Department of Physics
香港城市大學
City University of Hong Kong

Celebration of Physics
Department of Physics
Annual Symposium 2022

Program & Abstract Book

1 JUNE 2022

Contents

Preface

Welcoming remarks from the Head

Welcome to the 2022 PHY Annual Symposium organized by the Department of Physics, City University of Hong Kong. The Annual Symposium, named *Celebration of Physics*, is designed to connect our students and faculty members and celebrate their achievements in the past academic year. This departmental tradition, which started in 2019, has three components: science talks by faculty members and invited external speakers, a poster session by our students, and awards announcements. For the undergraduate students, the recipients of the Distinguished Final-Year-Project (FYP) Awards will be announced. Poster Awards will be presented for the best posters from the students. Finally, a faculty member will be recognized with the Faculty Service Award for his/her distinguished service to the department. The science talks culminate with a distinguished external speaker. For a list of the past distinguished speakers, please see the Appendix of this program book.

The Annual Symposium has been a success since the beginning. The poster session was particularly lively, as it provided students an excellent opportunity to interact and learn from each other. The Covid-19 pandemic presented a challenge. For the past two years, the symposium was moved online. Still, it attracted enthusiastic participation by the students and faculties and was enjoyed by all.

This year's symposium will be held once again online via Zoom on Wednesday, June 1st, 2022. Already, the online poster session has attracted more than 30 posters, one of the highest numbers in the last few years. A strong scientific program has been prepared, with the following external speakers:

- Prof. Kui Jin, Institute of Physics, Chinese Academy of Sciences, China.
- Prof. Beatrice Soh, Institute of Materials Research & Engineering, Singapore.
- Prof. Marlan Scully (Keynote speaker), Texas A&M University, United States.

Their talks cover a broad range of topics, including polymer physics of DNA, superconductivity, and quantum optics. In addition, four faculty members who recently joined our department will share their latest discoveries in quantum materials, soft matter, and machine learning, including

- Dr. Junzhang Ma
- Dr. Haixing Li
- Dr. Ge Zhang
- Dr. Bastien Michon

We hope that you will enjoy this year's Symposium!

Prof. Xun-Li Wang
Head of Department
Chair Professor of Physics
May 2022

Organizing Committee

DR. XIAO LI (CHAIR)
Assistant Professor

DR. LIANG DAI
Assistant Professor

DR. IO CHUN HOI
Associate Professor

DR. DANFENG LI
Assistant Professor

DR. ZHEDONG ZHANG
Assistant Professor

Registration Details

Please register for the Symposium Webinar via this link: https://bit.ly/3wbQhgw.

In addition, you may view this year's posters via this link: https://go.cityu.hk/gwgnx2. Note that the poster website is accessible by CityU members only, as the posters may contain unpublished data.

Acknowledgement

The Organizing Committee would like to acknowledge the generous support from the General Office and also thank Mr. Sam Chan for carefully preparing the poster website. Finally, the Committee thank the University Press for designing the cover page, and also thank Dr. Xin Wang and his student Han Xu for affixing the departmental logo on the cover page.

Program Rundown

09:15 – 09:30 **Welcoming Remarks—Chair: Prof. Xun-Li Wang**
Speaker: Prof. Michael Yang [Vice-President (Research & Technology)]

Keynote Talk—Chair: Prof. Xun-Li Wang

09:30 – 10:30 **Of Bose condensates, squeezed light, and black holes**
Speaker: Prof. Marlan Scully (Distinguished Professor, Texas A&M University)
Introduction by Dr. Zhedong Zhang

Student Awards

10:30 – 10:45 **Announcement of FYP Awards**
Dr. Xiao Li (Assistant Professor, City University of Hong Kong)
Announcement of Poster Awards
Dr. Liang Dai (Assistant Professor, City University of Hong Kong)

Research Talks Session (I)—Chair: Dr. Danfeng Li

10:45 – 11:20 **Scaling of the strange-metal scattering in high-T_c superconductors**
Speaker: Prof. Kui Jin (Professor, Institute of Physics, Chinese Academy of Sciences)

11:20 – 11:45 **Observation of dispersive excitons in 1D metallic $TaSe_3$**
Speaker: Dr. Junzhang Ma (Assistant Professor, City University of Hong Kong)

11:45 – 12:10 **Stereoelectronic switching in single molecule junctions**
Speaker: Dr. Haixing Li (Assistant Professor, City University of Hong Kong)

Research Talks Session (II)—Chair: Dr. Io Chun Hoi

14:00 – 14:35 **Polymer physics of topologically complex DNA**
Speaker: Prof. Beatrice Soh (Research Scientist,
Institute of Materials Research & Engineering, Singapore)

14:35 – 15:00 **An entropy perspective on neural networks' loss functions**
Speaker: Dr. Ge Zhang (Assistant Professor, City University of Hong Kong)

15:00 – 15:25 **Quantum criticality in unconventional superconductors**
Speaker: Dr. Bastien Michon (Assistant Professor, City University of Hong Kong)

Departmental Service Award

15:30 – 15:45 **Announcement of Departmental Service Award**
Speaker: Prof. Xun-Li Wang (Head of Department; Chair Professor of Physics)

Program Details

The Keynote Talk

Of Bose condensates, squeezed light, and black holes

Prof. Marlan Scully
Texas A&M, Baylor and Princeton Universities

Time: 09:30 – 10:30

Abstract: The interface between statistical and optical physics is rich and full of surprises. The present perspective is based on the analogy between ordinary (photon) lasers [1] and the BEC atom laser [2], on the one hand, and Unruh radiation emitted by accelerating atoms in the vicinity of a black hole, on the other. The formalism developed by Bogoliubov in the context of superfluid behavior is a powerful tool in these studies. The dynamics of interacting superfluid Bose condensates is naturally developed in the Bogoliubov formalism in which atom pairs, $\boldsymbol{k}$ and $-\boldsymbol{k}$, are studied [3]. New insights into the Unruh-Hawking radiation problem come from similar pairing correlations between photons above and below the black hole horizon [4]. The quantum optical approach to the problem of Unruh-Hawking radiation gives us new insight into Einstein's equivalence principle [5,6] and into rather subtle aspects of causality and entanglement associated with acceleration radiation.

[1] M. O. Scully and S. Z. Zubairy, *Quantum Optics*, Cambridge University Press (1997).

[2] M. O. Scully, *Condensation of N Bosons and the Laser Phase Transition Analogy*, Phys. Rev. Lett. **82**, 3927 (1999).

[3] V. V. Kocharovsky, Vl V. Kocharovsky, and M. O. Scully, *Condensate Statistics in Interacting and Ideal Dilute Bose Gases*, Phys. Rev. Lett. **84**, 2306 (2000).

[4] M. O. Scully, A. A. Svidzinsky, and W. Unruh, *to be published*.

[5] M. O. Scully et al., *Quantum optics approach to radiation from atoms falling into a black hole*, Proc. Natl. Acad. Sci. **115**, 8131 (2018).

[6] A. A. Svidzinsky et al., *Excitation of an Atom by a Uniformly Accelerated Mirror through Virtual Transitions*, Phys. Rev. Lett. **121**, 071301 (2018).

Speaker bio: Dr. Marlan Scully is a world-renowned physicist recognized for his lifetime leadership in groundbreaking research on quantum physics and optics. He received the Ph.D. from Yale University in 1966, supervised by Nobel Laureate Willis E. Lamb. Soon after that he became an assistant professor at MIT, where he received early promotion and moved to the University of Arizona to become full professor before age 30. In 1992, he moved to Texas A&M, where he is now Burgess Distinguished Professor of Physics, holding the TEES Distinguished Research chair and is director of the Center for Theoretical Physics and the Institute for Quantum Science and Engineering. Dr. Scully is a member of National Academy of Sciences (NAS), the American Academy of Arts & Sciences (AAAS), the Academia Europaea, and the Max Planck Society, and is a foreign member of the Russian Academy of Sciences and the Chinese Academy of Sciences. Dr. Scully's research covers all aspects of AMO physics and quantum optics, including seminal works such as quantum theory of the laser, lasing without inversion, and the use of quantum coherence to detect anthrax & SARS-COVID-2 in real time. He has authored over 800 peer-reviewed papers and two world-famous textbooks *Quantum Optics* and *Laser Physics*; has numerous awards including the Federic Ives Medal, APS Schawlow Prize, OSA Townes Award, IEEE Quantum Electronics Award, Franklin Institute's Elliott Cresson Medal and OSA Lomb Medal.

Invited Talk #1

Scaling of the strange-metal scattering in high-T_c superconductors

Prof. Kui Jin
Institute of Physics, Chinese Academy of Sciences
Time: 10:45 – 11:20

Abstract: Soon after the discovery of cuprate superconductors, the strange-metal behavior of their normal-state resistivity was observed, namely, a linear resistivity as a function of temperature (T-linear resistivity) persisting much lower than the Debye temperature. About one decade ago, several groups [1-3] unveiled an intimated correlation between the superconducting transition temperature (T_c) and the slope of the T-linear resistivity (A_1). That is, these two quantities increase or decrease simultaneously. Consequently, the question the community has been after is: what connects the strength of superconductivity with electron scattering? To solve this issue, one needs to quantify the relationship between T_c and A_1. However, it turns out to be a great challenge to manipulate external parameters for marked evolution of properties with minute changes. In this talk, I would like to share with you two pieces of our recent work [4,5] and report on the discovery of $T_c \sim A_1^{0.5}$ relationship in different families of high-temperature superconductors. For a cuprate system $La_{2-x}Ce_xCuO_4$, we developed advanced high-throughput techniques and used a combinatorial library to map how superconducting properties and normal-state properties of the superconductor evolve with minute compositional variation (Δx) with unprecedented resolution and accuracy [4]. We also achieved continuous evolution of superconductivity in ion-gated FeSe film via electric-field gating technique integrated with two-coil mutual inductance and electrical transport property measurements [5]. Such a relationship between T_c and A_1 is at work for both systems, yet different techniques were employed to tune the superconductivity minutely. Remarkably, the scaling is seemingly satisfied also in hole-doped cuprate, as well as a class of organic superconductors via pressure tuning. This unexpected universal scale indicates that there is perhaps a common origin of superconductivity in unconventional superconductors.

[1] Cooper et al., Science **323**, 603 (2009).

[2] Taillefer et al., Annu. Rev. Condens. Matter Phys. **1**, 51 (2010).

[3] Jin et al., Nature **476**, 73 (2011).

[4] Yuan et al., Nature **602**, 431 (2022).

[5] Jiang et al., *under review*.

Speaker bio: Kui Jin is a group leader (since 2013) and the deputy director (since 2017) of National Lab for Superconductivity in Institute of Physics (IOP), Chinese Academy of Sciences (CAS). He also leads a CAS Interdisciplinary Innovation Team on High-throughput Superconductivity Research since 2018 and serves as the chief scientist of both the Key-Area R&D Program of Guangdong Province (since 2020) and the National Key R&D Program of China (since 2021). He has been awarded the 5th Sir Martin Wood China Prize, and the Young Scientist Prize of Chinese Academy of Sciences in 2021. Jin and his team have been devoted to investigating the mechanism of high-temperature superconductivity and relevant key scientific issues in practical applications.

Invited Talk #2

Observation of dispersive excitons in 1D metallic $TaSe_3$

Dr. Junzhang Ma
Department of Physics, City University of Hong Kong
Time: 11:20 – 11:45

Abstract: Charge neutrality and an expected itinerant nature makes excitons potential transmitters of information. The creation in insulators of non-moving excitons (bound states from electrons and holes located at the minimum and maximum of the conduction band and valence band, respectively) by optical excitation is fairly standard and has been widely studied both theoretically and experimentally. Mobile excitons in metals have been elusive, as screening usually suppresses their formation. Here, we demonstrate such mobile bound states for the first time in quasi-one-dimensional metallic $TaSe_3$ [1], taking advantage of its low dimensionality and carrier density.

[1] J.-Z. Ma et al., Nat. Mater. **21**, 423 (2022).

Speaker bio: Dr. Junzhang Ma joined the department of physics, City University of Hong Kong as an assistant professor in the January of 2021. He got the degree of Doctor of Philosophy in 2017 from the Institute of Physics (IOP), Chinese Academy of Sciences in Prof. Hong Ding's group. He furthered his research career as a joint postdoctoral fellow in Swiss Light Source, Paul Scherrer Institute (PSI), and École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland supported by Prof. Ming Shi and Prof. Joël Mesot (current President of ETH, and former Director of PSI, former Professor of EPFL). Dr. Ma's research mainly focuses on the electronic structure of topological materials, superconductivity, low-dimensional materials, and correlated materials, studying by Angle-Resolved Photoemission Spectroscopy (ARPES). Dr. Ma has around 40 publications in high-impact journals such as Nature, Nature Physics, Nature Materials, Science Advances, Nature Communications, Physical Review X, Physical Review Letters, Advanced Materials, etc. These works include many breakthrough researches such as the discoveries of Weyl semimetal, three-component Fermion, Hourglass Fermion, fluctuated magnetic Weyl Fermion, mobile excitons in 1D metal, etc.

Invited Talk #3

Stereoelectronic switching in single molecule junctions

Dr. Haixing Li
Department of Physics, City University of Hong Kong

Time: 11:45 – 12:10

Abstract: Silicon is ubiquitously used as a semiconductor material and continues to be a vital component of modern information technology. Studies on atomically precise silicon structures help us understand the physics of electron transport through silicon at the nanoscale and allow for realization of silicon-based molecular devices. In this talk, I will present a study of silicon molecular wires that were realized as a single molecule switch operating through a stereoelectronic effect.

Speaker bio: Haixing Li obtained her B.S. in Physics from the University of Science and Technology of China in 2012 where she did her undergraduate thesis with Prof. Xianhui Chen growing oxides in search of superconductors. During her undergraduate studies, she also spent a summer at the University of Oxford learning quantum optics. She then moved to Columbia University and earned her Ph.D. in Applied Physics in 2017 under the guidance of Prof. Latha Venkataraman uncovering electronic properties of molecular silicon. She worked as a postdoctoral fellow and later a Charles H. Revson Senior Fellow in the laboratory of Prof. Ruben Gonzalez at Columbia University studying mechanisms of ribosomal frameshifting from 2017 to 2021. Haixing Li is currently an Assistant Professor in the Department of Physics at City University of Hong Kong.

Invited Talk #4

Polymer physics of topologically complex DNA

Prof. Beatrice Soh
Institute of Materials Research & Engineering, Singapore
Time: 14:00 – 14:35

Abstract: Over two decades ago, with advances in microfabrication techniques and fluorescence microscopy, single-molecule studies emerged as a powerful approach to investigate polymer dynamics at the molecular level. By providing a platform for the direct observation and precise manipulation of individual polymer molecules, single-molecule studies allow for the probing of microscopic interactions that give rise to the macroscopic properties of the polymer system. Single-molecule studies have been widely used to investigate the static and dynamic properties of double-stranded DNA as a model polymer. Such studies not only help to develop a fundamental understanding of key topics in polymer physics that cannot be easily accessed via traditional bulk experimental methods but also facilitate the development of emerging DNA mapping and sequencing techniques.

The majority of single-molecule studies to date have involved linear DNA molecules. It is known that topological constraints on the molecular level have a significant influence on polymer dynamics. A nascent area in the field of polymer physics is the study of polymers with complex topologies. In this talk, we discuss a series of single-molecule experiments and Brownian dynamics simulations used to investigate the polymer physics of topologically complex DNA. Specifically, we focus on knotted polymers, ring polymers and catenated polymer networks.

We also present recent work on developing an automated experimental platform for the high-throughput investigation of single-molecule behavior. While still in its early stages, the platform demonstrates exciting potential for integrating a data-driven approach to studying single polymer molecules.

Speaker bio: Beatrice Soh is a research scientist at the Institute of Materials Research and Engineering (IMRE) in Singapore. She received her B.S.E. in Chemical and Biological Engineering from Princeton University in 2014 and a Ph.D. in Chemical Engineering from Massachusetts Institute of Technology (MIT) in 2020. At MIT, Beatrice worked with Prof. Patrick S. Doyle to investigate the polymer physics of topologically complex DNA at the single-molecule level. She has received several awards for her graduate work, including the Ruth Lynden-Bell PhD Prize on Statistical Mechanics and Thermodynamics. Currently, her research interests lie in integrating data-driven approaches with microfluidics for applications in soft matter.

Invited Talk #5

An entropy perspective on neural networks' loss functions

Dr. Ge Zhang
Department of Physics, City University of Hong Kong

Time: 14:35 – 15:00

Abstract: A neural network contains a large number of parameters that are fitted to the training data. This is done by numerically minimizing the loss function, a function that quantifies the deviation of the fit from the actual training data. A highly desired goal in this field is to design neural networks with good generalization performance, i.e., one that performs well for data points not present in the training data set. The machine learning community generally believed that a flatter minimum of the loss function has better generalization performance than a shallower minimum. Here we show that this is not correct in general but may be correct in infinitely-deep neural networks. We do this by calculating the entropy (logarithm of the volume in the parameter space) versus the accuracy in training and test datasets using the Wang-Landau Monte Carlo algorithm and showing that the maximum-entropy state does not correspond to the highest test accuracy. Our current results are obtained from a very small-scale problem (a spiral dataset with about 40 data points and a fully connected neural network with a few hundred parameters), but we will also briefly discuss future plans to study larger-scale problems.

Speaker bio: Dr. Ge Zhang joined CityU as an assistant professor in physics last September. Before that, he was a postdoc with Prof. Andrea Liu in Department of Physics and Astronomy at the University of Pennsylvania, studying disordered solids using computational models. He earned his Ph. D. from Princeton University working on computational statistical physics, including packing problems and disordered classical ground states.

Invited Talk #6

Quantum criticality in unconventional superconductors

Dr. Bastien Michon
Department of Physics, City University of Hong Kong

Time: 15:00 – 15:25

Abstract: Superconductivity was initially discovered by Heike Kamerlingh Onnes in 1911 in pure Mercury where he noticed resistivity abruptly dropped below a certain temperature. This temperature, so-called the superconducting critical temperature T_c, saw its limit increase year by year with new alloys of pure metals up to $20\,\mathrm{K}$ until the 50's. At this time, thanks to the successful BCS theory explaining the pairing mechanism of electrons by a phonon exchange, the topic of superconductors seemed to be fully understood. With the discovery of unconventional superconductors in the 80's, the thematic has found great interest, especially with the high-T_c cuprates where T_c can reach $100\,\mathrm{K}$ at ambient pressure. However, the pairing mechanism of these superconductors is not due to a phonon exchange and remains an enigma for Physicists. The phase diagram of these unconventional superconductors encloses a superconducting dome located around the critical doping of an ordered phase. For cuprate superconductors, the phase diagram shows a complexity leading to the origin of the pairing mechanism puzzled. During this talk, I will present a recent set of data on cuprate materials demonstrating the presence of quantum criticality in the phase diagram, which could be a candidate for the pairing mechanism.

Speaker bio: Dr. Bastien Michon obtained his PhD degree in October 2017. His PhD was realized in an international collaboration between the groups of Pr. Louis Taillefer in Sherbrooke (Canada) and Pr. Thierry Klein in Grenoble (France). During this PhD, Dr. Bastien Michon developed strong skills in experimental Physics such as transport and specific heat under high magnetic field (up to $35\,\mathrm{T}$) and very low temperature (down to $400\,\mathrm{mK}$). From February 2018 to July 2021, he completed his academic background with a Postdoctoral position in the group of Pr. Dirk van der Marel in Geneva (Switzerland) where he developed an expertise on infrared spectroscopy and optics. Dr. Bastien Michon has recently joined CityU in October 2021 as an assistant professor. His research topics are based on cuprate superconductors and other unconventional superconductors using infrared spectroscopy. He is also interested on other quantum materials such as Weyl semi-metals and quantum spin liquids.

Appendix: List of past Keynote speakers

Year2019	**Prof. Kai-Ming Ho** *Distinguished Professor in Liberal Arts and Sciences,* *Department of Physics, Iowa State University, USA*
Year 2020	
Year 2021	**Prof. Hong Ding** *Professor,* *Institute of Physics, Chinese Academy of Sciences, China*
Year 2022	**Prof. Marlan Scully** *Distinguished Professor,* *Institute for Quantum Science and Engineering, Texas A&M University, USA*