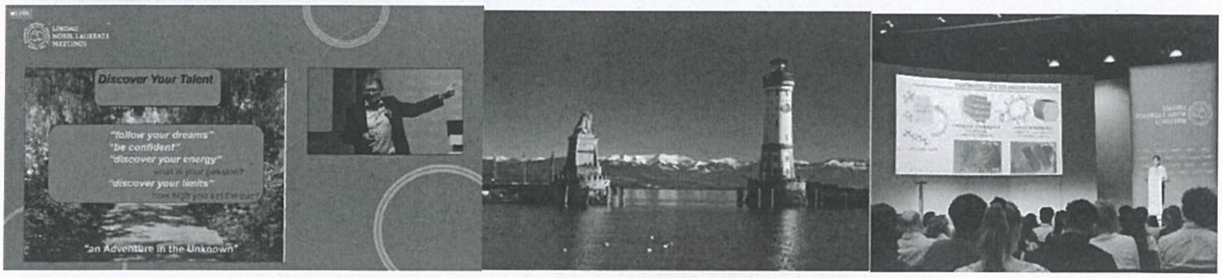
华中科技大学 物理学院

Chinesisch-Deutsches Zentrum für Wissenschaftsförderung

中德科学中心

APPLICATION FOR THE LINDAU PROGRAM

Topic	**Interdisciplinary （Chemistry, Physics and Medicine/Physiology）**		
Time of the Meeting	**2026.6.28-07.03**		
Time of the Science Tour	**The specific time will be advised in due course**		
Place	**Lindau and other German cities during the Science Tour**		
Name	Run-Ze Yu	**Gender**	Male
Date of Birth	April 30th, 2000	**Place of Birth**	Wuhan, Hubei
Institute/University	School of Physics, Huazhong University of Science and Technology		
Address/Zip Code **Phone** **E-Mail**	Luoyu Road 1037, Wuhan, Hubei 430074, China (+86) 136-2725-6520 yurunze01@hust.edu.cn		
Field of Research	Radiative helicity in electromagnetic and gravitational systems		
Certificates of English and other languages	CET 4		
Expected Date of Graduation	June, 2028		



华中科技大学 研究生院

1. **Statement of your qualifications**

a. **Research field:** My research focuses on helicity flux density in radiation theory, an observational physical quantity that remains underexplored in both electromagnetic and gravitational radiation processes. This quantity characterizes the difference in the number of particles with opposite helicities arriving per unit time and per unit solid angle at future null infinity, offering a novel perspective for understanding the physical properties of radiating systems. My work is dedicated to establishing the theoretical framework for this new observable, identifying its universal behavior in multipole radiation structures, and exploring its potential applications in astrophysics and cosmology.

Main contributions:
In the context of electromagnetic radiation, a theoretical foundation for the electromagnetic helicity flux density has been systematically established, clarifying its distinctions and connections with concepts such as magnetic helicity and optical helicity in terms of definition and physical implications. The expression for the helicity flux density of a point charge undergoing arbitrary accelerated motion was derived. A systematic multipole expansion of the helicity flux density was accomplished, yielding a general formula that incorporates contributions from electric and magnetic multipole moments of all orders. This expanded form exhibits a profound mathematical analogy with the classical multipole expansion of energy radiation, providing a unified theoretical tool for understanding the angular distribution of helicity in complex radiating systems. The theory was applied to several classical toy models, and the characteristics of the helicity angular distribution under these circumstances were analyzed. Furthermore, this framework was employed in the context of a pulsar magnetic dipole radiation model, revealing that the ratio of helicity flux to energy flux density is directly related to the pulsar period. Based on this relation, the magnitude estimate of the helicity flux density reached Earth from the Crab Pulsar was obtained. These findings suggest that helicity flux density holds promise for detection via high-precision polarimetric observations, thereby offering new perspectives for studying the radiation systems and magnetospheric physics of stars, pulsars, and other astrophysical objects.

In the context of gravitational radiation, the quadrupole formula for the gravitational wave helicity flux density was derived for the first time within the weak-field and slow-motion approximation. A systematic analysis was performed on the helicity angular distribution for binary systems in both bound and unbound orbits, and a general expression encompassing all higher-order mass and current multipole moments was established. These results not only provide a novel means to constrain gravitational wave source parameters (such as mass and orbital eccentricity), but also offer a potential discriminant for testing gravitational theories beyond general relativity. Furthermore, a new definition of cosmological distance based on helicity flux was proposed, which differs from the conventional luminosity distance and holds promise for offering new insights into the Hubble tension in modern cosmology. This study introduces a new physical observable for future gravitational wave observations and can be further extended to more astrophysical systems and broader radiation scenarios, exploring the role of helicity in understanding cosmic evolution and extreme physical environments.

Current work: In the case of linear gravitational theory, the helicity of gravitational radiation generated by a point particle in arbitrary motion at $\mathcal{I}+$, the corresponding post-Newtonian corrections, and explore the possibilities of the theory in nonlinear situations.

b. Motivation for pursuing a PhD and reasons for choosing the research topic:
The detection of gravitational waves (awarded the 2017 Nobel Prize in Physics) has opened a new window for observing the universe, motivating my in-depth investigation into physical quantities (such as the radiative helicity) that remain understudied in radiation processes. The limited discussion of the helicity flux in textbooks and literature has prompted me to undertake a systematic study of it. Helicity flux not only carries geometric and topological significance in fundamental theory but may also provide novel observational perspectives for fields such as astrophysics, gravitational wave physics, and magnetohydrodynamics.

c. International Exchange Experience:
During the summer of my undergraduate studies, I participated in an academic exchange program at the University of Naples Federico II in Italy. I hope that through this conference, I will be able to engage in deeper discussions with scholars from around the world, establish international collaborations, and further enhance the global impact of my research.

d. Development Plan:
In subsequent research, the primary focus will be on deepening the theoretical study of radiative helicity. In the context of gravitational theory, efforts will be made to extend the analysis to higher-order post-Newtonian approximations and apply it to actual astronomical observational data (e.g., from LIGO/Virgo, FAST, and SKA), in order to provide specific observational predictions for helicity and frameworks for data interpretation. In electromagnetic theory, a thorough investigation will be conducted into the helicity flux during magnetic reconnection processes, linking it with stellar systems and magnetohydrodynamics. In astrophysics and cosmology, it is worth aiming to explore the theoretical feasibility of establishing helicity flux density as a standard astrophysical probe, and on this basis, develop a unified theoretical, numerical, and observational research methodology from solar physics to cosmological scales, which will be applicable to a wide range of astrophysical systems.

Declaration

We confirm with our signature that the information provided by the applicant is true. We are willing to recommend the applicant to participate in the selection of the 75th Lindau Nobel Laureate Meeting organized by the Sino-German Center.

Run-Ze Yu

Signature of the applicant

华中科技大学 研究生院

Seal of the university

华中科技大学 物理学院

Attachment

1. **Letter of recommendation from your thesis advisor and/or the academic committee of your current institution. Please fill in the template.**

INSTITUTE OF FUNDAMENTAL THEORETICAL PHYSICS

HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

1037 Luoyu Road, Wuhan, Hubei，430074，P.R.China

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Oct. 12, 2025

Dear Committee members,

I am writing with pleasure to recommend Run-Ze Yu, a third year graduate student in my group, to attend the 74th Lindau Congress of Nobel Prize Winners.

Run-Ze has been working on the application of helicity flux density to real-world systems. This novel quantity characterizes the angular dependence of the difference in number between particles of opposite helicity in radiative systems. This is a topic which originates from flat holography and may yield new findings in gravitational wave astronomy. Our work has led to a quadrupole formula for gravitational helicity flux density, extending the Bondi's mass loss formula in the Newton limit. We applied this to binary systems, defining new observables in gravitational wave physics. Additionally, we derived a dipole formula for electromagnetic helicity flux density and applied it to pulsar systems. Run-Ze played an important role in this series of projects. The expertise he has gained in this promising field will be a key asset for his future career. Run-Ze studied paleontology at the undergraduate level and then turned into theoretical physics. His ability to quickly immerse himself in cutting-edge research within a few years demonstrates both his passion and aptitude for physics.

Direct interaction with Nobel Laureates offers a unique opportunity to grasp both the historical context and future trajectories of scientific advancement. This Lindau Nobel Laureate Meeting can provide valuable opportunities for his future development, and I strongly recommend him for participation.

Sincerely,

Jiang Long

Associate Professor

华中科技大学 物理学院

华中科技大学 研究生院

2. Curriculum vitae and publication list (The co-first author is marked with '#', and the corresponding author is marked with '*')

[1] #Z.-Y. Heng, #J. Long, #,*R.-Z. Yu and #X.-H. Zhou. *Electromagnetic helicity flux density for radiative systems*, arXiv: 2507.14966.

[2] #J. Long and #,*R.-Z. Yu, *Gravitational helicity flux density from two-body systems*, Class. Quant. Grav. 42 (2025) 045005.

[3] #A. Li, #W.-B. Liu, #,*J. Long, and #R.-Z. Yu, *Quantum flux operators for Carrollian diffeomorphism in general dimensions*, JHEP 11 (2023) 140.

3. Copy of ID card

中华人民共和国

居民身份证

签发机关 武汉市公安局汉阳分局

有效期限 2019.07.08-2029.07.08

姓名 余润泽

性别 男 民族 汉

出生 2000 年 4 月 30 日

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公民身份号码 420105200004300011

Sino-German Center for Research Promotion
Shuangqing Road 83
Haidian District
Beijing 100085, VR China

Dear applicant,

Thank you for submitting your application for the Lindau programme to the Sino-German Center for Research Promotion (SGC). In order to comply with relevant regulations on personal data protection, we need to obtain your informed consent by signing the following statement. Please return the signed form to us, both as a hard copy and a scanned copy by e-mail to Ms. Zhu Meilan (Zhu@sinogermanscience.org.cn).

The Sino-German Center for Research Promotion

Informed Consent form for applicants in the Sino-German Center for Research Promotion Lindau programme

☑ I hereby agree to the Sino-German Center for Research Promotion (hereinafter referred to as SGC) and its parent institutions (National Nature Science Foundation of China and Deutsche Forschungsgemeinschaft) storing and processing my personal information (including but not limited to: surname, first name, academic title, field of research and specialism, country, gender, date of birth, telephone number, postal address, e-mail address, current university/research institution) and the application materials for the purpose of review and funding management in the SGC's programme. I consent to my data being shared with the reviewers in the course of the application evaluation process, with the Lindau Foundation and the Lindau Council in case of a positive decision, and with Third Party data Processors such as Evaluation Agencies supporting the SGC in assessment of its funding programmes.
I am aware that I can withdraw my consent, partially or wholly, at any time, with or without giving reasons, by writing to Ms Zhu Meilan under zhu@sinogermanscience.org.cn. If my consent is withdrawn, any processing of my data which occurred on my consent before the withdrawal of the same shall not be considered objectionable.

☑ I also agree to the SGC using my contact data for informational purposes and to including me in the Lindau Alumni information network.

For more details please see the attached file for personal information processing.

余润泽

Name in print

October, 9th
余润泽, Run-Ze Yu

Date, Signature

School of Physics, Huazhong University of Science and Techonology

Name of University/Research Institution

物理学院

研究生院

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Classical and Quantum Gravity

PAPER

Gravitational helicity flux density from two-body systems

Jiang Long and Run-Ze Yu*

Published 27 January 2025 •

Classical and Quantum Gravity, Volume 42, Number 4

Focus on Gravitational-Wave Memory Effects: From Theory to Observation

Citation Jiang Long and Run-Ze Yu 2025 *Class. Quantum Grav.* 42 045005

DOI 10.1088/1361-6382/ada863

Authors References Open science

Article information

Abstract

The helicity flux density is a novel quantity which characterizes the angle-dependence of the helicity of radiative gravitons and it may be tested by gravitational wave experiments in the future. We derive a quadrupole formula for the helicity flux density due to gravitational radiation in the slow motion and the weak field limit. We apply the formula to the bound and unbound orbits in two-body systems and find that the total radiative helicity fluxes are always zero. However, the radiative helicity flux density, which is in the Newtonian limit, still has non-trivial dependence on the angle. Furthermore, we also find a formula for the total helicity flux by including all contributions of the higher multipoles.

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Quantum flux operators for Carrollian diffeomorphism in general dimensions

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Volume 2023, article number 140, (2023) Cite this article

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Ang Li, Wen-Bin Liu, Jiang Long & Run-Ze Yu

A preprint version of the article is available at arXiv.

Abstract

We construct Carrollian scalar field theories in general dimensions, mainly focusing on the boundaries of Minkowski and Rindler spacetime, whose quantum flux operators form a faithful representation of Carrollian diffeomorphism up to a central charge, respectively. At future/past null infinity, the fluxes are physically observable and encode rich information of the radiation. The central charge may be regularized to be finite by the spectral zeta function or heat kernel method on the unit sphere. For the theory at the Rindler horizon, the effective central charge is proportional to the area of the bifurcation surface after regularization. Moreover, the zero mode of supertranslation is identified as the modular Hamiltonian, linking Carrollian diffeomorphism to quantum information theory. Our results may hold for general null hypersurfaces and provide new insight in the study of the Carrollian field theory, asymptotic symmetry group and entanglement entropy.

全国大学英语四级考试(CET4)成绩报告单

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证件号码：420105200004300011

学　　校：中国地质大学（武汉）

笔试成绩

准考证号：420065192100406

总　　分：**550**

听　　力：**187**

阅　　读：**191**

写作和翻译：**172**

考试时间：2019年12月

口试成绩

准考证号：--

等　　级：--

考试时间：--

成绩报告单编号：192142006000066