布局，积极引进天文与天体物理研究领域优秀团队，推动教授工作室的筹建工作。另外积极筹建数学科学学部，拟筹建数学科学一系(基础数学)和数学科学二系(应用数学)，主要开展分析、概率统计、微分方程、动力系统、数学物理、计算机科学等方向的研究。在学术活动方面，学院成功举办了“Workshop on Grand Unified Theories: Phenomenology and Cosmology”、第一届中微子散射：理论、实验、唯象研讨会、2024 BESIII新物理研讨会、2024杭州引力与宇宙学研讨会等。

GOVERNANCE

ICTP-AP, which is the first Category 2 Centre established by UNESCO in basic science in China, was jointly founded by CAS, NSFC, and the International Centre for Theoretical Physics, relying on UCAS for the Centre's construction and development.

ICTP-AP has an international Governing Board, which sets general guidelines for the Centre's activities and follows a seat-based system. ICTP-AP holds regular board meetings to report on its annual working progress and propose its development plan for the next stage. ICTP-AP also has an international Scientific Council that comprises of distinguished specialists in basic sciences from different areas. The Council advises ICTP-AP on its programmed of activities in the light of major academic, scientific, educational and cultural trends relevant to its objectives.

中心由中国科学院、国家自然科学基金委员会和国际理论物理中心共同建设，依托于中国科学院大学进行机构建设和发展。是联合国教科文组织在中国基础科学方面设立的第一个二类中心。

中心设立国际理事会和国际科学委员会。国际理事会负责对中心规划和发展工作进行指导和监督，并采用席位制。中心定期召开理事会会议，进行工作汇报和总结，提出下一阶段发展计划。国际科学委员会负责对中心学术工作进行指导和监督。学术委员会委员由来自世界各地的基础科学领域的专家组成，他们根据与中心目标有关的主要学术、科学、教育和文化趋势，就中心的活动方案向中心提供咨询意见。

ICTP-AP INTERNATIONAL GOVERNING BOARD

CAS

A representative from CAS serving as the ex officio chairman of the board.
中国科学院代表一名，担任中心理事会的当然主席

UNESCO

Two representatives of the Director-General of UNESCO, including one from the ICTP
教科文组织总干事代表两名，包括ICTP代表一名

Chinese Government

Up to three representatives from the government (e.g. NSFC, Ministry of Education, UCAS)
中国政府代表至多3人（如国家自然科学基金委员会、教育部、中国科学院大学）

ICTP-AP INTERNATIONAL SCIENTIFIC COUNCIL

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Song He	ITP, CAS
Kimyeong Lee	KIAS
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Subir Sarkar	Univ. of Oxford
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Chun-Nong Zhao	Univ. of Western Australia
Hong Liu	MIT
Yang Bai	Wisconsin Univ.
Francesco Sannino	Univ. of Southern Denmark; Univ. of Federico II, Italy

SUPPORTERS

ICTP-AP would like to express its deep gratitude to all who supported us in 2024.

ICTP-AP对所有在2024年支持中心的学校和院所表达深深的感谢。

- Academy of Mathematics and Systems Science, CAS
- Asia-Pacific Center for Theoretical Physics, Korea
- Bureau of International Cooperation, CAS
- Changchun Institute of Optics, Fine Mechanics and Physics, CAS
- Chinese Society of Space Research
- Hangzhou Institute for Advanced Study of UCAS
- Hunan University
- Innovation Academy for Microsatellites of CAS
- Innovation Academy for Precision Measurement Science and Technology, CAS
- Institute for the History of Natural Sciences, CAS
- Institute of High Energy Physics, CAS
- Institute of Mechanics, CAS
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- National Natural Science Foundation of China
- National Space Science Center, CAS
- Shandong University
- Shanghai Astronomical Observatory, CAS
- Shanghai Institute of Optics and Fine Mechanics, CAS
- University of Chinese Academy of Sciences
- Zhejiang University of Technology
- Songshan Lake Materials Laboratory
- Kunming Institute of Botany, CAS
- Kunming Institute of Zoology, CAS
- Xishuangbanna Tropical Botanical Garden, CAS
- Institute of High Energy Physics, Austrian Academy of Sciences
- University of Valencia, Spain.
- Vrije Universiteit Brussel, Belgium.

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VICE DIRECTOR

Song He

OFFICE DIRECTOR

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Yun-Song Piao	UCAS
Yu-Xiao Liu	LanzhouUniv.
Zhou-Jian Cao	Beijing Normal Univ.
Zong-Kuan Guo	ITP, CAS

PUBLICATIONS

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