The 2022 Annual Report
National Center of Theoretical Sciences
Division of Mathematics

Contents

1 Overview

1.1 Report from the Director

1.1.1 Introduction

The NCTS Mathematics Division, hereinafter referred to as the Center, strives to be a research center of excellence in Asia. Its aim is to promote and enhance research in all important disciplines in mathematical sciences in Taiwan, and at the same time also to encourage new promising research directions that may have impact in the future development of mathematics.

Another important aim of the Center is for it to play a leading role in fostering talents in mathematical sciences and help training the next generation of scientific leaders in Taiwan. Although the Center is located on the campus of the National Taiwan University, the NCTS, as its name infers, is foremost a national center. It therefore needs to serve the mathematical community of all of Taiwan and provides a national platform for research collaboration. At the same time the Center is to be an international meeting place for stimulating discussions and exchange of new developments and ideas. To achieve this goal, the Center also endeavors to establish, cooperate and collaborate with other international research institutions. It has maintained close connections with many leading mathematical research institutions, e.g., SLMath (formerly MSRI) in Berkeley, RIMS in Kyoto, KIAS in Seoul, PIMC in Vancouver and the Fields Institute in Toronto.

In these first two years of Phase 5 of the NCTS, the Mathematics Division faces new challenges mostly related to the pandemic; due to travel restrictions the number of international visitors has dropped substantially compared to the pre-pandemic years. Because of this, virtually all international conferences and workshops had to be either postponed, cancelled, held in hybrid format or moved entirely online. Although online software and hardware have significantly improved because of increasing demand created by pandemic, even the best ones are not able to replace direct personal interaction that is so important in mathematics. However, because of recent relaxation of travel restrictions in Taiwan, we do expect that the situation will improve significantly soon. There is a reasonable chance that operations of the Center will resume its pre-pandemic level in 2023. Nevertheless, over the last two years the Center has collaborated with other leading research institutes from different countries to host very successful international online seminars which are the best substitutes during the days of pandemic.

From August 19 to 20, the Center held its annual NCTS Review and Strategic Development Meeting with its core members in Yilan. Last year's meeting had to be held online due to the pandemic restrictions. This year's physical meeting was attended by the executive, academic, program committee members, Center Scientists, and Young

Theoretical Scientists along with the administrative staff members of the Center. The main purpose of the meeting is for the core members to share their experiences and make constructive suggestions to the administration of the Center. It is essential for the Center to review and fine-tune its operations so that it can continuously improve and adapt itself.

1.1.2 Scientific Highlights

The research achievements of the core members in the second year of this phase continue to be outstanding. Many of the results obtained by core members appear in some of the most prestigious mathematical journals, e.g, Duke Mathematical Journal.

We are also pleased that close affiliates of the Center who have been very actively involved in its operation continue to receive recognition for their research achievements. Prof. Mu-Tao Wang of Columbia University, was bestowed upon the highest national honor and elected an academician of Academia Sinica in this year's Convocation of Academicians. Prof. Wang is a frequent visitor of the NCTS and over the years has maintained close ties with members of the Center through collaboration and organization of many joint scientific activities.

Also, Prof. Chia-Fu Yu from Academia Sinica and Prof. Jin-Cheng Jiang from the National Tsing Hua University received the 2022 Outstanding Research Award from NSTC (formerly MOST). They both have been very actively involved in the academic activities in the Center that include organizing conferences and seminars, teaching courses, and helping with URP and USRP. Before receiving the award, Prof. Yu and Prof. Jiang visited the Center from 2020-10-12 to 2021-02-05 and from 2020-09-01 to 2021-01-31, respectively, to concentrate on their research.

Finally, Prof. Chih-Whi Chen of the National Central University, who is a 2021 NCTS Young Theoretical Scientist awardee and who also was a postdoc at the NCTS, has received this year's Wu Ta-You Memorial Award of the NSTC.

1.1.3 Academic Activities

The second year of this phase remains challenging for the Center due to the ongoing worldwide pandemic. Although some travel restrictions in Taiwan have been relaxed or lifted, many of the remaining government imposed pandemic prevention measures do not allow for some of the planned physical scientific activities to take place. Therefore, as in the previous year, some of the activities had to be postponed, cancelled or moved to an online or hybrid platform. Because some other countries have less restrictive covid measures and people prefer an in-person meeting more, some activities were forced to move their venues to other places in the last minute. For instance, the MSRI-NCTS Joint Summer School: Recent Topics in Well Posedness, July 18, 2022 – July 29, 2022, was moved to the University of Hawaii at Hilo and the planned Interna-

tional Conference on Recent Developments of Theory and Methods in Mathematical Biology, October 24–28, 2022, will be held in France instead. This year a total of 25 conferences and workshops were organized and hosted by the Center, in addition to 181 seminar talks at the time of writing. Regular seminars are particularly important in mathematics, and promotion of those is an important task for the Center. We note that the numbers of workshops and seminars are almost identical to those from last year.

Adapting to the present challenging environment, the Center continues to emphasize and support high quality online seminars organized jointly with leading institutions: The NCTS International Geometric Measure Theory Seminar, initiated last year, is a seminar organized jointly by NCTS affiliated member Ulrich Menne (who held the position of an NCTS Center Scientist until July 31), and faculty members from University of Cambridge, University of Pisa and Tokyo Institute of Technology, and it is held every two months. The seminar continues to attract among the speakers some of the world's foremost leading experts in the field. The Seminar of Algebraic Geometry in East Asia is a two-lecture seminar that takes place every two weeks. Among the organizers are former NCTS director Jungkai Chen and faculty members from University of Tokyo, Korean Institute of Advanced Study, University of Singapore, Chinese University of Hong Kong, Vietnam Academy of Sciences and Technology, Chinese Academy of Sciences and Kyungpook National University. This online seminar remains an important vehicle of learning and international collaboration for algebraic geometers in East Asia during the pandemic. Also, the Korea-Taiwan-Vietnam Joint Seminar in Combinatorics and Analysis, is a new online international seminar that was launched this March and that takes place every two week. It is organized by Center Scientist Chun-Yen Shen and faculty members from Chungbuk National University, Vietnam National University, and University of Science and Technology of China.

1.1.4 Postdoctoral Program

A highly diverse and international postdoctoral program is essential for the Center to thrive and achieve its long term goals. The outstanding research environment that the Center has been able to provide for its postdoctoral fellows is essential for their mathematical growth. Such an international program also greatly benefits the Taiwanese postdoctoral fellows at the Center and plays an important part in the Center's mission to foster the next generation of scientists in Taiwan. The Center is pleased to report that its postdoctoral program remains strong; indeed this year several of its postdoctoral fellows were able to find positions in universities in the US, Germany, and Italy, while some others were recruited as tenure-track faculty members in some of the universities of Taiwan. For this reason, 5 postdocs resigned from positions in the Center before the end of their terms, and the total number of postdocs decreases after August this year. The program continues to be very international, with Taiwanese forming a mi-

nority as in the past years. There are 15 postdocs currently stationed at the Center from countries like the US, UK, Japan, Germany, Italy, Korea, Vietnam et cetera. Besides meeting with their mentors and participating in activities in their topical programs, the NCTS postdocs are actively involved in the biweekly Taipei Postdoc Seminar which the Center jointly runs with the Institute of Mathematics Academia Sinica. The speakers are chosen from the large pool of postdoctoral fellows in the larger Taipei area and the lectures are given in an informal relaxed atmosphere.

Other activities such as Meeting with Directors, Spring Day and individual interviews are also arranged. The NCTS Spring Day is a one-day event, in which every postdoc is asked to give a talk on their recent works. On this occasion the annual NCTS Young Theoretical Scientist award ceremony is also held. The deputy director conducts an individual interview with every postdoc every half a year to update on the progress and check on the their needs. To assist foreign postdocs of the Center integrate better into the Taiwan community, the Center now also provides financial support for their Chinese language lessons. Some postdocs give short courses in the Center, serve as TAs for USRP or other courses, or teach Calculus at NTU. These not only help them merge better into local mathematics community, but also offer additional manpower for us. There are already a few former international postdocs of the Center that now work in universities in Taiwan.

1.1.5 NCTS Education and Outreach

While last year's NCTS Undergraduate Summer Research Program had to be held entirely online, the situation this year has improved enough so that some of the groups have been able to conduct their programs entirely on-site at the Center. Other groups held some of the meetings online and some of them in-person. In most cases students met physically for their study and discussion sessions. A USRP program, as the name suggests, is a 6-week program in the summer in which 1-2 faculty members supervise a group of 2-4 undergraduate students to do original research in a topic agreed upon. This year's USRP was held from July 4–August 12. An important factor in research in mathematics is the ability to absorb new materials in a non-linear fashion, and the USRP and its counterpart URP (Undergraduate Research Program) are designed partially with this in mind to help undergraduate students reach this stage and introduce them to the process of solving original problems under the guidance of professional mathematicians. This year's USRP consists of 9 research programs and they cover a wide spectrum of topics in mathematical sciences, from pure subjects such as algebraic geometry and deformation quantization to applied topics such as numerical methods of image processing and quantum computation.

The URP program starting in fall 2021 ended on June 30, 2022, and consisted of 9 groups. The URP program starting in fall 2022, as the one from last year, also received many more applications than can be supported due to our budget limitation. In URP, a

group of 1–3 undergraduate students carries out an original research project under the guidance of a professional mathematical scientist. The duration of this program is 9 months. Among the 18 applications received this year only 8 of them were accepted due to our budget constraints. The topics of this year cover a wide range of fields from pure to applied mathematics to statistics as well. This year the Center held two one-day activities for the participants of its URP and RA programs: NCTS URP/RA Winter Research Reports and NCTS URP/RA Summer Research Reports on February 10 and June 27, 2022, respectively. We are very pleased that this year's URP has attracted more female students to participate.

The NCTS Taiwan Mathematics School (TMS) program this year offered 5 courses. The TMS program was initiated in 2017 with the aim of improving the quality of graduate mathematics education in Taiwan. After 5 years, the Center believes that it is a good time to carefully evaluate the achievements of the program and fine-tune it, if necessary, so that it could better meet the needs of graduate students in Taiwan. In addition to the TMS courses, the Center also offered 13 short courses that focused on advanced and more specialized topics.

The Center has now completed the home pages for TMS, USRP and URP&RA. These programs are unified under the category of NCTS Education on the NCTS web page. These web pages contain a wealth of information about past programs, including the midterm and final reports et cetera, and they provide a rich source of data for interested students.

The NCTS has a research assistant (RA) program that is open to college graduates who are interested in pursuing graduate studies abroad. The aim of the program is to better prepare highly motivated Taiwanese students for their graduate studies. The duration of a typical research assistant appointment is usually one year. Currently, there are 5 research assistants at the NCTS. Every NCTS research assistant is assigned a Center affiliated mentor who provides guidance and closely oversees the assistant's scientific progress. Selection is based on the candidate's potential and ability to pursue and complete a doctoral program in mathematical sciences at a first rate research university. This program has been quite successful, as many of the program's alumni have been admitted to top graduate schools.

The Simons Laufer Mathematical Sciences Institute (SLMath), formerly Mathematical Sciences Research Institute (MSRI), is one of the most prestigious mathematics institutions in the world. It hosts and organizes many conferences, workshops, summer and winter schools of the highest quality every year. It organizes a wide spectrum of Summer Graduate Schools each year in the world. The NCTS is a full member of the SLMath Academic Sponsoring Institutions, and as such, at least two of its nominations of summer school attendees will receive full local support in addition to travel support of up to USD700 from the SLMath every year. In 2022, we successfully recommended 3 students in this category to attend SLMath Summer Graduate Schools on Geometric Flows, Tropical Geometry, and Mathematics of Machine Learning that

took place in Athens in Greece, New York City and California in the USA, respectively. Because the NCTS co-hosted with SLMath/MSRI Summer Graduate School: Recent Topics in Well Posedness that was originally planned to be held in the Center and later moved to Hawaii, we recommended and supported additional 6 students, one TA and one professor to this school.

For the two-week residential programs of SLMath Summer Graduate Schools, there are intensive lectures from usually 3 professors, and problem/discussion sessions led by two teaching assistants. The NCTS received very positive feedbacks from the Taiwanese participants. The SLMath Summer Graduate Schools not only deepen and broaden their knowledge and research interests, but also provide a invaluable opportunity for the students to interact and make friends with international students and scholars from all over the world. There will be 11 SLMath Summer Graduate Schools 2023. The Center is now calling for applications of interested students to determine NCTS Nomination for SLMath Summer Graduate School 2023. To promote and help students understand the program, we arrange an activity for prospective student participants and invite some of participants of previous SLMath Summer Graduate Schools to share their experiences.

The Center also cooperates with other institutions and the Taiwan Mathematical Society on some outreach activities such as International Day of Mathematics, Salon de Mathématiques, Public Talks, etc. NCTS Scholar Prof. Horng-Tzer Yau from Harvard University gave a public talk entitled "Mathematics and Technology" on July 13. The activity was co-organized by NCTS, CASE of NTU and MRPC. It was not only very well attended onsite and online, but also the YouTube video for this talk already has 7736 views. Together with the Student Society of Mathematics department of NTU, the Center arranged a Forum on September 5 discussing students' experiences in graduate school abroad and the application process. The panelists include two NCTS student visitors from Columbia University and UC Irvine, and two NCTS RAs who are going to pursue their graduate studies at the University of Cologne in Germany. We hope that the Center can create a lot of interactions between NCTS student visitors and local students and serve as a meeting place or platform for students in Taiwan and from abroad.

The NCTS has played an important role in the training and development of scientists in Taiwan in the past, and we believe that the NCTS Education and Outreach program is key for the Center to continue to do so in the future.

1.1.6 Future Plans

Because Taiwan has recently loosened Covid prevention measures substantially, some postponed international conferences are planned to resume, and we expect the number of visitors will increase as well. In particular, this December there are "NCTS Conference on Fractional Integrals and Related Phenomena in Analysis" from December 19

to December 23, and "The 10th NCTS-POSTECH-PMI Joint Workshop on Number Theory" from December 28 to December 30. From January 3 to January 6 of 2023, the "East Asia Core Doctoral Forum in Mathematics" will be held that was postponed from 2021. The "NCTS Higher Dimensional Algebraic Geometry Minicourses and Workshop" that was also postponed from 2021 will take place from March 13 to March 24, 2023.

Furthermore, there will be the "2023 Conference on Advanced Topics and Auto Tuning in High-Performance Scientific Computing" in March or April of 2023, and the "NCTS International PDE conference" from June 12 to June 16, 2023. In the summer of 2023, another conference on algebraic geometry "Modern perspectives on birational geometry" will be held from July 29 to August 4, 2023. In the fall of 2023, the Center will host "The Fourth Japan-Taiwan Joint Conference on Differential Geometry" and in the winter of 2023, we also plan to resume "The Fifth International Conference on Differential Geometry" that was postponed from 2020. This series of conferences takes place every 2-3 years and an important area in geometry is specified as the main theme each time. The topics of the fifth conference include the main research topics in geometric analysis such as General Relativity, Minimal Submanifolds and Geometric Evolution Equations.

Iwasawa Conference has been the largest and probably the most important conference in Iwasawa theory. Following the conferences in Besancon (2004), Limoges (2006), Irsee (2008), Toronto (2010), Heidelberg (2012), London (2015), Tokyo (2017), Bordeaux (2019), it was originally planned to take place at the NCTS in 2021, but postponed due to the pandemic. It was scheduled to resume at the NCTS next July. But because of Prof. John Cotes' pass away this May, the organizers decided to move the activity to University of Cambridge in memory of him. The NCTS will host Iwasawa 2025 Conference instead.

The international travels have been gradually back to normal. One of our main goals in 2023 is to solidify and develop new collaborations with other international research institutions. For example, the number for students that can be admitted to SLMath Summer Graduate Schools are very limited, and we thus consider to cooperate with other research centers and establish similar summer school programs in Asia.

1.2 Summary of Data

This section gives a structural overview of the Center. More complete and detailed information can be found in the Appendix. The appointment of a Center Scientist is for two years a term and may be renewed for another term. Young Theoretical Scientists can be appointed only once, and it is also for two years. The data of publication by members in Section 1.2.6 reflect those available to the Center by August 30, 2022.

1.2.1 Committees and Members

International Advisory Committee: Russel Caflisch (New York University), Hélène Esnault (Freie Universität Berlin), Shigefumi Mori (RIMS), Horng-Tzer Yau (Harvard University), Shing-Tung Yau (Harvard University), Robert Bryant (Duke University).

Executive Committee: Chiun-Chuan Chen (NTU), Shun-Jen Cheng (AS), Ming-Lun Hsieh (NTU), Yng-Ing Lee (NTU), Wen-Wei Lin (NYCU), Yuan-Chung Sheu (NYCU), Mao-Pei Tsui (NTU).

Academic Committee: Yi-Fan Yang (NTU), Ching-Jui Lai (NCKU) (until August 2022), Jungkai Chen (NTU) (starting September 2022), Nan-Kuo Ho (NTHU), Chun-Hsiung Hsia (NTU), Tsung-Ming Huang (NTNU), Je-Chiang Tsai (NTHU).

Topical Program Committees:

(A) *Number Theory and Representation Theory*: Yifan Yang (NTU, chair), Chieh-Yu Chang (NTHU), Chun-Ju Lai (AS), Fu-Tsun Wei (NTHU)

(B) *Algebraic Geometry*: Ching-Jui Lai (NCKU, until August 2022, chair), Jungkai Chen (NTU, starting September 2022, chair), Hsueh-Yung Lin (NTU), Jeng-Daw Yu (NTU).

(C) *Differential Geometry and Geomtric Analysis*: Nan-Kuo Ho (NTHU, chair), River Chiang (NCKU), Chun-Chi Lin (NTNU), Chung-Jun Tsai (NTU).

(D) *Differential Equations and Stochastic Analysis*: Chun-Hsiung Hsia (NTU, chair), Jung-Chao Ban (NCCU), Chun-Yen Shen (NTU), Lung-Chi Chen (NCCU), Chi Hin Chan (NYCU).

(E) *Scientific Computing*: Tsung-Ming Huang (NTNU, chair), Wei-Fan Hu (NCU), Matthew M. Lin (NCKU), Ming-Cheng Shiue (NCTU), Suh-Yuh Yang (NCU).

(F) *Interdisciplinary Studies*: Je-Chiang Tsai (NTHU, chair), Te-Sheng Lin (NYCU), Hau-Tieng Wu (Duke), Yng-Ing Lee (NTU), Shun-Jen Cheng (AS).

Center Scientists:

- ◇ Fu-Tsun Wei (NTHU), Chung-Jun Tsai (NTU), Ulrich Menne (NTNU), Chi Hin Chan (NYCU), Gi-Ren Liu (NCKU) (all until July 31).
- ◇ Chun-Yen Shen (NTU), Hao-Wei Huang (NTHU), Hsin-Yuan Huang (NYCU), Yung-Ning Peng (NCKU).

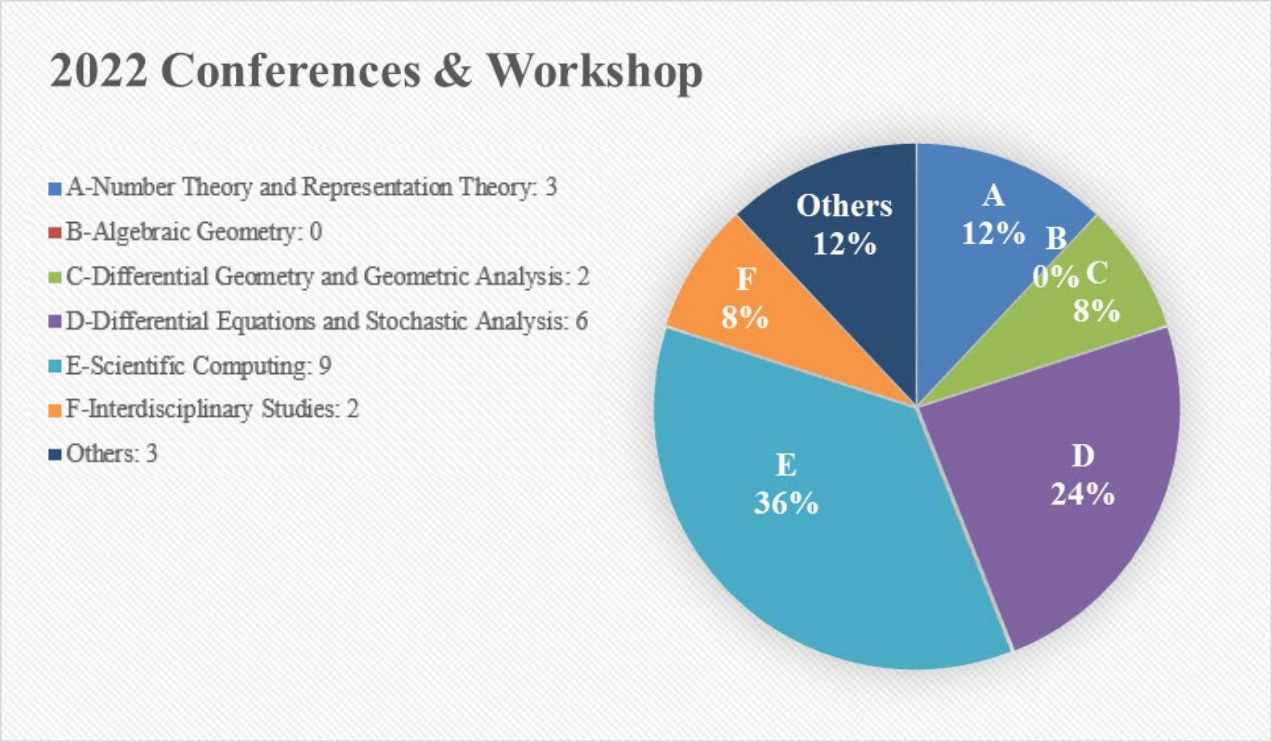
◇ Wei-Fan Hu (NCU), Hsueh-Yung Lin (NTU), Feng-Bin Wang (Chang Gung U.), We-Kai Wang (NYCU) (all starting August 1).

Young Theoretical Scientists: Chih-Whi Chen (NCU), Adeel Khan (AS), Chun-Ju Lai (AS), Ting-Jung Kuo (NTNU).

NCTS Scholars: Yujiro Kawamata (University of Tokyo), Gunther Uhlmann (University of Washington), Nikolaos Zygouras (University Warwick), Horng-Tzer Yau (Harvard University), Fan Chung Graham (UC San Diego), Paolo Cascini (Imperial College), Richard Schoen (UC Irvine), Kaoru Ono (Kyoto University), Keiji Oguiso (University of Tokyo).

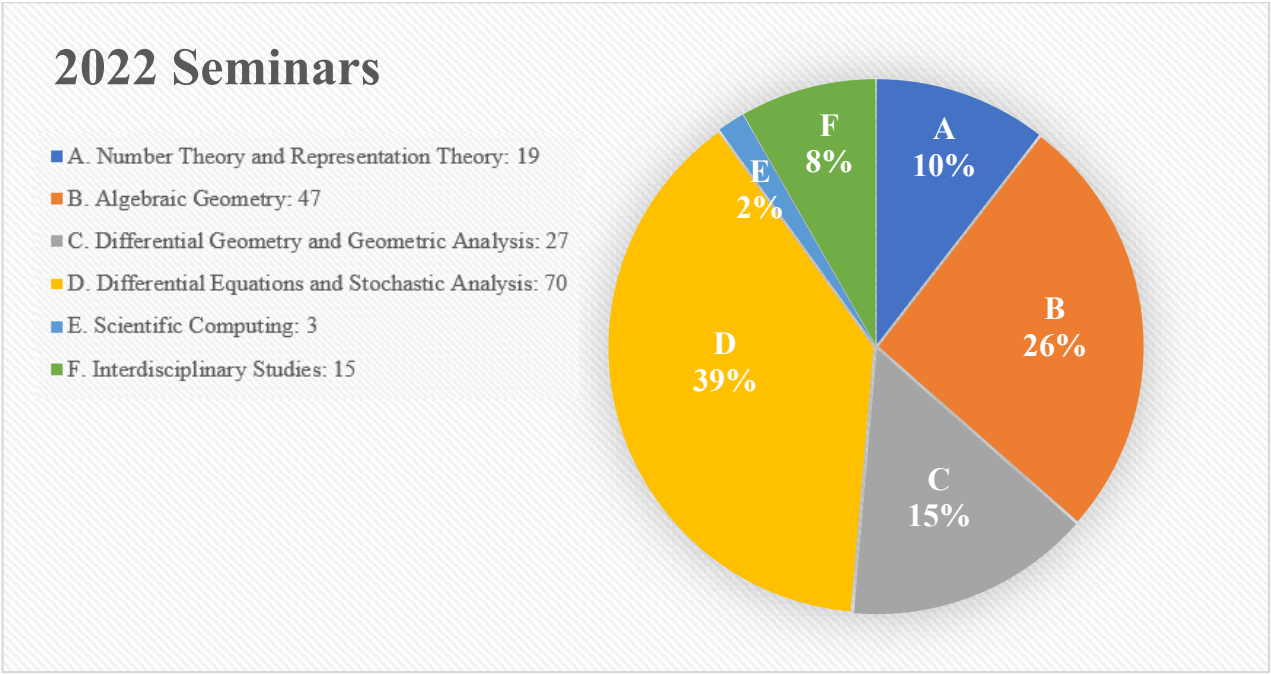
1.2.2 Workshops and Conferences

2022 Conferences & Workshops	
A-Number Theory and Representation Theory: 3	3
B-Algebraic Geometry: 0	0
C-Differential Geometry and Geometric Analysis: 2	2
D-Differential Equations and Stochastic Analysis: 6	6
E-Scientific Computing: 9	9
F-Interdisciplinary Studies: 2	2
Others: 3	3
	25



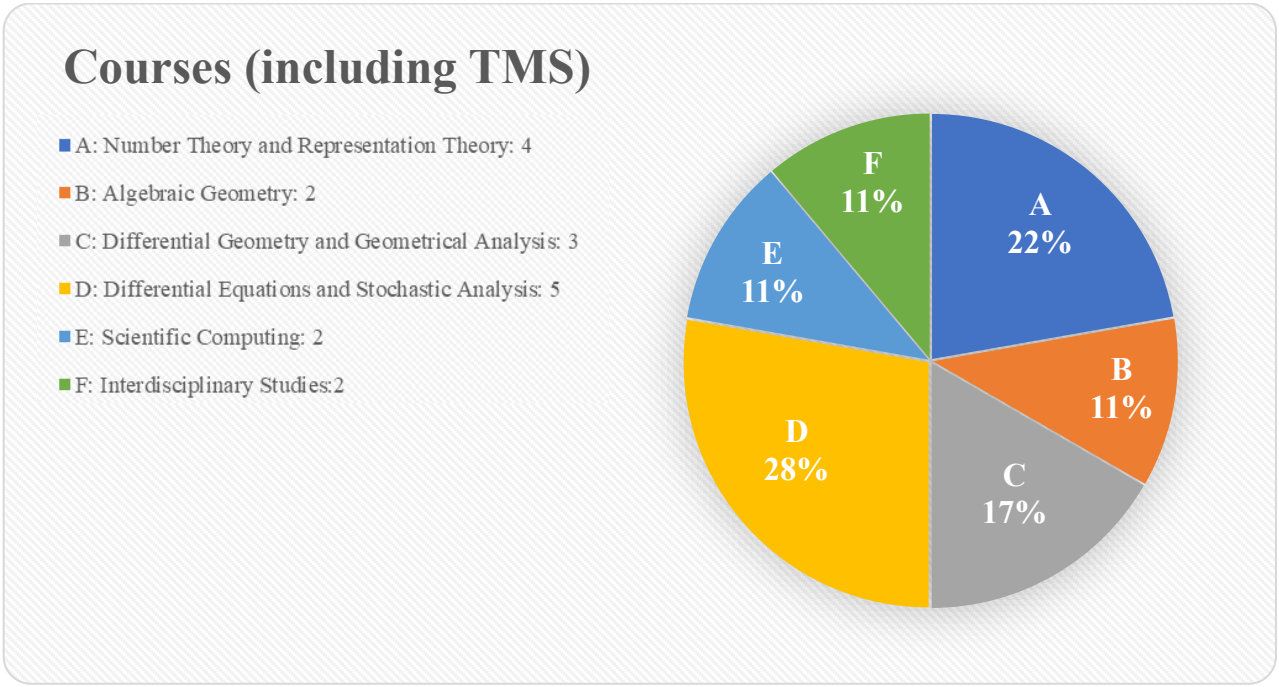
1.2.3 Seminars

2022 Seminars	
A-Number Theory and Representation Theory: 19	19
B-Algebraic Geometry: 47	47
C-Differential Geometry and Geometric Analysis: 27	27
D-Differential Equations and Stochastic Analysis: 70	70
E-Scientific Computing: 3	3
F-Interdisciplinary Studies: 15	15
	181

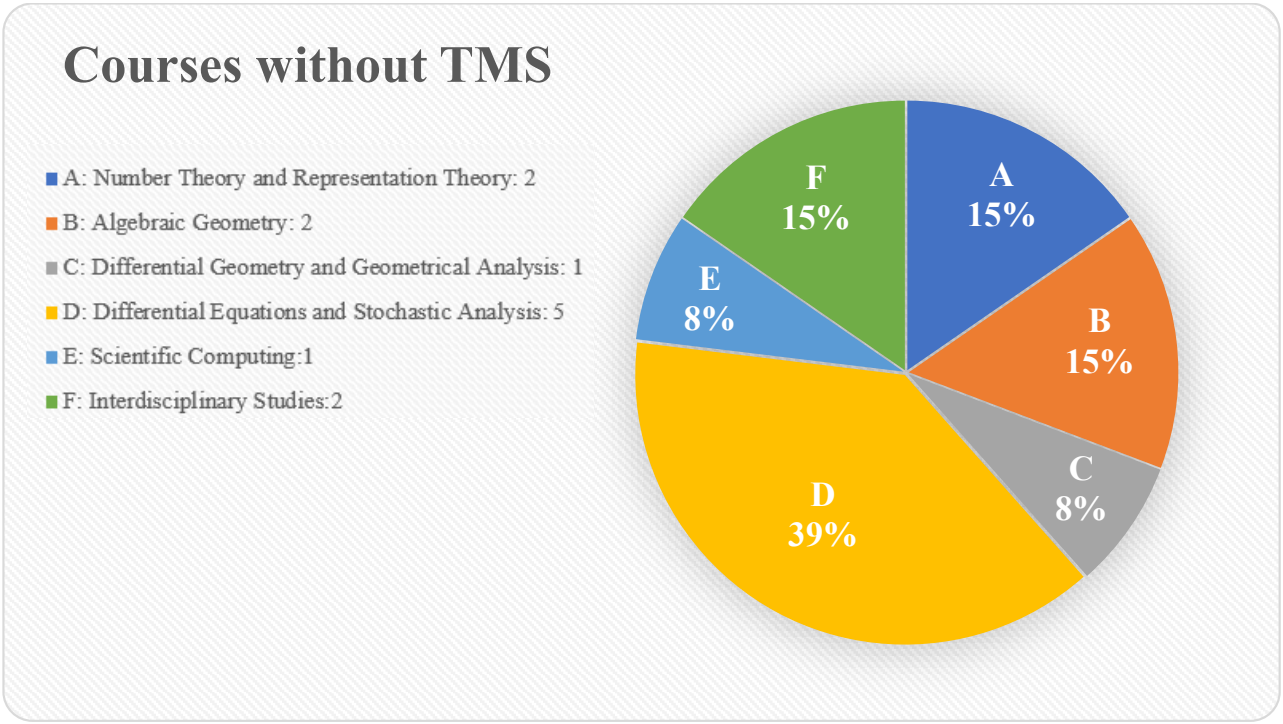


1.2.4 Courses

2022 Courses (including TMS)	
A-Number Theory and Representation Theory	4
B-Algebraic Geometry	2
C-Differential Geometry and Geometrical Analysis	3
D-Differential Equations and Stochastic Analysis	5
E-Scientific Computing	2
F-Interdisciplinary Studies	2
	18

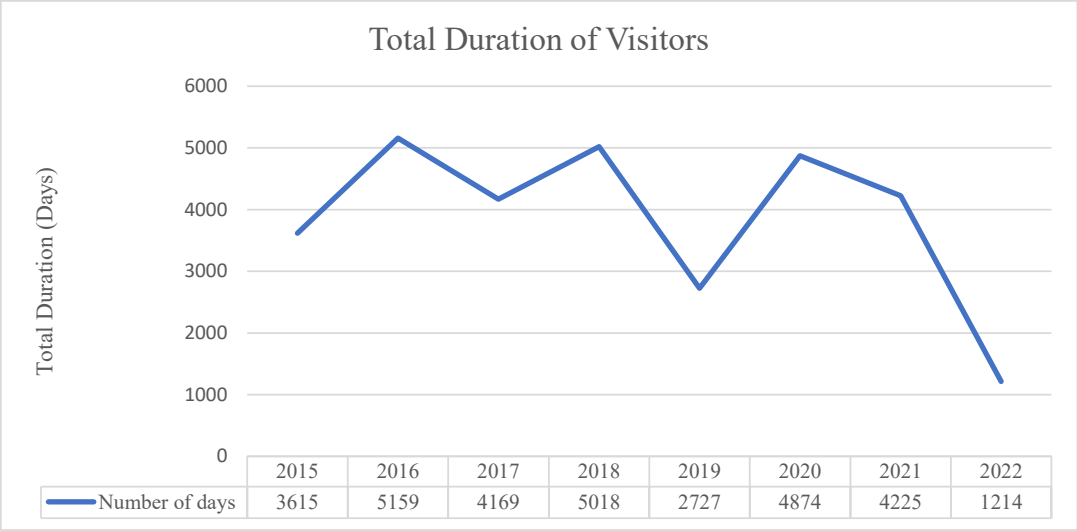


2022 Courses (without TMS)	
A-Number Theory and Representation Theory	2
B-Algebraic Geometry	2
C-Differential Geometry and Geometrical Analysis	1
D-Differential Equations and Stochastic Analysis	5
E-Scientific Computing	1
F-Interdisciplinary Studies	2
	13



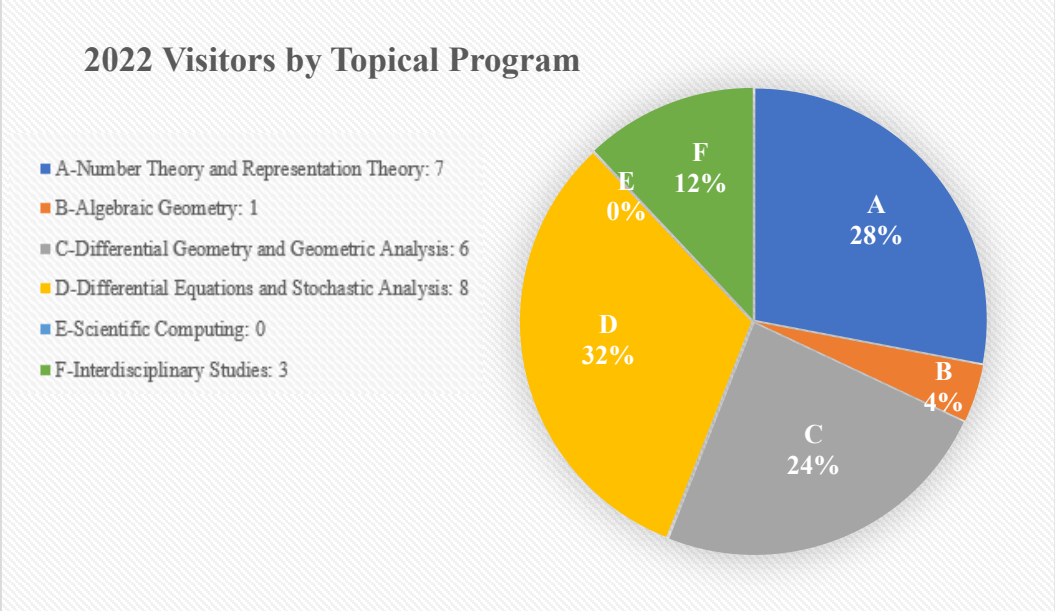
1.2.5 Visitors

Year	2015	2016	2017	2018	2019	2020	2021	2022
Number of visitors	269	407	359	246	197	62	23	25
Number of days	3615	5159	4169	5018	2727	4874	4225	1214



Visitors from Abroad

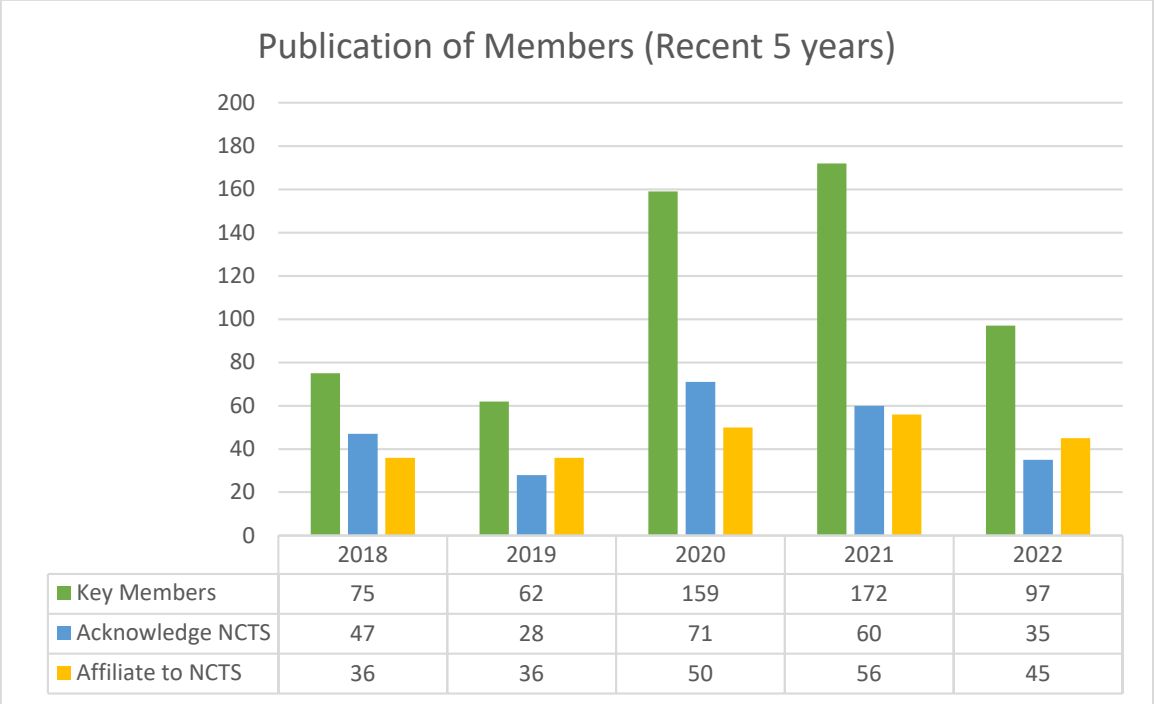
2022 Visitors		
A-Number Theory and Representation Theory: 7	7	28%
B-Algebraic Geometry: 1	1	4%
C-Differential Geometry and Geometric Analysis: 6	6	24%
D-Differential Equations and Stochastic Analysis: 8	8	32%
E-Scientific Computing: 0	0	0%
F-Interdisciplinary Studies: 3	3	12%
	25	100%



2022 Visitor		
Country	Number	%
Japan	4	16%
France	2	8%
Canada	1	4%
USA	17	68%
Chile	1	4%
	25	100%

1.2.6 Summary of publication data

The 2022 publications below are counted until July.



	2018	2019	2020	2021	2022
Key Members	75	62	159	172	97
Acknowledge NCTS	47	28	71	60	35
Affiliate to NCTS	36	36	50	56	45

2 Topical Programs

2.1 Number theory and Representation Theory

2.1.1 Core Members

1. Program Committee Members: Chieh-Yu Chang (NTHU), Chun-Ju Lai (AS), Fu-Tsun Wei (NTHU), Yifan Yang (NTU, committee chair).

2. Affiliated Faculty Members: Ming-Lun Hsieh (NTU), Ming-Hsuan Kang (NYTU), Nobuo Sato (NTU), Tzu-Yue Wang (AS), Liang-Chung Hsia (NTNU), Chia-Fu Yu (AS), Chih-Whi Chen (NCU), Shih-Chang Huang (NCKU), Ching Hung Lam (AS), Shun-Jen Cheng (AS), Yung-Ning Peng (NCKU), Yao Cheng (Tamkang U.), Wei-Hsuan Yu (NCU).

3. NSTC Independent Researcher: Jia-Wei Guo (NTU).

4. Postdoctoral Fellows: Chen-Hua Chen (NTHU), Harrison Chen (AS), Shih-Yu Chen (AS), Sheng-Fu Chiu (NCTS), Hang Fu (NTU), Oguz Gezmis (NCTS), Ryotaro Harada (NTHU), You Hung Hsu (AS), Jiun-Wen Peng (NCTS), Yasuhiro Terakado (NCTS), Kazuki Tokimoto (AS), Peng-Jie Wong (NSYSU), Ziqiang Xiang (AS).

2.1.2 Program Overview

The purpose of the number theory and representation theory program at NCTS is to assist domestic number theorists and algebraists to continue developing active and promising research topics, and create opportunities for international cooperation as well as cultivating young researchers and students. Our research topics cover a wide spectrum of algebra and number theory from various perspectives. In the past year, our members focus on the following areas:

1. Iwasawa theory and p-adic methods in algebraic number theory and automorphic forms.

2. Special values over function fields and related topics.

3. Arithmetic and geometry of moduli spaces and explicit methods.

4. Arithmetic dynamical systems and Diophantine problems.

5. Lie superalgebras.

6. Vertex operator algebras (VOAs).

7. Hecke algebras and Cherednik algebras.

8. Geometric representation theory.

We run this program by having regular seminars on number theory and arithmetic geometry, summer/winter schools and hosting international workshops and conferences. NCTS Number theory seminars are organized by C.-Y. Chang, F.-T. Wei, and Y. Yang, and they are held in Taipei on Fridays and in Hsinchu on Wednesdays. Seminars on arithmetic geometry and representation theory are organized by C.-F. Yu and they are held in Taipei. These regular seminars provide a platform for research exchanges and discussions, and an opportunity for young scholars to broaden their horizons.

2.1.3 Research Highlights

In this section, we give a quick overview of research highlights of our members in the past year.

1. Special values over function fields, *by C.-Y. Chang*.
   Chang's most important published results in five years are the joint paper with Y. Mishiba published in Inventiones 2021 [2], and the joint paper with Y.-T. Chen (his PhD student) and Y. Mishiba accepted by Cambridge Journal of Mathematics [3]. In the former paper, they proved a function field analogue of Furusho's conjecture. More precisely, they showed that there is a well-defined linear map from the ∞-adic multiple zeta values (abbreviated as MZV's) to the v-adic MZV's with kernel containing the one-dimensional vector subspace spanned by the signal zeta value when the weight is "q"-even. In the later one, they further generalized the above work in the sense that the map is indeed an algebra homomorphsim. Their ultimate goal is to prove the challenge that the kernel of the homomorphism is generated by the single zeta value at $q-1$ as is inspired by the spirit of Grothendick's period conjecture for real and p-adic multiple zeta values.

2. Representations of Lie algebras and Lie superalgebra, *by C.-W. Chen*.
   Chen's research focuses on the following topics:

   (a) Irreducible character problem of Lie superalgebras: periplectic Lie superalgebras, queer Lie superalgebras, exceptional Lie superalgebras.

   (b) The structure of modules in the BGG category O for Lie superalgebras, including their homological properties.

   (c) The primitive spectrum and Harish-Chandra bimodules for Lie superalgebras, in particular, developing a description of primitive spectrum for periplectic Lie superalgebras.

(d) Classification of irreducible representations for Lie superalgebras

In joint works with his collaborators, Chen establishes a bijection between simple supermodules over an arbitrary type-I Lie superalgebra and simple supermodules over the even part of this Lie superalgebra. The construction of this bijection is very explicit and useful, namely, it is given by the so-called Kac induction functor. Consequently, this method reduces the classification problem for the supermodules over Lie superalgebras to the modules over Lie algebras. In addition, several criteria for the simplicity of Kac induced modules are also obtained. In particular, this applies to the study of Whittaker modules.

3. Arithmetic dynamical systems, *by L.-C. Hsia*.
In [13], we study the iterated Galois groups associated to unicritical polynomials defined over function fields of transcendence degree 1 over $\overline{\mathbb{Q}}$.

Let K be the function field of a smooth irreducible curve defined over $\overline{\mathbb{Q}}$. Let $f(x) = x^d + c \in K[x]$ with $d = \deg f \geq 2$ and let $\beta \in \mathbb{P}^1(K)$. For $n \in \mathbb{N}$, the Galois group $G_n(\beta)$ of $f^n(x) - \beta$ can be shown to be embedded into $\mathrm{Aut}(T_n^d)$, the automorphism group of d-ary rooted tree T_n^d of level n, which is isomorphic to $[S_d]^n$, the nth iterated wreath product of the permutation group S_d on d letters. The inverse limit $G_\infty(\beta)$ of $G_n(\beta)$ is thus embedded into $\mathrm{Aut}(T_\infty^d)$, the automorphism group of an infinite d-ary rooted tree T_∞^d. It can be shown that $G_\infty(\beta)$ sits inside $[C_d]^\infty$, the iterated wreath product of the cyclic group C_d of order d. As an analogue of Serre's open image theorem, we show that for $d = p^r$, $r \geq 1$, a power of a prime p, and for $c \in K \backslash \overline{\mathbb{Q}}$, the image of $G_\infty(\beta)$ in $\mathrm{Aut}(T_\infty^d)$ is of finite index in $[C_d]^\infty$ if and only if β is neither periodic nor in the orbits of the critical point under the action of f. Moreover, we show that if $f_i(x) = x^d + c_i$, $i = 1, 2$, are distinct polynomials, then the two towers of extensions associated to $\{f_i^{-n}(\beta)\}_n$, $i = 1, 2$, are disjoint over a finite extension of K.

4. p-adic automorphic representations, *by M.-L. Hsieh*.
In [10], we construct the three-variable p-adic triple product L-functions attached to Hida families of elliptic newforms and prove the explicit interpolation formulae at all critical specializations by establishing explicit Ichino's formulae for the trilinear period integrals of automorphic forms. Our formulae perfectly fit the conjectural shape of p-adic L-functions predicted by Coates and Perrin-Riou. As an application, we prove the factorization of certain unbalanced p-adic triple product L-functions into a product of anticyclotomic p-adic L-functions for modular forms. By this factorization, we obtain a construction of the square root of the anticyclotomic p-adic L-functions for elliptic curves in the definite

case via the diagonal cycle Euler system á la Darmon and Rotger and obtain a Greenberg-Stevens style proof of anticyclotomic exceptional zero conjecture for elliptic curves due to Bertolini and Darmon.

5. Representation theory for Lie superalgebras, *by C.-J. Lai and Yung-Ning Peng*.
The 104-page research monograph [13] is dedicated to the canonical basis theory of the quantum symmetric pairs (or i-quantum groups) of affine type using techniques from the theory of affine Hecke algebras. This is the algebraic enhancement of [11], which deals with geometry of affine flag varieties and counting over finite fields. This in turn provides an affinization of Bao-Wang's foundational work on quantum symmetric pairs and i-quantum groups which led to their 2020 AMS Chevalley Prize as well as Wang's 2022 ICM invited talk. While there are 5 authors, a large portion of the main text of [13] is based on Lai's PhD thesis regarding the non-trivial multiplication formulas with tridiagonal generators.

   In [12], Lai established the canonical basis theory for the unequal-parameter Schur algebras as a parallel theory to Lusztig's canonical basis theory for unequal-parameter Hecke algebras. As an application, we obtain a stabilization realization of the quantum symmetric pairs of types AIII and AIV, which plays an essential role in the establishment the Kazhdan-Lusztig theory for the orthogonal symplectic Lie superalgebras. Our work is the only known way up-to-date to deal with unequal parameters, as the usual geometric method relying on counting over finite fields fails. Lai made a major contribution to the main text, except for that the final section was equally contributed by the two authors. The appendix should mostly be credited to Lai's collaborator.

   Peng's recent research focuses on the study of finite W-superalgebra associated to an arbitrary even nilpotent element in a general linear Lie superalgebra. In particular, he gives a presentation of a finite W-superalgebra in terms of a quotient of the shifted super Yangian. His results [15] are generalizations of well-known results of Brundan-Kleshchev to the case of general linear Lie superalgebras in full generality, which settled down a well-known open problem in this field. His approach has impact on the study of super Yangian, for these papers are the first introducing the notion of 01-sequence (or parity sequence) to the study of super Yangian.

6. Hecke eigensystems of automorphic forms, *by Y. Terakado*.
In joint work with C.-F. Yu [21], Terakado generalized Serre's mod p the Jacquet-Langlands correspondence to automorphic forms on Shimura varieties of Hodge type having good reduction at p. As an application, we gave an explicit and good upper bound of the number of the systems of Hecke eigenvalues of mod p automorphic forms on totally indefinite quaternionic PEL-Shimura varieties. This

result suggests that automorphic forms in general settings also satisfy numerous congruence properties.

7. Automorphic representations over function fields, *by F.-T. Wei*.
   In [16], Wei derive a generalized version of the Kronecker limit formula for GL_n in a conceptual way when n is arbitrary, and proposed the "period" interpretations of various "Kronecker terms". This result enables him to prove a function field analogue of the Colmez conjecture for CM Drinfeld modules, and also applies to the arithmetic of special values of Rankin-Selberg and Godement-Jacquet L-functions associated to automorphic cuspidal representations of GL_n. This generalization gives rise to many subsequent problems, which are his current pursuit in his research topics.

8. Modular curves and Shimura curves, *by Yifan Yang*. In a joint work with Jia-Wei Guo and Chang-Shou Lin [17], Yang studied the classical problem of existence of a conformal metric of constant curvature on the Riemann sphere with conic singularities. A key ingredient in their approach is the transformation of curvature equations into modular differential equations. This allows them to use theory of modular forms to prove solvability or insolvability of a given curvature equations in some cases. They found that when the number of non-integer angles are three and the angles are rational multiples of π, there exists a differential form on a certain algebraic curve such that a metric exists if and only if the differential form is exact.

9. Arithmetic of Shimura varieties, *by Chia-Fu Yu*.
   In [18], jointly with Karemaker and Yobuko, Yu introduces the mass stratification on the supersingular locus S_g of the Siegel modular variety A_g for which the mass function is constant. An arithmetic significant is that this stratification controls the jumps of the automorphism groups and endomorphism rings of points in S_g. For points in each mass stratum of S_3, they give an explicit mass formula and investigate possible automorphism groups. In particular, they show that the automorphism group of every point in the largest mass stratum has order two. This proves the Oort Conjecture on the automorphism groups of generic supersingular abelian threefolds.

   In [20], jointly with Shen and Zhang, he constructs the EKOR stratification in the special fiber of the Kisin-Pappas model. The EKOR stratification is the conjectural stratification described by work of He and Rapoport which interporates the EO strata when the level structure at p is hyperspecial and the KR strata in the Iwahori case. The main tools are the theory of G-zips and mixed characteristic local G-Shtukas. They also establish several geometric properties of EKOR

strata including the smoothness, dimension formula and closure relation and use them to study Newton strata and central leaves.

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Due to the travel restriction arising from the covid-19 pandemic, there were very few international visitors and all the international conferences and workshops were either cancelled or postponed in the past year.

Seminars

1. NCTS seminar on arithmetic geometry and representation theory.
   Organizer: Chia-Fu Yu.

2. NCTS seminar on number theory.
   Organizer: Chieh-Yu Chang, Fu-Tsun Wei, and Yifan Yang.

3. NCTS seminar on combinatorics.
   Organizer: Wei-Hsuan Yu.

4. NCTS seminar on representation theory.
   Organizer: Chun-Ju Lai.

Lectures and Courses

1. NCTS summer course on polarized abelian varieties over function fields.
   Instructor: Chia-Fu Yu.

2. Taiwan mathematics school: analytic number theory.
   Instructors: Peng-Jie Wong and Yifan Yang.

3. Taiwan mathematics school: Introduction to Drinfeld modular varieties.
   Instructor: Chia-Fu Yu.

4. NCTS short course on representation theory: mini-course on Whittaker modules and categories for Lie algebras and Lie superalgebras.
   Instructor: Chih-Whi Chen, Chun-Ju Lai, and Yung-Ning Peng.

2.1.4 Future Plans

Conferences and workshops:

Before the pandemic started, we have regularly organized workshops and conferences with our international partners, including

1. Japan-Taiwan joint conference on number theory, held every two years.

2. NCTS-Postech joint workshop on number theory, held every one and half a years.

We plan to resume these activities once it becomes safe to travel internationally and travel restrictions are lifted. In addition to the conferences above, we plan to organize the following workshops and conferences.

1. Workshop on function field arithmetic, to be held in September.

2. NCTS Number Theory Day, to be held in the next winter.

3. IWASAWA 2025. IWASAWA is a series of conferences on Iwasawa theory held every two years. It is one of the most important conferences on the subject.

Seminars

1. NCTS seminar on arithmetic geometry and representation theory.
   Organizer: C.-F. Yu.

2. NCTS seminar on number theory.
   Organizers: C.-Y. Chang, F.-T. Wei, and Y. Yang.

3. NCTS seminar on representation theory.
   Organizer: Chun-Ju Lai.

4. NCTS seminar on combinatorics.
   Organizer: W.-H. Yu.

5. NCTS mini-course on trigonometric Cherednik algebras by Wille Liu.
   Organizer: Chun-Ju Lai.

2.2 Algebraic Geometry

2.2.1 Core Members

1. Program Committee Members: Ching-Jui Lai (NCKU, committee chair until August), Hsueh-Yung Lin (NTU), Jeng-Daw Yu (NTU).

2. Affiliated Faculty Members: Jungkai Chen (NTU, committee chair since September), Jheng-Jie Chen (NCU), Shin-Yao Jow (NTHU), Adeel Khan (AS), Ting-Yu Lee (NTU), Yuan-Pin Lee (AS), Frank Liou (NCKU), Chih-Chung Liu (NCKU), Zhu Eugene Xia (NCKU).

3. Postdoctoral Fellows: Iacopo Brivio (NCTS), Chih-Wei Chang (NCTS), Hsin-Ku Chen (NTU), Yen-An Chen (NCTS), Sheng-Fu Chiu (AS, NCTS), Bin Nguyen (NCTS), Ryo Yamagishi (NTU, NCTS).

4. Doctoral Students: Chi-Kang Chang (NTU), Shi-Xin Wang (U. Utah).

2.2.2 Program Overview

Algebraic geometry studies the geometry of algebraic and analytic objects and it has been a core area of the modern mathematics for more than a century. Today it remains a very active area in mathematics and related fields with many of its techniques, notions, and methods having important applications in number theory, differential geometry, physics, and even in statistics and data analysis. Thanks to the consistent and generous support of NCTS, the research group of algebraic geometry in Taiwan has maintained a good size and has been active in various fields of study. Research areas include, but are not limited to, classification in higher dimensional geometry, dynamics of varieties, generalized Hodge theory, linear systems and positivity, instantons and quiver varieties, and moduli spaces of sheaves and Higgs bundles.

In this year, we have several important activities and major achievement:

- In fall 2021, Prof. Keiji Oguiso visited the NCTS as an NCTS distinguished scholar. He lectured a course in Taiwan Math School, and gave a talk in the Workshop on Arithmetic and Algebraic Geometry in Tunghai University. During his visit, constant research discussion with Jungkai Chen and Hsueh-Yung Lin also leads to a joint work [5].

- In spring 2022, we initiated parallel topical research seminars conducted by junior researchers. The topics includes moduli problem in positive characteristics, tropical geometry, algebraic foliations and web geometry, geometry of Burniat surfaces, etc. These seminars have helped greatly our NCTS postdocs to develop their own research and resulted in several preprints [6, 7, 8, 9, 10, 11, 12, 1].

- In summer 2022, we have successfully recruited 8 students for our USRP program to study toric varieties and weighted complete intersections. After USRP, the size of the study group has doubled: We will run two students seminars on moduli space of sheaves and mixed Hodge modules. Indeed, most of the participants are planning to apply for study abroad for the next year.
- In fall 2022, many of our junior researchers involved in NCTS activities will be visiting abroad:
  - NCST postdoc Chih-Wei Chang will visit Prof. Sam Payne at Univ. Texas in Austin.
  - NTU postdoc Hsin-Ku Chen will visit Korean Institute for Advanced Study.
  - NTU graduate Chi-Kang Chang will visit Prof. Yoshinori Gongyo at University of Tokyo.

  Moreover, NTU undergraduate Shi-Xin Wang is now a graduate student at University of Utah.

In the coming year, with Lab in Birational Geometry established by Prof. Jungkai Chen (with the financial support from NSTC) and the support of NCTS, we shall have great chance to develop many more working activities, and opportunities to interact with leading experts in the field. Especially, in March 2023, there will be many prestigious international researchers coming to the NCTS Higher Dimensional Algebraic Geometry, Minicourses and Workshops, and we are looking forward to meeting all of them.

2.2.3 Research Highlights

Below are some of the highlights and breakthroughs in 2022.

1. Mori's program and its extensions, by *Yen-An Chen, Iacopo Brivio*

   Minimal model program (MMP) provides a unified way to understand the geometry of varieties, by creating a "minimal" representative in the birational class of a given variety. For projective surfaces, this leads to the Castelnuovo-Enriques classification in mid 19th century. However, the geometry is much more complicated in higher dimensions and it is still an active research topic. NCTS has many researchers working in this direction, on the one hand towards its extension to fields of finite or mixed characteristics and in the setting of algebraic foliations. We highlight some recent achievement in this report.

   After the work of S. Keel on threefold base point freeness in positive characteristics, the MMP in positive characteristics has been revived after the seminal work

of Hacon-Xu on the existence of threefold flips in 2013, with the help of many significant progress on the theory of F-singularities. Since then, MMP has been extended also to mixed characteristics, a realm with a more number theoretic flavor. Iacopo, being one of the working expert in the field, has found important pathological examples to the classic invariance of plurigenera [10]. He is also working on the geometry of moduli space of elliptic surfaces in positive characteristics, in order to explore bizarre geometry that cannot exist classically, and hoping to find more number theoretical applications. Yen-An Chen, on the other hand, works on the extension of MMP to foliations. The theory of foliated MMP has been developed by McQuillen, Brunella, extending early work of Mori and Miyaoka. The foliated MMP has been greatly advanced to threefolds by recent work of Spicer, Cascini, and Svaldi. However, a better understanding of foliated geometry in general is still intricate. In this direction, Yen-An has explicated the numerical behaviour of singularities in foliated MMP [1], and he is currently working on resolution and classification of higher dimensional foliations.

2. Explicit geometry of surfaces and threefolds, *Bin Nguyen, Ching-Jui Lai*

   We also have working groups in explicit higher dimensional geometry. By exploring or constructing concrete examples, the aim is to reveal the hidden geometry or provide more evidence to some general conjectures. For example, Bin Nguyen has specialized in the geography of surfaces of general type, and he has constructed several examples of surfaces with prescribed canonical degrees [6, 7, 8, 9]. For threefolds, Ching-Jui Lai has collaborated with Atsuhi Ito (Okayama University) and Sz-Sheng Wang (postdoc at Academic Sinica) to provide more supporting examples of Calabi-Yau threefolds for Morrison-Kawamata Cone conjecture, cf. [14, 15]. Both groups are currently working to extend these results.

3. Generalized Hodge theory and applications, by *Jeng-Daw Yu*.

   Hodge theory lies in the crossroads of frontier research in algebraic geometry, singularity theory, algebraic differential equations, theoretical physics and arithmetic. In the last decade we have developed the irregular Hodge theory, extending the classical Hodge theory. The new theory and its potential connections to other topics open many possible further research directions.

   With Sabbah, we investigate the Hodge theoretic aspects of power moments of classical Airy functions using irregular Hodge theory. This work is an extension of previous work [1], joint with Fresán and Sabbah, in the case of Bessel functions, which are the complex counterpart of the classical Kloosterman sums. Although in the Bessel case, the underlying exponential motives are classical motives, this is no longer true for the Airy case. Indeed, we find that the underlying exponential mixed Hodge structures are classical after a pullback by a

finite cyclic covering, a property that we call monodromic. They are truly non-classical, but may be regarded as the next easiest case after the classical mixed Hodge structures. The pure ones of such monodromic Hodge structures already appear in the language of Anderson's ulterior motives. Their arithmetic aspects are interesting and are under investigation.

4. Geometry of compact Kähler manifolds, by *Hsueh-Yung Lin*.

   (1) Deformations of compact Kähler manifolds

   Let X be a compact Kähler manifold. An algebraic approximation of X is a deformation $X \to \Delta$ of X such that the subset parameterizing projective manifolds in this family is dense in Δ. Whether or not a compact Kähler manifold admits an algebraic approximation is known as the Kodaira problem, due to the pioneering result of Kodaira in the 1960s that algebraic approximations always exist for compact Kähler surfaces. In the opposite direction, there exist compact Kähler manifolds constructed by Voisin starting from dimension 4 and on which we do not have any algebraic approximation. For most compact Kähler manifolds, the existence of algebraic approximations is still unknown. Among the known ones, Claudon proved that smooth fibrations in abelian varieties over a projective manifold always admit algebraic approximations. They form an interesting class of examples because they exist in arbitrary dimension, and also there are sufficiently many to show that every linear Kähler fundamental group is projective as a corollary.

   Despite its application to the study of Kähler fundamental groups, from a geometric viewpoint the examples in Claudon's work are arguably too specific, as a fibration is rarely smooth. We therefore ask whether Claudon's result still holds if we drop the smoothness assumption.

   Question 1. Let $f : X \to B$ be a fibration whose general fiber is an abelian variety. Assume that X is a compact Kähler manifold and B a projective manifold, does f have an algebraic approximation?

   We prove the following theorem in [2]: Let $f : X \to B$ be a fibration with X being a compact Kähler variety, B a smooth projective curve, and a general fiber of f an abelian variety. Then f has an algebraic approximation. This answers Question 1 in the affirmative when $\dim B = 1$.

   (2) Dynamics of compact Kähler manifolds

   Let X be a compact Kähler manifold. Let $f \in \mathrm{Aut}(X)$ be an automorphism of X, namely a biholomorphic self-map $f : X \to X$. By the Gromov–Yomdin theorem, the topological entropy $h_{\mathrm{top}}(f)$ of f is equal to the spectral radius of f^* on $H^\bullet(X, \mathbb{C})$. Recall that f^* preserves the grading and the Hodge decomposition. It

is well-known that $h_{\rm top}(f) = 0$ if and only if f^* on $H^{1,1}(X)$ is quasi-unipotent; such an automorphism f is called a zero entropy automorphism.

We prove the following result in [3]: Let $f \in {\rm Aut}(X)$ be a zero entropy automorphism. For any norm $\|\bullet\|$ on $H^{1,1}(X)$, we have $\|(f^*)^m : H^2(X, \mathbb{C})\| \sim O(m^{2d-2})$ when $m \to \infty$ where $d = \dim X$. Moreover, such an estimation is optimal in terms of d.

This generalizes a statement proven by Lo Bianco from dimension 3 to arbitrary dimension. According to Cantat's ICM report, the above Theorem appears to be the first general result on the growth of the actions on $H^2(X, \mathbb{C})$ induced by zero entropy automorphisms. What lies behind this Theorem are the so-called dynamical filtrations that we discover, and we believe that this fundamental structure will lead to more applications in the future. Based on more refined dynamical filtrations, we also prove the following in the same paper: For any zero entropy subgroup $G < {\rm Aut}(X)$, the essential derived length of the G-action on X is bounded above by $\dim X - 1$.

5. Linear Systems and Positivity, *Shin-Yao Jow*

   In the paper [4], we generalize some fundamental results about asymptotic constructions for complete graded linear series to arbitrary ones. This is useful because incomplete graded linear series do naturally arise, most notably in connection with the restricted volume. Our results generalize and unify several previous results in the literature.

6. Spectral geometry of conical Riemann surfaces, *Jia-Ming (Frank) Liou*

   The study of determinant of Laplacians on Riemann surfaces is motivated from the quantum field theory and the Sarnak program. In string theory, the formula for the determinant of the Laplacian on compact Riemann surfaces with respect to the Arakelov metric is related to so-called the bosonization formulas. Geometers and physicists also consider the determinant of Laplacians for various singular metrics on Riemannian manifold. Our research is motiated by the study of the computation of the determinant of Laplacians on compact Riemann surfaces with conical singularities. K. Aleskey and K. Dmitry considered the singular flat metric form on a Torelli marked Riemann surface Σ where ω is an abelian differential on Σ. They proved the following formula

$$\det \Delta^{|\omega|^2} = C{\rm Area}(\Sigma, |\omega|^2) \det({\rm Im}B)|\tau|^2,$$

   where B is the matrix b-periods of Σ and τ is the Bergman tau function on the Hurwitz space. H. Luke, K. Victor, A. Kototov calculated the determinant of the Laplacians on Riemann surfaces with respect to the singular metric of the form $m = f^* ds^2_{\rm FS}$ where $ds^2_{\rm FS}$ is the Fubini-Study metic on $\mathbb{P}^1$. Here $f : \Sigma \to \mathbb{P}^1$ and

assumed that ∞ is not a branch point of f. In their research, they obtained the following formula

$$\det \Delta^m = C \det(\mathrm{Im}B)|\tau|^2 \prod_{i=1}^{r}(1+|z_i|^2)^{-4},$$

where z_i is a branch point of f and r is the number of branch points of f. In our research, we extend their results to the case when $f : \Sigma \to \mathbb{P}^1$ is a branched cover with a fixed monodromy group G.

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2.2.4 Highlights of Events

Seminars

1. NCTS Seminar in Algebraic Geometry

   Due to the diversity of interest of domestic researchers, we encourage each person with interest in a particular subject, to lead a learning seminar with a small group people, especially for those who are currently developing his/her research in a specific topic. As a result, we have formed five study working groups:

   - Moduli Spaces of Elliptic Surfaces in Positive and Mixed Characteristics (Iacopo Brivio)
   - Tropical Geometry (Chih-Wei Chang)
   - Anticanonical Geometry (Ching-Jui Lai)
   - Foliation and Web Geometry (Yen-An Chen)
   - Burniat Surfaces (Bin Nguyen)

   Some of them have led to promising research results, and we will continue or expand this working style. On the other hand, most people are integrated into the seminar in Lab in Algebraic Geometry, led by Prof. Jungkai Chen, focusing on higher dimensional geometry.

2. Algebraic Geometry in East Asia (AGEA) and Zoom Algebraic Geometry Seminar (ZAG)

   Due to the global pandemic, most research activities are current still online. NCTS has joined and supported two of these activities, AGEA and ZAG. AGEA

is a collaborative program conducted by China, Japan, Korea, Singapore, Taiwan, and Vietnam, which consists of regular research talks from algebraic geometers worldwide. Through participating AGEA seminars, researchers in Taiwan can understand the research work in current trends and keep in contact with the global community. On the other hand, ZAG is run in a similar way and is a global collaboration of international algebraic geometers. Joining ZAG will keep researchers in Taiwan informed about new work in the field.

3. Seminar on Arithmetic Geometry and Algebraic Groups (Ting-Yu Lee)

   This seminar is focusing on various research topics in arithmetic geometry with special regard to algebraic groups, homogeneous spaces and related structures or problems.

Lectures and Courses

1. NCTS Winter Short Course on Algebraic Geometry, Jan. 2021 (Chia-Fu Yu)

   Aim: We will mainly cover standard contents on schemes, equivalently, Chapter II Sections 1-7 of Hartshorne's textbook: Sheaves and presheaves, locally ringed spaces, schemes, separated and proper morphisms, quasi-coherent and coherent sheaves, Weil and Cartier divisors, projective morphisms.

   Remark: This has helped many students, especially those not in Taipei, to enter the field of algebraic geometry.

2. Taiwan Mathematics School: Arithmetic Dynamics for Rational Dominant Self-maps of Projective Varieties, Oct.–Dec. 2021 (K. Oguiso, U. Tokyo)

   Aim: In this course, in the first few lectures, I would like to introduce Weil height and the so called Weil Height Machine following M. Hindry and J.H. Silverman. Then I would like to introduce the notion of arithmetic degree for a self-morphism of a normal projective variety and its basic properties following Kawaguchi-Silverman. Then as concrete important cases, I would like to explain the full solution of KSC for an endomorphism of a surface and an endomorphism of an abelian variety (Kawaguchi-Silverman-Sano-Matsuzawa-Shibata) and a self-morphism for hyperkähler manifold by Leiseutre and Satriano. Then (probably the last one third of lectures) we start to generalize for dominant self-maps or birational self-maps. This part is under progress by many researchers, and, except some basics, the choice of topics will be fixed later.

   Remark: A companion workshop in arithmetic geometry was held in Tunghai University. This series of activities also generate a collaborative work [5].

3. Taiwan Math School: Introduction to Riemann Surfaces, fall 2021 (Ching-Jui Lai)

Aim: In this course, we will introduce the notion of Riemann surfaces, holomorphic functions, meromorphic functions, differential forms on Riemann surfaces, maps between Riemann surfaces, Riemann-Roch Theorem, Abel-Jacobi theorem. We might discuss the existence of meromorphic functions and the uniformization theorem if time allows.

4. Taiwan Math School: Introduction to Complex Geometry, fall 2021 (Hsueh-Yung Lin)

5. USRP: Toric varieties and weighted complete intersections, Jul.-Aug. 2022 (Jheng-Jie Chen, Jungkai Chen, Ching-Jui Lai)

   Aim: In this project, we introduce the theory toric geometry to students following the textbook, Toric Varieties, Cox-Little-Schenck. The plan is to establish the foundation for the students and then move to the more specialized topic of weighted projective spaces, weighted hypersurfaces, and weighted complete intersections (WCI). Some research problems will also be introduced if time permits. For example, the mirror construction of Batryev via small resolution of toric hypersurfaces, boundedness of mildly singular Fano and Calabi-Yau WCI's, WCI of general type with large volumes, etc.

   Remark: The size of the student group has doubled after the program, and the students will continue their study in algebraic geometry by running two student seminars, one in moduli space of sheaves and another on mixed Hodge modules.

Conferences and Workshops

1. NCTS Workshop on Arithmetic and Algebraic Geometry, Nov. 2021, Tunghai University (Jungkai Chen, Ching-Jui Lai, Hsueh-Yung Lin)

   Aim: Many arithmetic problems can be understood in terms of algebraic geometry, which helps to develop many useful tools and theory. The purpose of this workshop is to introduce some of the problems and current research in this active topic.

2. Singular Promenade, Mar. 2022, Hualien (Jheng-Jie Chen, Jungkai Chen, Ching-Jui Lai)

   Aim: In this workshop, a group of undergraduate students present chapters of "A sinuglar mathematical promenade" by É. Ghys. The purpose of the workshop on the one hand is to train students' presentation skills, and on the other hand serves as an invitation to the study of singularities in higher dimensional algebraic geometry.

   Remark: Some of USRP participants are students who have come to the promenade.

2.2.5 Future Plans

Conferences and workshops:

1. NCTS Higher Dimensional Algebraic Geometry, Minicourses and Workshop, Mar. 13–24, 2023 (Jungkai Alfred Chen) link

   Remark: We expect many students currently enrolled in student seminars and domestic researchers will greatly benefit from the mini-courses and the workshop, by learning and interacting with so many prestigious international experts in the field.

2. (TBD) NCTS Conference organized by Evgeny Shinder, Jungkai Chen and Hsueh-Yung Lin (Aug. 2023)

Visitors, Courses, and Lectures:

1. Short Course by Young Theoretical Scientist awardee Adeel Khan: A Modern Introduction to Algebraic Stacks

2. Yerko Alejandro Torres Nova (Chile) is currently visiting Taiwan with the support of Prof. Jungkai Chen

3. Lecture by prospective international visitors (TBD, supported by Jungkai Chen): Paolo Cascini (Imperial, postponed); Ivan Cheltsov (Ediburgh, postponed); Yujiro Kawamata (Tokyo, Spring 2023); De-Qi Zhang (Singapore, Fall 2023); Caucher Birkar (Cambridge, Spring 2024)

Seminars and others

1. Seminar in algebraic and complex dynamics, Yu-Wei Fan (YMSC, Beijing) and Hsueh-Yung Lin

2. Lab in Birational Geometry seminars

3. Student seminars: Moduli space of sheaves; Mixed Hodge modules

4. NCTS seminar in Algebraic Geometry, by request

5. AGEA

2.3 Differential Geometry and Geometric Analysis

2.3.1 Core Members

1. Program Committee Members: River Chiang (NCKU), Nan-Kuo Ho (NTHU, committee chair), Chun-Chi Lin (NTNU), Chung-Jun Tsai (NTU).

2. Affiliated Faculty Members: Jih-Hsin Cheng (AS), Chin-Yu Hsiao (AS), Shu-Cheng Chang (NTU), Siao-Hao Guo (NTU), Yng-Ing Lee (NTU), Mao-Pei Tsui (NTU), Ting-Jung Kuo (NTNU), Ulrich Menne (NTNU), Mei-Heng Yueh (NTNU), Hsiao-Fan Liu (TKU), Rung-Tzung Huang (NCU), Mei-Lin Yau (NCU), Ye-Kai Wang (NYCU), Hung-Lin Chiu (NTHU), Hsuan-Yi Liao (NTHU), Chiung-Jue Anna Sung (NTHU), Dong-Ho Tsai (NTHU), Siye Wu (NTHU), Sin-hua Lai (NCUT), Kuo-Wei Lee (NCUE), Jui-En Chang (CCU), Shu-Yu Hsu (CCU), Chih-Chung Liu (NCKU), Ryosuke Takahashi (NCKU), Eugene Zhu Xia (NCKU), Chung-I Ho (NKNU), Chih-Wei Chen (NSYSU), Yi-Sheng Wang (NSYSU), Chin-Tung Wu (NPTU).

3. Postdoctoral Fellows: Andrea Galasso (NCTS), Sheng-Fu Chiu (NCTS), Brian Harvie (NCTS), Simon-Raphaël Fischer (NCTS), Ser-Wei Fu (NTU), Albert Wood (NTU), Wei-Bo Su (AS), Kuang-Ru Wu (AS), Nicolau Sarquis Aiex (NTNU), Sean McCurdy (NTNU), Yang-Kai Lue (NYCU).

2.3.2 Program Overview

The aim of our program is twofold.

1. Create an engaging and thriving research environment for differential geometers in Taiwan: (a) To provide resources for interaction with international scholars for collaboration and developing future directions by holding special lecture series, international conferences, and hosting visitors. (b) To provide opportunity for interaction within the Taiwan community by holding regular seminars and symposia that rotate their venues.

2. Create a friendly and exciting learning environment for young students. We wish to attract outstanding students to the field, and help them to establish a solid foundation on the subjects as well as having some understanding of important topics in Geometry and Topology by providing high quality courses and lecture series on current research topics.

The Program of Differential Geometry and Geometric Analysis covers a broad spectrum of themes, including a more analytic perspective as well as a more topological incarnation of modern geometry. Manifold learning and other applications are also introduced recently. Our current research directions cover:

1. Minimal submanifolds, geometric flows and mathematical general relativity

2. Cauchy-Riemann geometry and spectral geometry
3. Geometric measure theory and geometric variational problems
4. Geometric PDEs (and metric structures)
5. Gauge theory, moduli space problems and mathematical physics
6. Symplectic and contact geometry
7. Discrete differential geometry and manifold learning theory

2.3.3 Research Highlights

Below are some of the research highlights and breakthroughs in 2022 in our group.

1. Cauchy-Riemann geometry and spectral geometry

   Jih-Hsin Cheng (AS)

   In [1] we consider the Cauchy-Riemann Yamabe equation with critical Sobolev exponent on a closed contact manifold M of dimension $2n + 1$. The problem of finding solutions with minimum energy has been resolved for all dimensions except dimension 5 ($n = 2$). In this paper we prove the existence of minimum energy solutions in the 5-dimensional case when M is spin. The proof is based on a positive mass theorem built up through a spinorial approach.

   Chin-Yu Hsiao (AS)

   The first goal of [2] is to develop a differential geometric formalism on strictly pseudoconvex CR manifolds with $\mathbb{R}$-action, analogous to the Kähler identities and Bochner-Kodaira-Nakano formula for Hermitian manifolds. We refine in this way Tanaka's formulas in the spirit of Demailly's general version of the latter formulas. This formalism leads to vanishing theorems and L^2-estimates for the $\bar{\partial}_b$-operator for complete CR manifolds.

   The second goal of [2] is to generalize the result of Boutet de Monvel-Sjöstrand about the singularities of the Szegõ kernel for complete strictly pseudoconvex CR manifolds with $\mathbb{R}$-action. This entails global and local embeddability theorems for CR manifolds with $\mathbb{R}$-action, including Sasakian manifolds. Moreover, by applying our result for the Grauert tube of a positive line bundle we obtain a new result about the expansion of the Bergman kernel on complete Kähler manifolds.

   In [3], we consider $(X, T^{1,0}X)$ a compact connected orientable strongly pseudoconvex CR manifold of dimension $2n + 1$, $n \geq 1$. Assume that X admits a

connected compact Lie group action and a transversal CR S^1-action, we compute the coefficients of the first two lower-order terms of the equivariant Szegõ kernel asymptotic expansions with respect to the S^1-action.

2. Geometric PDEs

   Ting-Jung Kuo (NTNU)

   The study of nonlinear integral equations plays an important role in modern analysis of integrable system and has lots of applications such as prescribed curvature problem on Riemann surfaces, and mean curvature flow etc. Among these, the analysis for complex linear ODEs comes to be a fundamental issue especially the developments of the monodromy theory for the related complex linear ODE and the structure of its background geometry.

   In the past few years, we mainly focused on the study of a wide class of generalized Lamé-type equations which is related to the monodromy theory to the Painlevé VI equation and stationary KdV equation as well. In fact, our motivation is from a nonlinear PDE so called the Liouville equation or the mean field equation which is originated from conformal geometry and also plays an important model in physics such as superconductivity and Chern-Simon-Higgs model as well [6].

   From our previous study, we found a deep relation between the Liouville equation and the Lame equation and integrable system as well [4, 5]. In particular, we found that that there is a hyperelliptic curve associated to this Lamé-type equation which is indeed the spectral curve in KdV theory. The study of the background geometry of this hyperelliptic curve is particular interesting to us. Recently, we succeed to compute the genus of this spectral curve and also determined the degree of its associated addition map which is the key step to understand the geometry of this algebraic curve. As a consequence, we are able to construct a pre-module form which can give us a criterion of the existence or non-existence of solutions to the mean field equation. Based on this result, we hope that we could have a complete understanding of the mean filed equation defined on tori.

3. Geometric measure theory and geometric variational problems

   Chun-Chi Lin (NTNU)

   In [7], we developed some techniques inspired from the joint work with Anna and Paola to elastic flows for nonlinear spline interpolations in R^n. The proof for the long-time existence in this article has been completed a while ago, while the proof of the short-time existence is finally added in 2021. In fact, we developed a new technique in the short-time existence, which provides a new way for the

proof of the long-time existence. One of the crucial point is to deal with diffeomorphisms, which convert solutions of PDEs, degenerate or non-degenerate (due to the fact that the flow is only geometric not really PDE/analytical). In other words, our work on the short-time existence could be viewed as a replacement for DeTurck's simplified argument for Ricci flow; however our case contains boundaries and is for the fourth-order geometric flow instead of second-order ones.

Ulrich Menne (NTNU)

The main research activity in the past year was a collaboration [8] with Christian Scharrer (Bonn, Germany). It leads to a series of papers "A priori bounds for geodesic diameter" consisting of three parts with currently 110 pages in total.

In [8], first, as a service to the community, we provide - for Euclidean space - a basic treatment of locally rectifiable chains and of the complex of locally integral chains. In this setting, we may beneficially develop the idea of a complete normed commutative group bundle over the Grassmann manifold whose fibre is the coefficient group of the chains. Our exposition also sheds new light on some algebraic aspects of the theory. Finally, we indicate an extension to a geometric approach to locally flat chains centring on locally rectifiable chains rather than completion procedures. This is currently under review.

4. Minimal submanifolds, geometric flows and mathematical general relativity

Chung-Jun Tsai (NTU)

In [9], we apply a recent technique of Brendle to the Lorentzian ambient space. We prove an isoperimetric inequality for spacelike, maximal submanifolds. We also provide examples to demonstrate that the result is sharp in some sense.

In [10], we study submanifold geometry of the Atiyah–Hitchin manifold, a double cover of the 2-monopole moduli space, which plays an important role in various settings such as the supersymmetric background of string theory. When the manifold is naturally identified as the total space of a line bundle over S^2, the zero section is a distinguished minimal 2-sphere of considerable interest. In particular, there has been a famous conjecture of Micallef and Wolfson about the uniqueness of this minimal 2-sphere among all closed minimal 2-surfaces. We show that this minimal 2-sphere satisfies the "strong stability condition" proposed in our earlier work [11], and confirm the global uniqueness as a corollary.

Ye-Kai Wang (NYCU)

The asymptotic symmetry of an isolated gravitating system, or the Bondi-Metzner-Sachs (BMS) group, contains an infinite-dimensional subgroup of supertranslations. Despite decades of study, the difficulties with the "supertranslation ambiguity" persisted in making sense of fundamental notions such as the angular

momentum carried away by gravitational radiation. The issues of angular momentum and center of mass were resolved by the authors recently. In [12], we address the issues for conserved charges with respect to both the classical BMS algebra and the extended BMS algebra. In particular, supertranslation ambiguity of the classical charge for the BMS algebra, as well as the extended BMS algebra, is completely identified. We then propose a new invariant charge by adding correction terms to the classical charge. With the presence of these correction terms, the new invariant charge is then shown to be free from any supertranslation ambiguity. Finally, we prove that both the classical and invariant charges for the extended BMS algebra are invariant under the boost transformations.

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2.3.4 Highlights of Events

Due to continuing travel restrictions caused by COVID-19 pandemic, some of the already postponed activities involving overseas scholars have been further postponed. Nevertheless, we were able to have some hybrid activities and some completely virtual ones. The activities in 2022 are summarized as follows:

Seminars

One of the goals of our program is to create an engaging environment for the differential geometers in Taiwan. Thus, activities such as seminars are very important for exchanging ideas and stimulating interaction:

1. NCTS iGMT Seminar

   Organizers: Ulrich Menne (NTNU), Giovanni Alberti (University of Pisa, Italy), Yoshihiro Tonegawa (Tokyo Institute of Technology, Japan), and Neshan Wickramasekera (University of Cambridge, UK).

   This is an online seminar which is held bimonthly since 2020. It has been able to keep the quality of presentations high, because we keep the frequency of presentations low on purpose. The audience ranges from Japan and Taiwan in the East all the way to Europe and the East Coast of the US. During the period of this report, from August 1, 2021 to July 31, 2022, the seminar has continued to secure speakers from first-rate institutions including a Fields Medalist. Namely,

   - Alessio Figalli (ETH Zurich), on September 22, 2021,

- Otis Chodosh (Stanford University), on November 18, 2021,
- Paul Minter (University of Cambridge), on January 18, 2022,
- Simone Steinbrüchel (Leipzig University), on March 16, 2022,
- Alessandro Pigati (New York University, Courant Institute), on May 18, 2022,
- Costante Bellettini (University College London), on July 20, 2022.

As these speakers were younger than those in the first year and due to increased competition from physical events, the average number of persons participating decreased from around 60 to 46; nonetheless, the total number of registered participants increased by around 100 to more than 300.

2. NCTS Differential Geometry Seminar

   Organizers: Siao-Hao Guo (NTU), Ulrich Menne (NTNU), Chung-Jun Tsai (NTU) and Mao-Pei Tsui (NTU).

   Speakers include domestic researchers for onsite talks and international researchers for virtual talks.

3. AS-NCTS Seminar on Geometry, organized by Jih-Hsin Cheng (AS) and Kuang-Ru Wu (AS).

Lectures and Courses

The aim of the lecture series is to provide an opportunity for researchers to learn about current topics within a manageable time frame. As for cultivating and fostering outstanding students, NCTS has the *Taiwan Math School course*, *URP*, and *USRP* programs.

1. Taiwan Math School:
   - Real Analysis I & II, given by Ulrich Menne (Fall 2021 and Spring 2022)
   - Geometry and Quantum Field Theory, given by Siye Wu (Spring 2022)
2. Short Course: Introduction to Holonomy and G-structures, given by Jesse Madnick (March 15 - May 10, 2022)

Conferences and Workshops

1. The Third Japan-Taiwan Joint Conference on Differential Geometry, Osaka and NCTS hybrid (Oct 30 - Nov 3, 2021)

   Organizers: Shu-Cheng Chang (NTU), River Chiang (NCKU), Martin Guest (Waseda), Nan-Kuo Ho (NTHU), Yng-Ing Lee (NTU), Yoshihiro Ohnita (Osaka), Takashi Sakai (Tokyo Metropolitan University), and Mao-Pei Tsui (NTU).

   The purpose of the Taiwan-Japan Joint Conference on Differential Geometry is to develop collaboration, foster discussions and interactions between the differential geometry communities of Taiwan and Japan. The first one was held at Waseda University in 2016, the second one at NCTS in 2019, and the third one was a hybrid one held in November 2021. There are two on-site venues, one at OCAMI in Osaka and the other at NCTS in Taipei. Other participants can also join using Webex.

   This activity has been published in OCAMI Reports at the following URL: OCAMI

2. NCTS Workshop on Mathematical General Relativity, NCTS (Aug 8, 2022) Organizers: Chung-Jun Tsai (NTU), Mao-Pei Tsui (NTU), and Mu-Tao Wang (Columbia University)

   Due to the equivalence principle and the lack of an absolute space, the understanding of this fundamental notion for gravitation has been subtle since Einstein's time. There was an intense period of study and the efforts culminated in the proof of the positive mass theorem by Schoen-Yau in 1980's (a different proof was given by Witten later). The subject has since undergone rapid developments over the past decade. In particular, many new ideas and techniques from geometric analysis were applied and major progress has been achieved. Questions from this subject also stimulate researches in differential geometry.

   The Schoen–Yau "positive mass theorem" constituted an essential first step for defining "quasi-local" physical quantities. The talks of this workshop will introduce recent developments on the mathematics of mass and angular momentum.

   Invited Speakers: Po-Ning Chen (University of California, Riverside), Lan-Hsuan Huang (University of Connecticut), Mu-Tao Wang (Columbia University).

3. The 22nd Taiwan Geometry Symposium, NCKU (April 23, 2022)

   Organizers: River Chiang (NCKU), Nan-Kuo Ho (NTHU), Chun-Jun Tsai (NTU), Mao-Pei Tsui (NTU) and Ye-Kai Wang (NCKU).

   This is a series of regular meetings aiming to foster discussions and interactions within the geometry community in Taiwan. It is held once every semester. We did not have one in the Fall of 2021 due to COVID restrictions.

2.3.5 Future Plans

It has been another tough year under COVID. As the pandemic finally starts to look like it is nearing its end, and the border restriction has been loosened gradually, we look forward to having more international visitors and activities that are "in-person" to better build communications and learning experiences.

Conferences and workshops:

1. The Fifth International Conference on Differential Geometry, NCTS (Winter 2023)

   It will be organized by Yng-Ing Lee (NTU), Chung-Jun Tsai (NTU), Mao-Pei Tsui (NTU), and Mu-Tao Wang (Columbia University). Potential speakers include world experts like Leon Simon, André Neves, Shing-Tung Yau etc.

2. The Fourth Japan-Taiwan Joint Conference on Differential Geometry, NCTS (Fall 2023)

3. The 23rd Taiwan Geometry Symposium, (Fall 2022)

4. The 24th Taiwan Geometry Symposium, (Spring 2023)

Seminars

1. NCTS iGMT Seminar (bimonthly)

   Organizers: Ulrich Menne (NTNU), Giovanni Alberti (University of Pisa, Italy), Yoshihiro Tonegawa (Tokyo Institute of Technology, Japan), and Neshan Wickramasekera (University of Cambridge, UK).

   The upcoming schedule is as follows:

   - Gábor Székelyhidi (Northwestern University) on September 21, 2022
   - Speakers TBA: Nov. 16 , 2022, Jan. 18, 2023, Mar. 15, 2023, May 17, 2023, and Jul. 19, 2023

2. NCTS Differential Geometry Seminar, organized by Siao-Hao Guo (NTU), Ulrich Menne (NTNU), Chung-Jun Tsai (NTU) and Mao-Pei Tsui (NTU).

Courses and lectures:

1. Lectures on Groupoids, algebroids, and their roles in symplectic and Poisson Geometry (Winter 2022). It will be given by Camille Laurent-Gengoux (Université de Lorraine).

2. Lectures on Ricci flow (2022/2023). It will be given by Chih-Wei Chen (NSYSU).

3. Lectures on various topics in symplectic and contact geometry and topology (2022/2023). It will be organized by River Chiang (NCKU) and Kaoru Ono (RIMS, Kyoto).

4. Short course on Geometric evolution equations and inverse mean curvature flow (spring 2023). It will be given by Brian Harvie (NCTS).

5. Summer short course on singular Liouville equation (Summer 2023). It will be given by Ting-Jung Kuo (NTNU).

2.4 Differential Equations

2.4.1 Core Members

1. Program Committee Members: Chun-Hsiung Hsia (NTU, committee chair), Chih-Hung Chang (NUK), Lung-Chi Chen (NCCU), Chun-Yen Shen (NTU).

2. Affiliated Faculty Members: Chiun-Chuan Chen (NTU), I-Kun Chen (NTU), Jenn-Nan Wang (NTU), Hung-Wen Kuo (NCKU), Kung-Chien Wu (NCKU), Ching-hsiao (Arthur) Cheng (NCU), Chi Hin Chan (NYCU), Hsin-Yuan Huang (NYCU), Jin-Cheng Jiang (NTHU), Dong-Ho Tsai (NTHU), Jong-Shenq Guo (TKU), Jann-Long Chern (NTNU), Zhi-You Chen (NCUE), Jia-Yuan Dai (NCHU), Jung-Chao Ban (NCCU), Kuo-Chang Chen (NTHU), Cheng-Hsiung Hsu (NCU), Yi-Chiuan Chen (AS), Chii-Ruey Hwang (NCCU), Guan-Yu Chen (NYCU), Yuki Chino (NYCU), Ching-Wei Ho (AS), Hsin-Lun Li (NSYSU), Yuan-Chung Sheu (NYCU), Hao-Wei Huang (NSYSU), Shang-Yuan Shiu (NCU), Gi-Ren Liu (NCKU), Kyung-Youn Kim (NCHU), Wai Kit Lam (NTU), Jhih-Huang Li (NTU), Chin-Cheng Lin (NCU), Daniel Spector (NTNU).

3. Postdoctoral Fellows: Junsik Bae (NCTS), Shih-Hsin Chen (NCTS), Sanghyuck Moon (NCTS), Kuan-Hsiang Wang (NCTS), Yoshinori Kamijima (NCTS).

2.4.2 Program Overview

The study of differential equations is one of the most traditional fields of mathematics in Taiwan. The NCTS Topical Program Differential Equations and Stochastic Analysis also aims to incorporate interdisciplinary research as one of its priorities, and its four main directions are: partial differential equations, dynamical systems, stochastic analysis and harmonic analysis. Partial differential equations are one of the most widely adopted mathematical tools in modern sciences. Members of this NCTS Topical Program group are interested in both the developments of the mathematical theory and scientific applications. This includes, for example, synchronization problem, kinetic theory, elliptic partial differential equations, fluid dynamics, inverse problem and reaction-diffusion equations. Interests of the research groups in dynamical systems include bifurcation theory, chaotic systems, ergodic theory, fractal geometry, arithmetic dynamical systems, and complex dynamical systems. The research interests of harmonic analysis group include two weights problems for singular integrals, additive combinatorics and their connections to geometric measure theory. Probability theory plays an important role in many other areas of mathematics, such as partial differential equations, analysis, and combinatorics. It provides the theoretical basis for statistics. In stochastic analysis at the NCTS, the focus is placed on statistical mechanics, mathematical biology, finance, theoretical computer science, branching processes and SPDE.

2.4.3 Research Highlights

Below are some of the highlights and breakthroughs in the past year.

a. Differential Equations

(1) In these two years, Chi Hin Chan, Magdalena Czubak, and Tsuyoshi Yoneda obtained a geometric invariant double Lie-Derivative formula for the restriction or the pull back of the Euclidean Laplacian in their recent arXiv e-print. The potential significance of this result points to novel alternatives for the elliptic operator representing proper viscous effect in incompressible Navier-Stokes flows on the ellipsoid rotating around the z-axis. Empirical evidences show that a rotating planet has the shape of an ellipsoid, and the centrifugal force caused by the self-rotation about the z-axis affects the thin atmosphere around the planet in a way proportional to the distance from the axis of rotation. Under such a centrifugal force due to self-rotation, every single thin layer of atmosphere around the planet will also take the shape of a ellipsoid self-similar to that of the rotating planet. This gives us a strong motivation to use a defining function which reflects the linear scaling of the self-similarity of the family of ellipsoids. Our work points to new directions in the finding of a proper operator which reflects viscous effect of incompressible Navier-Stokes on a rotating ellipsoid (e.g., Jupiter). We refer the readers for a more detailed description to the arXiv e-print: Chi Hin Chan, Magdalena Czubak, Tsuyoshi Yoneda, The restriction problem on the ellipsoid, arXiv e-print March 30, 2022, arXiv:2203.16050v1.

(2) In collaboration with Professor Wang and Professor Yang, Hsin-Yuan Huang studies the mean field equation and the relativistic Abelian Chern-Simons equations (involving two Higgs particles and any two gauge fields) on finite connected graphs. For the former equation, we establish existence results and some uniqueness results. In particular, we find that there is no set of critical parameters for the mean field equation on finite graphs and the existence is ensured for any non-negative parameters, which is in contrast to the continuous case. In addition, we give the optimal constant which is the threshold for the uniqueness of the equation on finite complete graphs with simple weight.

(3) In the joint work with his collaborators, Kung-Chien Wu gets the quantitative space-time behavior of the full Boltzmann equation with soft potentials $(-2 < \gamma < 0)$ in the close to equilibrium setting, under some velocity decay assumption, but without any Sobolev regularity assumption on the initial data. We find that both the large time and spatial behaviors depend on the velocity decay of the initial data and the exponent γ. The key step in our strategy is to obtain the L^∞ bound of a suitable weighted full Boltzmann equation directly, rather than using Green's function and Duhamel's principle to construct the

pointwise structure of the solution introduced by Tai-Ping Liu and Shih-Hsien Yu. This provides a new thinking in the related study.

(4) In the joint work with Bongsuk Kwon, Junsik Bae studies the asymptotic linear stability of a two-parameter family of solitary waves for the isothermal Euler–Poisson system. When the linearized equations about the solitary waves are considered, the associated eigenvalue problem in L^2 space has a zero eigenvalue embedded in the neutral spectrum, i.e., there is no spectral gap. To resolve this issue, use is made of an exponentially weighted L^2 norm so that the essential spectrum is strictly shifted into the left-half plane, and this is closely related to the fact that solitary waves exist in the super-ion-sonic regime. Furthermore, in a certain long-wavelength scaling, we show that the Evans function for the Euler–Poisson system converges to that for the Korteweg–de Vries (KdV) equation as an amplitude parameter tends to zero, from which we deduce that the origin is the only eigenvalue on its natural domain with algebraic multiplicity two. We also show that the solitary waves are spectrally stable in L^2 space. Moreover, we discuss (in)stability of large amplitude solitary waves.

b. Dynamical System

(1) Topological entropy is an important indicator for dynamical systems. It is known that topological entropy is well-defined for symbolic dynamical systems on amenable groups and can be used to distinguish various systems. After Petersen and Salama demonstrated the well-definedness of topological entropy for symbolic systems on free semigroup, Jung-Chao Ban, Chih-Hung Chang and their collaborators showed that it is also well-defined on a broad class of semigroups. Since topological entropy is not an invariant on non-amenable groups such as free semigroups, Ban and Chang studied entropy dimension on a class of semigroups, for which it is an invariant. On the other hand, the properties of topological entropy on free semigroups can be characterized more explicitly for the axial product of shifts of finite type. Homomorphism shift spaces (hom-shifts) is a special case of axial product spaces. Unlike the classical result that the topological entropy of hom-shifts is decreasing with respect to the dimension of the lattice, the topological entropy of hom-shifts on free semigroups is increasing with respect to the number of generators.

(2) Yi-Chiuan Chen focused on the characterization of structure of Mandelbrot set, which is a connected set consisting of parameters of complex quadratic maps corresponding to connected Julia sets. It is a well-known result that every point in the Julia set of the quadratic family $f_c(z) = z^2 + c$, with c in the exterior of the Mandelbrot set, moves holomorphically when c varies. The boundary behavior of the holomorphic motion along the parameter rays of Mandelbrot

set has attracted a lot of attention recently. Shishikura revealed that the semi-hyperbolic parameters form a set of Hausdorff dimension 2. Yi-Chiuan Chen and his collaborators illustrated the speed of motions and the degeneration of the dynamics along internal and external parameter rays.

(3) Cheng-Hsiung Hsu has be mainly concerned about the properties of traveling waves such as the pulsating traveling waves of a periodic lattice dynamical system with monostable nonlinearity. In addition to examining the existence and uniqueness of traveling waves, the asymptotic behavior of the traveling waves were also demonstrated in his works. One of the many applications of traveling waves is the spreading speed of considered disease (to be precisely, the asymptotic speed of disease spread). The spreading speed, introduced by Aronson and Weinberger, is an important ecological metric to estimate the rapidity of disease spread. Cheng-Hsiung Hsu and his collaborators studied a nonlocal dispersal vaccination model with general incidence in which, under some presumptions, the existence and non-existence of non-critical traveling waves are connected to the disease-free and endemic equilibria of the system.

(4) Kuo-Chang Chen has devoted to the study of two-center problem (aka Euler's three-body problem) and orbits of lemniscate type and planetary type. A lemniscate type orbit consists of two lobes with one center inside each lobe, and a planetary type orbit encloses both centers. The motion of a free particle moving in a gravitational force field generated by two stationary point masses is a famous example of an integrable system which is not exactly solvable but solvable by quadrature in terms of elliptic coordinates. The interplay between masses of centers, their separations, and the time interval was investigated. The existence and minimizing property of planetary type periodic solutions for any given masses of centers at fixed positions are demonstrated, and the period can be arbitrary as long as it is above a mass-dependent threshold value.

c. Probability

(1) Hao-Wei Huang and his collaborator contributed to the research topic by proving strong regularity results for free additive and multiplicative Lévy processes. Motivated by the use of regularizing properties of free diffusions and non-commutative entropies, they studied the so-called property (H) introduced by Belinschi, Benaych-Georges and Guionnet. Necessary and sufficient conditions for the free additive and multiplicative Lévy processes having this property are offered. The problem about the number of components in the support of Lévy processes was also considered. Based on elementary integration theory, they constructed concrete examples with or without the property (H). Another research theme of Huang concerns applications of free probability theory and random matrix theory to quantum information theory, especially to the

additivity violation problem. The additivity problem of the minimum output entropy of quantum channels has been one of the core issues in quantum information theory. Huang and his collaborator considered quantum channels composed of non-white Wishart ensembles and explore their additivity violations of minimum output entropy. They noted additivity violation occurring in constructed models of quantum channels is acquired by utilizing the knowledge of free probability theory and random matrix theory. Also, they examined the maximum output p-norm of the erected quantum channels and gained the multiplicativity violations. Once again, these conclusions primarily rely on the asymptotic freeness and strong convergence of random matrices.

(2) Gi-Ren Liu and his collaborator analyzed the scaling limit of random processes arising from the scattering transform coefficients of Gaussian processes without depth limitation. They proved that the total variation distance between the normalized scattering transform with the quadratic nonlinearity (STQN) of Gaussian processes and a chi-square process with one degree of freedom converges to zero at an exponential rate. To show these, they derived a recursive formula to represent the intricate nonlinearity of STQN by a linear combination of Wiener chaos, and then applied the Malliavin calculus and Stein's method to control the distance of interest. It allows them to understand the deep scattering network from a probabilistic viewpoint.

(3) Kyung-Youn Kim studied the heat kernel estimates for a large class of non-local operators. For an elliptic differential operator, the fundamental solution of the heat equation corresponding to this operator is called a heat kernel. In probability theory, this function is a transition density of a diffusion process with the operator as an infinitesimal generator. Therefore, accurate estimation for the heat kernel (or the transition density) is a very interesting research topic in analysis as well as probability theory. However, it is difficult to obtain the fundamental solution for the non-local operators using analytic approaches. Related to non-local operators, there are discontinuous Markov processes and recently there are plenty of researches on this topic in probability theory as well as in PDE. In the above project, (Estimates of Dirichlet heat kernel for symmetric Markov processes), we study the heat kernel for the discontinuous processes. We consider the large class of Markov processes corresponding to non-local operators which have characteristic functions satisfying the weak scaling condition. We obtain sharp two-sided heat kernel bounds for the process in $\mathbb{R}^d$ and $C^{1,1}$-open set $D \subset \mathbb{R}^d$. Especially, it is difficult to get the heat kernel estimates on $D \subset \mathbb{R}^d$ since it is complicated to consider the process where the process is close to the boundary with the exit distribution. Also, as an application, we obtain Green function estimation for the Markov process. It covers very diverse Markov processes, and provides motivation for the potential theory of non-local operators.

(4) Wai-Kit Lam and his collaborators studied first-passage percolation. In one of Lam's work, he and his collaborators considered a dynamical version of first-passage percolation on the triangular lattice, and studied the so-called "exceptional times": the set of random times such that the system exhibits an unusual behavior. They gave a more complete picture to the phase transition of the set of exceptional times in the critical case, which can be described by the behavior of the distribution function of the weights near 0. In another work of Lam, he and his collaborators studied the metric geometry of the infected region $B(t)$ in first-passage percolation on $\mathbb{Z}^d$. They showed that the number of holes in $B(t)$ is of order t^{d-1}, and the size of the largest hole in $B(t)$ is at least of order $\log t$. Under the unproven uniform curvature assumption, they showed that the size of the largest hole is of order at most $(\log t)^C$ when $d = 2$. Without the curvature assumption, this quantity is of order at most $t \log t$.

d. Harmonic Analysis

(1) Chun-Yen Shen and his collaborators, in an on-going series of projects, have made an improvement on the Falconer's distance problem regarding nonempty interiors of distance set for general product sets in $\mathbb{R}^d$ for $d \geq 5$. This is the first improvement since the first result of Mattila in 1985. In addition, we have also proved a very general result for three variables expanding functions in terms of Hausdorff dimension.

(2) Daniel Spector and his collaborators, in an on-going series of papers, have established new Lebesgue and Lorentz space estimates for solutions of partial differential equations (PDE) with L^1 data. The type of PDE considered are Div-Curl, or more generally, Hodge systems, and arise in the study of electricity and magnetism. The analogous estimates for L^p data, $p > 1$, are classical, and can be proved using soft analysis arguments. However, the assumption the data is in L^1 is the natural physical one, and requires different techniques.

(3) Chin-Cheng Lin, Ming-Yi Lee and Keng Hao Ooi study the real Hardy spaces $H^p(\Omega)$ defined over certain open subsets $\Omega \subset \mathbb{R}^n$. Various characterizations of such Hardy spaces in terms of radial maximal function, grand maximal function, and atomic decomposition are investigated. It is shown that the characterizations are not equivalent to each other which differ significantly from the classical results of $H^p(\mathbb{R}^n)$.

2.4.4 Highlights of Events

Seminars

1. NCTS Nonlinear PDE Seminar, NTU. Organized by I-Kun Chen and Chun-Hsiung Hsia.

2. NCTS Webinar on Nonlinear Evolutionary Dynamics. Organized by Jia-Yuan Dai, Chih-Chiang Huang and Chang-Hong Wu.

3. NCTS Korea-Taiwan-Vietnam Joint Seminar in Analysis and Combinatorics, March–June 2022. Organized by Chun-Yen Shen.

4. NCTS Seminar on Dynamical Systems, Spring, 2022. Organized by Jung-Chao Ban and Chih-Hung Chang.

5. European-Asian Joint Webinar on Dynamical Systems, Spring, 2022. Organized by Jung-Chao Ban and Chih-Hung Chang.

Lectures and Courses

1. NCTS Introduction to Decoupling Inequalities. Lecture series by Zane Kun Li, April–May 2022. Organized by Chun-Yen Shen.

2. Distinguished Lecture: Curvature Equation from the Aspect of Integrability, Speaker : Chang Shou Lin (National Taiwan University), July 11–12, 2022. Organized by Yng-Ing Lee.

3. Distinguished Lecture: Random Matrix Theory and Applications to Statistics, Speaker : Horng-Tzer Yau (Harvard University), July 12, 2022. Organized by Mao-Pei Tsui .

4. MSRI-NCTS joint summer school : Recent Topics in Well Posedness, University of Hawaii at Hilo, July 18–29, 2022. Organized by Jungkai Chen et al.

5. NCTS Summer School on Dynamical Systems: Fractals in Diophantine approximation August 8–24, 2022. Organized by Jung-Chao Ban and Chih-Hung Chang.

6. USRP 2022: Topics in Boltzmann equation. Organized by Kung-Chien Wu.

7. USRP 2022: Two dimensional random walk. Organized by Lung-Chi Chen.

8. USRP 2022: Planar Statistical Physics and Bernoulli Percolation. Organized by Wai Kit Lam and Jhih-Huang Li.

Conferences and Workshops

1. 2021 Dong Hwa Workshop in Probability and Related Fields, February 26–27, 2021. Organized by Chia-Li Wang.

2. Third NCTS PDE Symposium, NUK, March 26, 2021. Organized by Chun-Hsiung Hsia, Ying-Chieh Lin, Kung-Chien Wu and Tsung-Fang Wu.

3. 2022 NCTS Young Dynamics Day, NTNU, February 18, 2022. Organized by Jung-Chao Ban, Chih-Hung Chang, Kuo-Chang Chen, Shyan-Shiou Chen, Cheng-Hsiung Hsu and Shih-Feng Shieh.

4. 2022 NCTS (online) Workshop on Dynamical Systems, May 26–28, 2022, Organized by Jung-Chao Ban, Chih-Hung Chang, Kuo-Chang Chen and Cheng-Hsiung Hsu.

5. Fourth NCTS PDE Symposium, NTHU, August 31, 2022. Organized by Chun-Hsiung Hsia, Jin-Cheng Jiang and Kung-Chien Wu.

2.4.5 Future Plans

Conferences and workshops:

1. 2022 Cheng Kung Workshop in Probability and related fields, October, 2022. Organized by Gi-Ren Liu and Jyy-I Hong.

2. International Conference on Recent Developments of Theory and Methods in Mathematical Biology, October 24–28, 2022. Organized by Chiun-Chuan Chen and Jong-Shenq Guo et al.

3. (online) Conference on Fractional Integrals and Related Phenomena in Analysis, December 19–23, 2022. Organized by Chun-Yen Shen and Cody Stockdale.

4. PDE and Dynamical System Young Scholar Workshop. Organized by Chun-Hsiung Hsia and Kung-Chien Wu et al.

5. 2023 NCTS Young Dynamics Day, Spring 2023. Organized by Jung-Chao Ban, Chih-Hung Chang, Kuo-Chang Chen, Cheng-Hsiung Hsu and Kung-Chien Wu.

6. 2023 NCTS Workshop on Dynamical Systems, Spring 2023. Organized by Jung-Chao Ban, Chih-Hung Chang, Kuo-Chang Chen and Cheng-Hsiung Hsu.

7. Spring Probability Workshop, April, 2023. Organized by Lung-Chi Chen et al.

8. NCTS (international) PDE conference, May, 2023. Organized by Chun-Hsiung Hsia and Kung-Chien Wu et al.

9. NCTS PDE Symposium (3 times per year). Organized by Chun-Hsiung Hsia and Kung-Chien Wu et al.

Seminars

1. NCTS Nonlinear PDE seminar, NTU. Fall 2022, Spring 2023. Organized by Chun-Hsiung Hsia et al.
2. NCTS Webinar on Nonlinear Evolutionary Dynamics. Organized by Jia-Yuan Dai, Chih-Chiang Huang and Chang-Hong Wu.
3. NCTS Seminar on Dynamical Systems. Organized by Jung-Chao Ban and Chih-Hung Chang.

2.5 Scientific Computing

2.5.1 Core Members

1. Program Committee Members: Wei-Fan Hu (NCHU), Tsung-Ming Huang (NTNU, committee chair), Matthew M. Lin (NCKU), Ming-Cheng Shiue (NCTU), Suh-Yuh Yang (NCU).

2. Affiliated Faculty Members: Meng-Ho Chen (CCU), Pengwen Chen (NCHU), Ray-Bing Chen (NCKU), Chien-Hong Cho (CCU), Chia-Chieh Jay Chu (NTHU), Feng-Jui Hsieh (NTNU), Po-Wen Hsieh (NCHU), Chieh-Sen Huang (NSYSU), Feng-Nan Hwang (NCU), Yueh-Cheng Kuo (NUK), Ming-Chih Lai (NCTU), Tsung-Lin Lee (NSYSU), Jephian Chin-Hung Lin (NSYSU), Te-Sheng Lin (NCTU), Wen-Wei Lin (NCTU), Ching-Sung Liu (NUK), Ruey-Ling Sheu (NCKU), Yu-Chen Shu (NCKU), Yu-Hau Tseng (NUK), Weichung Wang (NTU), Chin-Tien Wu (NCTU), Mei-Heng Yueh (NTNU).

2.5.2 Program Overview

The NCTS Topical Program Scientific computing is an interdisciplinary filed of study that includes mathematical theories, computational algorithms, and domain knowledge. While pursuing the beauty of mathematics, this field also develops innovative tools to enhance engineering and science. Our research directions are based not only on members' strengths but also on new trends in scientific computations. These directions include matrix computations in the study of Maxwell's equations and discrete Laplacians, numerical PDEs and computational fluid dynamics, mathematical problems in image processing, entanglement qualification, phase retrieval, and artificial intelligence in geometric information and medical image.

2.5.3 Research Highlights

In recent years, the scientific computing groups in NCTS have obtained significant advances in the topics of numerical PDEs for fluid dynamics, matrix computations for nonlinear matrix equations and three-dimensional (3D) Maxwell equations, low rank approximation, volume-measure-preserving optimal mass transportation problems and its application for 3D brain tumor detection and segmentation, high performance computing and image processing. The most significant contributions include the following:

1. Local saddles of relaxed averaged alternating reflections algorithms on phase retrieval, by Peng-Wen Chen:

   We propose an ADMM formulation for one well-known algorithm called relaxed averaged alternating reflections algorithms (RAAR). The penalty is controlled by

the RAAR parameter. Since the objective function is nonconvex, we show the local convergence property via studying the Hessian structure of the objective of ADMM. Some idea in this work is motivated by the discussion with Albert Fannjiang, while he visited Taiwan under the support of NCTS.

2. PDE machine learning, by Wei-Fan Hu:

   (a) Discontinuity capturing shallow neural network
   A new Discontinuity Capturing Shallow Neural Network (DCSNN) for approximating d-dimensional piecewise continuous functions and for solving elliptic interface problems is developed. There are three novel features in the present network; namely, (i) jump discontinuities are accurately captured, (ii) it is completely shallow, comprising only one hidden layer, (iii) it is completely mesh-free for solving partial differential equations. The crucial idea here is that a d-dimensional piecewise continuous function can be extended to a continuous function defined in $(d+1)$-dimensional space, where the augmented coordinate variable labels the pieces of each subdomain. We then construct a shallow neural network to express this new function. Since only one hidden layer is employed, the number of training parameters (weights and biases) scales linearly with the dimension and the neurons used in the hidden layer. For solving elliptic interface problems, the network is trained by minimizing the mean square error loss that consists of the residual of the governing equation, boundary condition, and the interface jump conditions. We perform a series of numerical tests to demonstrate the accuracy of the present network. Our DCSNN model is efficient due to only a moderate number of parameters needed to be trained (a few hundred parameters used throughout all numerical examples), and the results indicate good accuracy. Compared with the results obtained by the traditional grid-based immersed interface method (IIM), which is designed particularly for elliptic interface problems, our network model shows a better accuracy than IIM. We conclude by solving a six-dimensional problem to demonstrate the capability of the present network for high-dimensional applications.

   (b) A shallow physics-informed neural network for solving partial differential equations on surfaces
   We introduce a mesh-free physics-informed neural network for solving partial differential equations on surfaces. Based on the idea of embedding techniques, we write the underlying surface differential equations using conventional Cartesian differential operators. With the aid of level set function, the surface geometrical quantities, such as the normal and mean curvature of the surface, can be computed directly and used in our surface

differential expressions. So instead of imposing the normal extension constraints used in literature, we take the whole Cartesian differential expressions into account in our loss function. Meanwhile, we adopt a completely shallow (one hidden layer) network so the present model is easy to implement and train. We perform a series of numerical experiments on both stationary and time-dependent partial differential equations on complicated surface geometries. The result shows that, with just a few hundred trainable parameters, our network model is able to achieve high predictive accuracy.

3. Nonlinear matrix equations and continuation methods, by Yueh-Cheng Kuo:

   (i). We consider the nonlinear matrix equations (NME) $X + BX^{-1}A = Q$, where A, B, and Q are square matrices. When $B = A^{\top}$, Q is complex symmetric, and the imaginary part of Q is positive definite, the NME has a unique complex symmetric stabilizing solution with a positive definite imaginary part. The assumption is satisfied for some applications including Nano Research and high-speed trains. The stabilizing solution is the solution of practical interest. The research results of this topic include the following:

   - We provide an elementary proof of the existence of the NME and develop an efficient algorithm to compute the stabilizing solution.
   - We constructed a nonlinear differential equation of matrix pairs that are invariant in the class of symplectic matrix pairs. The solution of this nonlinear differential equation passes the iterates generated by the fixed-point iteration, the SDA, and Newton's method with some additional conditions.
   - We solve the NME that arises from the vibration analysis of high-speed trains.
   - We develop a numerical method for computing the symplectic matrix pair (M, L) which represents Hamiltonian matrix exponential.

   (ii). We mainly employ the continuous method to study the solutions of a system of nonlinear equations with parameters. Under the continuous change of the parameter, we investigate the change of the solution by the continuation method. The continuation method has two advantages: 1. It can observe the continuous change of solution by changing the parameter. 2. The unstable solutions can be tracked by the continuation method. Recently, we have had some results including

   - We compute the Z-/H-eigenpairs of nonnegative tensors by continuation methods.
   - Computing the CP decomposition of an unbalanced tensor.

- Find the best rank-1 approximation of nonnegative tensors.

4. Numerical PDEs and computational fluid dynamics, by Ming-Chih Lai:

   Using the developed skew-adjoint property in our previous approach, we have successfully developed a linearly semi-implicit scheme for the inextensible interface with bending in unsteady Stokes flow and proved the scheme is unconditionally energy stable. Based on the unconditionally energy stable scheme, we are able to develop an Immersed Boundary Projection Method (IBPM) to efficiently solve the problem in a fractional-step manner. Both fluid incompressibility and interface inextensibility can be satisfied simultaneously. We adopt spherical harmonic representation for approximating vesicle configuration. By applying spectral differentiation, we are able to obtain high accuracy of geometric quantities such as the mean and Gaussian curvatures, and the surface Laplacian of mean curvature, which is not achievable via triangulation. The vesicle membrane (interface) immersed in 3D Newtonian fluid ensures the surface incompressibility constraint; thus, an unknown elastic tension acting as Lagrange multiplier must be introduced along the interface. We also have coupled different methods such as Grid Based Particle Method (GBPM) and Immersed Interface Method to solve 3D electrohydrodynamic problem. Our results show the coupled method's significant efficacy for simulating 3D interfacial flow problems. Meanwhile, we have developed a novel numerical method that redistributes unevenly given points on an evolving closed curve to satisfy equi-arclength condition. We demonstrate its practical applicability by showing an evolving curve with large deformation in various flows such as mean curvature flow, Willmore flow, and Stokes flow.

5. Entanglement qualification, by Matthew M. Lin:

   Entanglement, a well-discussed physical state, is the most common mode illustrating the coupling or interaction of multiple parts within a system. This mode is then used as a specific tool for setting up quantum communication so that information is transmitted through a "mysterious channel" instantaneously, concurrently, and securely. Separability, a counter phenomenon, is to represent the original complex system in an equivalent but a more manifesting relationship. Since not all quantum states can be separable, the immediate question is to ask whether a given mixed state can be approximated by its nearest separable state. Exactly determining whether a given state is entangled or not is NP-hard. Our work in this part it to characterize this relationship in terms of the Kronecker product over the complex Hilbert spaces so that a low-rank approximation to a mixed state is defined. In calculation, this approximation is hard due to the facts:

   - The added twist caused by the Kronecker product destroys the multi-linearity.

We can hardly apply the conventional alternating least squares techniques to make the approximation.

- We do not know a proper low rank for the approximation for calculating the nearest separable state in advance.
- We have to consider the approximation as optimization of real-valued functions over the complex spaces directly so as to reduce the size of the approximation.

Our major contribution to this study is to propose a dynamical system approach to work on low-rank approximation of entangled systems. This approach has multifold advantages:

- We can describe a gradient dynamics in the complex space in a fairly terse and succinct way.
- We can show that our method is guaranteed to converge globally from any starting point.
- We, in our method, preserve a probability distribution that is embedded in the combination coefficients of pure states.
- We can dynamically adjust the rank while making an approximation.

6. Maxwell's equations for three-dimensional photonic crystals, led by Wen-Wei Lin:

   This topic focuses on studying the eigenstructure of generalized eigenvalue problems (GEPs) arising in the three-dimensional (3D) source-free Maxwell's equations for photonic crystals and bi-anisotropic complex media with 3-by-3 permittivity tensor $\varepsilon > 0$, permeability tensor $\mu > 0$, and scalar magnetoelectric coupling constants $\xi = \bar{\zeta} = \imath\gamma$.

   For the photonic crystals, we propose the Fast Algorithms for Maxwell's Equations (FAME) package for solving Maxwell's equations for modeling three-dimensional photonic crystals. FAME combines the null-space free method with fast Fourier transform (FFT)-based matrix-vector multiplications to solve the generalized eigenvalue problems (GEPs) arising from Yee's discretization. The GEPs are transformed into a null-space free standard eigenvalue problem with a Hermitian positive-definite coefficient matrix. We successfully use FAME on a single P100 GPU to solve a set of GEPs with matrices of dimension more than 19 million, in 127 to 191 seconds per problem. These results demonstrate the potential of our proposed package to enable large-scale numerical simulations for novel physical discoveries and engineering applications of photonic crystals.

   The bi-Lebedev scheme is applied to discretize the Maxwell's equations for the bi-anisotropic complex media. The resulting GEP has eigenvalues appearing in

quadruples $\{\pm\omega, \pm\bar{\omega}\}$. We consider two main scenarios, where $\gamma < \gamma_*$ and $\gamma > \gamma_*$ with γ_* being a critical value. In the former case, all the eigenvalues are real. In the latter case, the GEP has complex eigenvalues, and we particularly focus on the bifurcation of the eigenstructure of the GEPs. Numerical results demonstrate that the newborn ground state has occurred after $\gamma = \tilde{\gamma} > \gamma_*$, and the associated eigenvector has an exotic phenomenon of localization. Moreover, the Poynting vectors of the newborn eigenvector are not only concentrated in the material but also display exciting patterns.

7. Volume-measure-preserving optimal mass transportation problems and its application to 3D brain tumor detection and segmentation, led by Wen-Wei Lin and S.-T. Yau:

   Optimal mass transportation (OMT), designed to move any irregular object without significant distortion, has been widely used in various fields, such as data compression, generative adversarial networks, and image processing. In 2021, we used the projected gradient and homotopy techniques to find a minimum volume-measure-preserving solution for the 3-manifold optimal mass transport problem. The proposed projected gradient method is shown to converge sublinearly at a rate of $\mathcal{O}(1/k)$.

   Furthermore, we used OMT theory to preprocess the irregular 3D brain images in the Brain Tumor Segmentation (BraTS) 2021 dataset. Based on the input format required by the Unet algorithm, using OMT technology to convert irregular 3D brain images into cubes is a new idea for medical imaging research. We developed a cubic volume measurement-preserving OMT (VOMT) model with a density function to achieve this transformation. And the corresponding density function is created by contrast-enhanced histograms of fluid-attenuated inversion recovery (FLAIR) in brain images equalize grayscales. Using these preprocessing OMT tensors, we propose an efficient two-stage residual Unet algorithm for training and validation:

   (a) In Phase I, we used residual Unet to predict the entire tumor (WT) area accurately.

   (b) We expand this predicted WT region by dilation and create a smooth function by convolving the step function associated with the WT region in the brain image with a $5 \times 5 \times 5$ blur tensor to construct a new density function.

   (c) In Phase II, VOMT algorithm with grid refinement and such a new density function is used to construct the new input tensors for the residual Unet algorithm to train Net1-Net3 models.

   Finally, we propose integrated voting post-processing to validate the final labels of brain images.

We randomly selected 1000 and 251 brain samples from the BraTS 2021 training dataset, including 1251 samples for training. The Net1-Net3 calculated Dice scores for the WT, tumor core (TC), and enhancing tumor (ET) regions and the validation were 0.93705, 0.90617, and 0.87470, respectively, which are significant improvements in brain tumor detection and segmentation with higher accuracy.

8. Analysis and computation of the geophysical fluid dynamics, by Ming-Cheng Shiue

   (a) Data assimilation algorithms based on the synchronization of nudging techniques.
   We study the analysis and computation of the data assimilation algorithm applied to geophysical fluid dynamics.

   (b) Long time stable numerical schemes and time periodic solutions.
   We consider a semi-discretized Euler scheme to solve the three-dimensional viscous primitive equations. Based on suitable assumptions on the initial data and forcing terms, the long-time stability of the proposed scheme is proven by showing that the H1 norm (in space variables) of the solutions is bounded at each time step when the time step satisfies certain smallness condition. This result matches the continuous case. Meanwhile, we consider several models including Primitive equations of large-scale ocean, atmosphere with moisture and two-dimensional Navier-Stokes equations with time-periodic forcing terms. The asymptotic stability criterion and the existence of the solution are proven under the smallness assumption on the nontrivial forcing terms.

   (c) Porous media flow modelled by Navier-Stokes equations coupling with Darcy flow.
   We performed numerical analysis of MAC scheme for Stokes and Darcy coupling flows and also gave a simple projection method for Navier-Stokes and Darcy coupling flow with curvy interface.

9. Numerical methods for simulating fluid-structure interaction and mathematical problems in image processing, by Suh-Yuh Yang:

   (a) We have continued to study the direct-forcing immersed boundary method for fluid-solid interaction problems. The method is based on the introduction of a virtual force. At first, the solid object region is regarded as made of fluid. Then we introduce a virtual force distributed only on that region that enforces it to behave like a real solid body with prescribed velocity. The most advantageous feature of the method is that it is conceptually simple

and relatively easy to implement without involving any discrete Dirac delta functions or post interpolations for accuracy like most immersed boundary methods in the literature. In our recent work [Advances in Applied Mathematics and Mechanics, accepted, 2021/11], we have further developed the method for simulating the dynamics in thermal fluid-solid interaction problems. We have introduced a virtual heat source inside the solid region near the boundary, which is added to the energy transport equation to impose the thermal boundary condition on the solid boundary. We have performed a series of numerical experiments to demonstrate the high performance of the method.

(b) We have proposed a novel adaptive variational model for contrast enhancement for partially shaded low-light images in the paper [SIAM Journal on Imaging Sciences, 13 (2020), pp. 1-28.]. The primary purpose of image contrast enhancement is to adjust the image intensity to enhance the quality and features of the image. The key idea of this adaptive approach is to employ the maximum image of the color RGB channels as a classifier to divide the image domain into relatively bright and dim parts. Then different fitting terms are used for each part. The proposed model considerably improves the existing variational models in the literature. In this work, we have conducted a number of numerical experiments and comparisons with other popular enhancement methods to demonstrate the high performance of the newly proposed method. In addition, we have established the existence and uniqueness of a minimizer for the variational minimization problem.

2.5.4 Highlights of Events

1. NCTS Winter Course: Parallel Finite Element Method using Supercomputer
   9:10 - 17:00 on February 10, 11, 12, 19, 20, 2022
   Cisco Webex, Online seminar
   Speaker: Kengo Nakajima (The University of Tokyo)

2. Taiwan Mathematics School: Machine Learning for PDEs
   14:00-17:00, every Friday, February 18 - March 25, 2022
   Cisco Webex, Online Course
   Speaker:
   Wei-Fan Hu (National Central University)
   Ming-Cheng Shiue (National Yang Ming Chiao Tung University)

3. NCTS Student Mini-Symposium in Applied Mathematics, January 20, 2022
   This mini-symposium aims at allowing students to present their works on ap-

plied mathematics and to exchange their ideas, thereby promoting their interest in applied mathematics. The topics include deep learning with application to license plate recognition, supervised dimensionality reduction, chemical master equations with application to gene regulation networks, image compression, periodic orbit via continuation methods, and so on.

4. 2022 NCTS Math-Phys Joint Workshop on Machine Learning, March 5, 2022, R202, Astronomy-Mathematics Building, NTU
   The purpose of this workshop is to foster interactions of experts from mathematics and physics on these interdisciplinary topics, especially in the fields of machine learning and related ones. In particular, invited scholars not only present their research but also share their experiences that will inspire more collaboration and interaction between mathematics and physics.

5. 2022 Conference on Advanced Topics and Auto Tuning in High-Performance Scientific Computing, March 29 - 30, 2022, Meeting Room 301, Department of Mathematics, NCKU
   The conference on advanced topics and auto tuning in high-performance scientific computing focuses on solving the scientific impacts of the latest computer architectures and providing high-performance computing approaches on these leading-edge computers. Advances in many-core architectures and high-end computers have unveiled their significance in scientific discoveries and engineering achievements. However, the complexity of these newly developed computers also leads to contemporary challenges of achieving the best efficiency of the highly promising computational capabilities. The conference encourages interdisciplinary communications between researchers from applied mathematics, statistics, computer science, physical sciences, engineering, and industry to prompt innovations and breakthroughs in this exciting field. The main themes include, but are not limited to, simulations, numerical methods, applications, hardware, and particularly software and algorithm auto-tuning via statistical methods.

6. Opportunities and Challenges in Numerical Algebra (9)-(12), 2022, 4/9, 5/8, 5/28, 6/5 (online workshop)
   Numerical algebra has played a pivotal role as the pillar of scientific computing for decades. Theories and numerical techniques for its core problems, including linear systems, least-squares problems, and eigenvalue problems, are taken very much for granted and used widely in science and engineering. Today, numerical algebra sits at the crossroad of reinventing itself to adapt to a rapidly changing landscape because of the emergence of data science and artificial intelligence. Since January 2021, we have successfully held eight series of online workshops on opportunities and challenges in numerical algebra. The original core mission

remains the same. Thus, they help promote multidisciplinary interconnection and interaction between numerical algebra and other fields, such as optimization and data science, to give new theories, methods, and algorithms for solving scientific computing problems.

7. 2022 NCTS Student Workshop on Scientific Computing, April 29, 2022, Online Conference
   The purpose of the workshop is to bring young researchers and graduate students in the field of scientific computing and related disciplines together to introduce and share their current works and findings.

8. 2022 NCTS South-Taiwan Workshop on Scientific Computations, Differential Equations and Application, August 17 - 18, 2022, A16-808, College of Sciences and Engineering Hall, Lantan Campus, NCYU
   This workshop includes two 65-minute and eight 35-minute presentations. This workshop series has been held since 2010. The aim of this annual workshop is to bring together active researchers in south Taiwan from various fields of scientific computation and differential equations, to discuss recent and prospective advances in research.

9. 2022 NCTS Workshop on Computational Mathematics and Scientific Computing for Young Researchers, August 26 - 27, 2022, Room 3174, Department of Mathematics, NCKU
   This workshop gives researchers an opportunity to share their work and interests in computational mathematics and related topics. We invite senior researchers to share their experiences and insights toward new methodologies and technologies. In particular, we hope to build a platform for mutual collaboration and interaction among senior and junior researchers.

2.5.5 Future plans

1. NCTS/NCU Seminar on Computational Optimization with Applications
   Organizer: Suh-Yuh Yang (NCU)
   Time: This seminar will be held bi-weekly on Monday, 03:00-05:00 pm
   Venue: Room 430, Hong-Jing Hall, NCU
   Theme: We will study some essential topics in computational optimization, with applications in image processing and data science. The techniques include robust PCA, low-rank representation, sparse representation, and dictionary learning. We will also explore fast and efficient global registration, convex relaxation techniques, etc.

2. Seminar on Ice sheet dynamics, Organizer: Ming- Cheng Shiue

3. Workshop on Numerical Algebra and Applications, 2023, February, 11–12

4. 2023 NCTS South-Taiwan Workshop on Scientific Computations, Differential Equations and Application

5. 2023 Conference on Advanced Topics and Auto Tuning in High-Performance Scientific Computing

6. 2023 NCTS Student Workshop on Scientific Computing

7. Short course on Scientific Deep Learning, 2023, July 3–14, Tan Bui-Thanh (University of Texas at Austin)

8. 2023 NCTS Workshop on Computational Mathematics and Scientific Computing for Young Researchers

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2.6 Interdisciplinary Studies

2.6.1 Core Members

1. Program Committee Members: Shun-Jen Cheng (AS), Yng-Ing Lee (NTU), Te-Sheng Lin (NYCU), Je-Chiang Tsai (NTHU, committee chair), and Hau-Tieng Wu (Duke).

2. Affiliated Faculty Members: Jein-Shan Chen (NTNU), Ray-Bing Chen (NCKU), Chang-Yuan Cheng (NPTU), Chia-Chieh Jay Chu (NTHU), Mei-Hui Guo (NSYSU), Tzyy-Leng Horng (FCU), Chih-Hao Hsieh (NTU), Chao-Ping Hsu (AS), Tai-Chia Lin (NTU), Yu-Lun Lo (CGMH), Hung-Chi Kuo (NTU), Chi-Jen Wang (CCU), Feng-Bin Wang (CGU), Weichung Wang (NTU), Tsung-Fang Wu (NUK).

3. Postdoctoral Fellows: Chun-Wei Chang (NCTS).

2.6.2 Program Overview

The purpose of the interdisciplinary studies program at NCTS is to assist domestic mathematicians whose research expertise is a combination of mathematics and different academic disciplines to develop scientific topics, which in turn stimulate the birth of new mathematical theories or problems. Our research topics are motivated by various scientific processes and phenomena. In the past year, our members focus on the following areas:

1. Mathematical ecology.

2. Mathematical modeling and analysis of ion channels.

3. Mathematical modeling on fluid dynamics.

4. Medical signal processing.

5. Gene network systems.

6. Optimization and big data.

7. Time series analysis for nonlinear dynamical systems.

2.6.3 Research Highlights

Below are some of the highlights and breakthroughs of our members' works in the past year.

1. Anticipating the occurrence and type of critical transitions (bifurcation) in natural dynamical systems, *by C.-W. Chang and C.-H. Hsieh*.

   Critical transition can occur in many real-world systems. The ability to forecast the occurrence of transition is of major interest in a variety of different contexts. Various early warning signals (EWS) have been developed to anticipate the coming critical transition or to distinguish types of transition. However, no effective method allows to establish a practical threshold indicating the condition when the critical transition is most likely to occur. Here, we introduce a powerful EWS, named Dynamical Eigen-Value (DEV), that is rooted in the bifurcation theory of dynamical systems to estimate the dominant eigenvalue of the system. Theoretically, the absolute value of DEV approaches one when the system approaches bifurcation, while its position in the complex plane indicates the type of transition. We demonstrate the efficacy of the DEV approach in model systems with known bifurcation types and in addition, we test the DEV approach on various critical transitions in real-world systems.

   In conclusion, the DEV approach developed in this study, for the first time, proposes an empirical EWS with the quantitative threshold to anticipate the occurrence of critical transition and simultaneously identify the type of bifurcation. Although the efficacy of DEV is likely undermined by measurement and process noises, the DEV has great potential to effectively anticipate the occurrence and type of critical transition with a more precautionary defined threshold. Because both occurrence condition and bifurcation type can be unambiguously revealed, this approach potentially brings great value to real-world management, making timely and effective responses when facing the coming of new regimes. The work is now under revision in Science Advances.

2. Reconstructing large interaction networks from empirical time series data, *by C.-W. Chang and C.-H. Hsieh*.

   We developed a novel method to reconstruct large interaction networks using empirical time series data. Our study [1] overcomes the long-lasting challenge of reconstructing high-dimensional interaction networks in natural environments based on empirical observations. The proposed method provides a powerful tool to investigate natural time-varying interaction networks composed of a large number of interacting components.

   Most of the ecological networks, such as food webs, mutualistic, and competition networks, are high-dimensional and composed of numerous time-varying

interactions among a large number of biological species, especially in those systems with high biodiversity (e.g., microbial communities, coral reefs, and rain forests). It is well-known that detailed information of network structure is needed to evaluate dynamic stability and resilience of natural systems. However, existing approaches for network construction are only applicable to small networks. Here, the research team developed a novel analytical method, multiview distance regularized S-map (MDR S-map), that overcomes "Curse of dimensionality" and reconstructs large interaction networks with time-varying interaction strengths, using time series data alone. The reconstructed networks faithfully preserved various key network properties, such as distribution of interaction strength, node centrality, and dynamical stability in numerous model systems. Applying the approach to natural bacterial communities (with 135 dominant species) tracked the temporal variations of key network topological properties and identified the most influential bacterial species occupying central positions in the network.

3. Impacts of Drugs Abuse on HIV Dynamics, *by C.-Y. Cheng and F.-B. Wang*.

   Drugs of abuse, such as opiates, have been widely associated with diminishing host-immune responses, including suppression of HIV-specific antibody responses. In particular, periodic intake of the drugs of abuse can result in time-varying periodic antibody levels within HIV-infected individuals, consequently altering the HIV dynamics. In [2], we develop a mathematical model to analyze the effects of the periodic intake of morphine, a widely used opiate. We consider two routes of morphine intake, namely, intravenous morphine (IVM) and slow-release oral morphine (SROM), and integrate several morphine pharmacodynamic parameters into HIV dynamics model. Using our non-autonomous model system we formulate the infection threshold for global stability of infection-free equilibrium, which provides a condition for avoiding viral infection in a host. We demonstrate that the infection threshold highly depends on the morphine pharmacodynamic parameters. Such information can be useful in the design of antibody-based vaccines. In addition, we also thoroughly evaluate how alteration of the antibody level due to periodic intake of morphine can affect the viral load and the CD4 count in HIV infected drug abusers. Motivated by [3], we further investigate a reaction-diffusion HIV model with spatial variations and the intracellular delay in [4], which describes the replication time between viral entry into a target cell and the production of new viruses by the infected cell.

4. Effects of age of infection, vaccination, quarantine and asymptomatic transmission on epidemiological dynamics, *by C.-Y. Cheng and F.-B. Wang*.

   We used the SVIRS model as our baseline in [5], to further classify infected individuals into classes according to them being symptomatic/asymptomatic and

quarantined/non-quarantined. The age at infection is also relevant to describe the population dynamics by detailed features, among which, the age-specific quarantine rate poses some mathematical challenges since the possibility of an infected individual being quarantined exists at any age of infection. We provided the model's well-posedness property by estimating some inequalities related to the specific age structure and formulated the basic reproduction number to determine whether the disease dies out or persists. Moreover, we demonstrated how backward bifurcation occurs in the proposed model under a complicated criterion and explored it to observe the effects of certain parameters on the dynamics. For example, it reveals a reason for the dynamics of backward bifurcation by distinguishing between symptomatic and asymptomatic classes. We also investigated the global convergence to an endemic equilibrium and obtained particular insights. In addition, the issues of multiple-strain virus and network-structured community were further explored in [5], and we found that two strains can coexist in the complicated community.

5. A neural network based on the metric projector for solving SOCCVI problem, *by J.-S. Chen*

   We propose an efficient neural network for solving the second-order cone constrained variational inequality (SOCCVI) [7]. The network is constructed using the Karush-Kuhn-Tucker (KKT) conditions of the variational inequality (VI), which is used to recast the SOCCVI as a system of equations by using a smoothing function for the metric projection mapping to deal with the complementarity condition. Aside from standard stability results, we explore second-order sufficient conditions to obtain exponential stability. Especially, we prove the nonsingularity of the Jacobian of the KKT system based on the second-order sufficient condition and constraint nondegeneracy. Finally, we present some numerical experiments, illustrating the efficiency of the neural network in solving SOCCVI problems. Our numerical simulations reveal that, in general, the new neural network is more dominant than all other neural networks in the SOCCVI literature.

6. Modeling K^+ permeation through the KcsA channel, *by T.-L. Horng.*

   Prof. Luigi Catacuzzeno (from Department of Chemistry, Biology and Biotechnology, University of Perugia, Perugia, Italy) visited NCTS in January 2020 for two weeks by the invitation of Prof. Tzyy-Leng Horng and Prof. Tai-Chia Lin. During his visit, Prof. Catacuzzeno participated in the NCTS workshop on analysis and its applications in biology and physiology and gave a talk with the title "A water free stable configuration of the KcsA selectivity filter suggested by molecular dynamics simulations". This subject coincides with Prof. Horng's long-term study on the permeation of KcsA potassium channel and immediately prompted a research collaboration between Prof. Horng and Prof. Catacuzzeno.

After two and half years' effort, their joint work [8] was published in July 2022. This joint paper combines continuum model, MD and kinetic model to form a multi-scale approach that can calculate the IV curve of KcsA channel. The computational result has an unprecedented good agreement with experiments. The continuum model applied here is Bikerman-Poisson-Boltzmann model which includes the steric effect into classical Poisson-Boltzmann model by adding the entropy of solvent into energy functional. This model is successful in predicting the distribution of potassium ion inside the channel at equilibrium, especially in the region of selectivity filter which is extremely narrow (3-4 Angstrom wide only). The predicted distribution from continuum model surprisingly agrees very well with atomic MD simulation. Based on this equilibrium result, a chemical reaction kinetic model is further constructed to calculate the IV curve.

7. Classification using mass spectrometry combined with machine learning, *by T.-S. Lin.*

   The use of machine learning techniques such as deep neural networks to solve classification problems has attracted a lot of attention in recent years. In this project, we collaborate with Prof. Yu-Chie Chen from the Department of Applied Chemistry, National Yang Ming Chiao Tung University, aiming to classify beans. We use the ambient ionization mass spectrometry (MS) to extract the mass spectra from a single bean. The resultant mass spectra can then be used to classify beans one by one. Based on the Universal Approximation Theorem of Cybenko [9], we know that classification can be achieved using a single-layer neural network. Therefore, to accelerate the classification, neural network-based machine learning was used to classify beans. For the trained network model, we use the deep SHAP (SHapley Additive exPlanations) method to find important features to explain the classification strategy of the network.

8. On the transition to dripping of an inverted liquid film, *by T.-S. Lin.*

   In joint work with M. G. Blyth and D. T. Tseluiko [10], we study the transition to dripping in the gravity-driven flow of a liquid film under an inclined plate at zero Reynolds number. We use a hierarchy of models including two lubrication models that incorporate the effects of linearized curvature and full curvature, and the full equations of Stokes flow. Of particular interest is the breakdown of travelling-wave solutions as the plate inclination angle is increased toward the fully inverted state. It was found that, for sufficiently small volume, solutions attain a weak Young-Laplace equilibrium profile and the approach to which was described by asymptotic analysis. For volume beyond a certain limit, the bifurcation curves have a turning point so that the fully inverted state is never reached. On the other hand, for a fixed flow rate, the bifurcation curve either has a turning point or else reaches a point at which the surface profile has an infinite slope

singularity, indicating the onset of multi-valuedness. The latter is confirmed by the Stokes model which can be continued to obtain overturning surface profiles.

9. Epigenetic control of microRNA via target-translated protein in a ceRNA network, *by J.-C. Tsai*

   MicroRNAs (miRNAs) play an important role in gene regulation by degradation or translational inhibition of the targeted mRNAs. It has been experimentally shown that the way miRNAs interact with their targets can be used to explain the indirect interactions among their targets, i.e., competing endogenous RNA (ceRNA). However, whether the protein translated from the targeted mRNAs can play any role in this ceRNA network has not been explored. Here we propose a deterministic model to demonstrate that in a network of one miRNA interacting with multiple targeted mRNAs, the competition between miRNA-targeted mRNAs is not sufficient for the significant change of those targeted mRNA levels, while dramatic changes of these miRNA-targeted mRNAs require transcriptional inhibition of miRNA by its target proteins. When applied to estrogen receptor signaling pathway, the miR-193a targets E2F6 (a target of estrogen receptor), c-KIT (a marker for cancer stemness), and PBX1 (a transcriptional activator for immunosuppressive cytokine, IL-10) in the ovarian cancer. Epigenetic silencing of miR-193a by E2F6 protein is required for the significant change of c-KIT and PBX1 mRNA level for cancer stemness and immunoevasion, respectively, in ovarian cancer carcinogenesis [11].

10. Formation of intercalated Cu carpets on MoS2, *by C.-J. Wang.*

    We model and use the calculations of first-principles density functional theory to interpret the observed formation of Cu carpets intercalated under the top layer of a 2H-MoS2 substrate [12]. In addition, Cu pyramids on the upper surface of a 2H-MoS2 substrate transport to the growing Cu carpet through surface point defects. We demonstrate that the competition between a preference for a thicker Cu carpet and the cost of elastic stretching of the top MoS2 layer results in a selected Cu carpet thickness. Moreover, we propose that Cu transport occurs primarily via vacancy-mediated diffusion through point defects.

11. Medical signal processing, *by H.-T. Wu.*

    The developed algorithm for analyzing multimodal and heterogeneous nonstationary long-term and high frequency biomedical signals is based on the unsupervised learning algorithm, diffusion maps, which we call the ”dynamic diffusion map (DDmap)”, and S+F operators. The S+F approach is the first existing algorithm to our knowledge that can handle time-varying manifold valued spatiotemporal datasets. It is applied to electrocardiogram and arterial blood

pressure signal analysis and its application to the liver transplant surgery (a collaboration with physicians from Veteran General Hospital Taipei) is very encouraging. Its application to other clinical problems is currently under exploration. Two theoretical papers about how the scattering transform functions on random process have been published in the top-tier journals with Professor Gi-Ren Liu from NCKU and Professor Yuan-Chun Sheu from NYCU.

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2.6.4 Highlights of Events

We run this program through regular seminars and summer courses, as well as workshops and conferences. We briefly describe them below.

Seminars

1. NCTS seminar on gene network analysis.
   Organizers: M. Chan & J.-C Tsai.

2. NCTS seminar on mathematical biology.
   Organizers: C.-Y. Cheng & F.-B. Wang.

3. NCTS seminar on optimization.
   Organizer: J.-S. Chen.

Lectures and Courses

1. Taiwan Mathematics School: Continuation method: theory and application, Fall, 2021
   Organizers: C.-C. Chu, Y.-C. Kuo, T.-S. Lin, and J.-C. Tsai.

2. NCTS summer course on mathematical biology, Aug. 1-5, 2022
   Organizers: C.-Y. Cheng and F.-B. Wang.

3. NCTS Phys-Math joint summer school on quantum information science, Aug. 22-24, 2022
   Organizers: M.-L. Hsieh, H.-S. Goan and J.-W. Chen.

Conferences and Workshops

1. Machine learning on solving partial differential equations, Sep. 2, 2021.
   Organizers: Y.-I. Lee and T.-S. Lin.

2. Interfacing mathematics and physical sciences through machine learning, mathematicians and statisticians, Sep, 4, 2021.
   Organizers: M.-L. Hsieh, W.-H. Hwang, Y.-J. Kao, and W. Wang.

3. NCTS student mini-symposium in applied mathematics, Jan. 20, 2022.
   Organizers: C.-C. Chu, Y.-C. Kuo, T.-S. Lin, S.-F. Shieh, and J.-C. Tsai.

4. Meet physicians, mathematicians and statistcians, part 3, June. 18, 2022.
   Organizers: Hau-Tieng Wu.

2.6.5 Future Plans

In the upcoming year, we will organize one symposium and one workshop. The first one is the mini-symposium which aims at allowing undergraduate students to present their works on applied mathematics and exchange their ideas, thereby promoting their interest in applied mathematics. Such activity was held in the past year and gained great success. In fact, some undergraduate students got ideas from the symposium and converted these ideas into NSTC undergraduate student projects. The second one is an international workshop on molecular dynamics and its application to physiology. This activity has been held regularly for several years and promotes some of the local interdisciplinary research topics. Due to the pandemic, it was canceled in the past two years. As the epidemic is slowing down, we hope that we can host this workshop this coming academic year. Finally, motivated by the success of the previous three meetings in the past years, we will gather physicians and mathematicians/statisticians who have common interest in biomedical signal processing for an interdisciplinary discussion. Several brief research talks will be given to introduce participants how math can help, and what new opportunities can be found from modern medicine. Topics range

from the photoplethysmogram and electroencephalogram signal analysis by modern manifold learning, time frequency analysis for sleep stage prediction, and a mathematical exploration of novel time frequency analysis tool motivated by the challenge inherited in the non contact sensor for digital medicine.

Below is the list of the scheduled workshops, seminars, and short courses.

Conferences and workshops:

1. NCTS student mini-symposium in applied mathematics
   Organizers: C.-C. Chu, Y.-C. Kuo, T.-S. Lin, S.-F. Shieh, and J.-C. Tsai.

2. NCTS workshop on molecular biology: modeling and analysis.
   Organizers: T.-L. Horng ,T.-C. Lin, and J.-C. Tsai.

3. Meet physicians, mathematicians and statisticians.
   Organizer: H.-T. Wu.

Seminars

1. NCTS seminar on gene network analysis.
   Organizer: J.-C Tsai.

2. NCTS seminar on mathematical biology.
   Organizers: C.-Y. Cheng and F.-B. Wang.

3. NCTS seminar on optimization.
   Organizer: J.-S. Chen.

Courses and lectures:

1. NCTS summer course on mathematical biology.
   Organizers: C.-Y. Cheng and F.-B. Wang.

2. NCTS summer course on medical signal processing.
   Organizers: Ronen Talmon (Technion, Israel), Zhou Zhou (U of Toronto, Canada), Lek-Heng Lim (U of Chicago, USA), and H.-T. Wu.

3 Host University Commitment

The commitment of the host institution, the National Taiwan University, consists of the following: budget, space, and logistic support. Overall, the host institution has been very supportive. Below we will focus on the part of its commitment regarding space and other logistic supports.

3.1 Space of NCTS

The Center moved to the newly-built Cosmology Building in October of 2020. The space in the new building is very nice and pleasant. According to the commitment of the host university, where the official document is attached in the following pages, NTU provides 200 ping in Cosmology Building free of charge for the Center to use. The Center also rents extra space in the building at a special and guaranteed rate. Space in parts of the second and third floor of the New Mathematics Building is also provided free of charge for the Center to use. Because it is an old building, the condition there is not perfect. We have made substantial efforts to improve the conditions in the building, and have converted some of the space there to offices for participants of USRP this summer. These offices are also suitable for hosting visitors and conference participants. We also use some space on the fourth floor of the Astronomy-Mathematics Building provided by the Department of Mathematics, which includes one lecture room for classes/talks and two offices for the NCTS research assistants. Because we managed to relocate the NCTS research assistants in the Cosmology Building after August, the two offices have been returned to the Department of Mathematics. A possible donation of a new building that the NCTS Mathematics division can partially use is currently under discussion. If things work out well, the building is expected to be completed in 2027. In this case, we will have a bigger and more unified space and will not need to pay for rents any more.

3.2 Logistic support of NTU

The logistic support of the NTU in recent years has been outstanding. Whenever needed, it is easy to make appointments to discuss directly with administrative officers including the President, Vice Presidents, Provost, Dean of Research and Development, Dean of General Affairs, etc. In addition to the items mentioned in the official document of commitment, Taiwan Mathematics School (TMS) also has been greatly supported by NTU. The Center can offer courses with credits, and allow students from the cooperative universities or cooperative departments of the NCTS to take the courses.

申請機構配合事項同意書

計畫名稱：國家理論科學研究中心第五階段運作計畫(2021.1.1-2025.12.31)

計畫主持人姓名/職稱：李百祺/教授

申請機構配合措施：本計畫業經單位內部審查，同意提供下列配合事項。

一、 配合款：本機構同意提供科技部核定經費之40%為配合款，於執行期間優先使用於計畫所需各項經費（含中心人員薪資、學術活動費用、使用空間的場租、軟硬體設備、裝修維護費、水電雜支等等）。本計畫執行期滿後，收支報告表內需詳細註明配合款支用情形。

二、 員額：

(1) 提供數學組、物理組至少各10名博士後研究員名額，以招募優秀年輕研究人員。(於配合款中編列相關薪資)

(2)中心主任與執行主任因推動中心業務，得依本校「專任教師授課時數減免要點」相關規定申請減免授課時數。

三、 管理費：依本校「建教合作計畫管理費分配處理細則」辦理，以科技部計畫15%管理費計，如不分配至計畫主持人所屬學院(須先與學院議定)，則分配至校級中心之管理費約32%。

四、 結餘款：依本校「建教合作計劃結餘款分配、運用及管理要點」辦理，依當年度結餘款總額扣除個別使用款項後之餘額結算。

五、 空間：

(1)數學組使用現況及規劃：

專屬空間共約 549 坪

次震宇宙館(數學組)	4樓(200坪)及5樓無償使用空間	辦公室、小型會議室與研究室。
	租用空間 (數學組另行租借246.51坪)	中心行政區，小型研討室(30人)及大型研討室(120人)各1間，4間訪問學者辦公室與交誼區；走道公共空間設有沙發及茶水區，為公告區及休息討論區。辦公室、小型會議室與研究室。
數學研究中心	2樓(約66坪)	5間辦公室(供博士後研究員使用)及休息區
	3樓(約36坪)	6間訪問學者辦公室。

(2)物理組使用現況及規劃：

專屬空間共約 501 坪

次震宇宙館(物理組)	4 樓(200 坪)	11 間辦公室、小型研討室(25 人)及大型研討室（100 人）各一間，設有開放式討論空間、休息討論區、茶水區。
	租用空間(物理組另行租借 246.51 坪)	中型討論室 3 間(50 人)、小型討論室 2 間(25 人)，12 間訪客辦公室，另設有茶水區、休息討論區與公告區。
物理系	8 樓(約 54 坪)	2 間辦公室(供博士後研究員與研究生使用)、小型研討室。

(3)於次震宇宙館無償使用空間之水電費，比照校內教學單位之收費標準收費；借用研究計畫辦公室之水電費，依研究計畫辦公室收費標準計收。

(4)本期執行期間得優先租用次震宇宙館之空間，其租金不高於現行之標準。

六、 其它相關配合措施：請詳細說明所提供之各項設備、學人宿舍、裝修維護費、水電雜支、停車、行政支援...等：

(1)依本校相關規定提供客座學人宿舍給國內、外長期訪問學者。

(2)國內、外學生至中心訪問期間，得依本校相關規定申請本校學生宿舍。

(3)提供一個月(含)以上中心訪客使用本校體育健身設施收費優惠。

(4)提供參加中心活動的成員停車費優惠。

此致

科技部

申請機構首長（簽章）：

學校用印：

中 華 民 國 109 年 6 月 9 日

4 Appendix

Throughout this Appendix, the following abbreviations are used for the Topical Programs:

- A = Number Theory and Representation Theory
- B=Algebraic Geometry
- C=Differential Geometry and Geometric Analysis
- D=Differential Equation and Stochastic Analysis
- E=Scientific Computing
- F=Interdisciplinary Studies

4.1 List of Workshops and Conferences

Workshop Title	Date	Venue	Organizers	Group
2022 NCTS Number Theory Day	2022/02/08-2022/02/09	NTU	Chieh-Yu Chang (NTHU) Fu-Tsun Wei NTHU) Yifan Yang (NTU)	A
NCTS Workshop on Function Field Arithmetic	2022/09/21-2022/09/22	Online	Chieh-Yu Chang (NTHU) Fu-Tsun Wei (NTHU)	A
The 8th (2022) NCTS -- POSTECH PMI Joint Workshop on Number Theory	2022/12/28-2022/12/30	NCTS+ Online	Sungmun Cho (POSTECH) YoungJu Choie (POSTECH) Chia-Fu Yu (AS)	A
The 22nd Taiwan Geometry Symposium	2022/04/23	NCKU	River Chiang (NCKU) Nan-Kuo Ho (NTHU) Chung-Jun Tsai (NTU) Mao-Pei Tsui (NTU) Ye-Kai Wang (NCKU)	C
2022 NCTS Workshop on Mathematical General Relativity	2022/08/08	NCTS+ Online	Chung-Jun Tsai (NTU) Mao-Pei Tsui (NTU) Mu-Tao Wang (Columbia U)	C
2022 NCTS Young Dynamics Day	2022/2/18	Online	Jiunn-Wei Chen(NTU) Pochung Chen (NTHU) Dimitrios Giataganas (NSYSU) Wei-Fan Hu (NCU) Tsung-Ming Huang (NTNU) Ming-Cheng Shiue(NYCU) Weichung Wang (NTU)	D
The 12th Japan-Taiwan Joint Workshop for Young Scholars in Applied Mathematics	2022/02/28-2022/03/01	Online	Chueh-Hsin Chang (THU) Chiun-Chuan Chen (NTU) Yan-Yu Chen (NTU) Jann-Long Chern (NTNU) Yung-fu Fang (NCKU) Chang-Hong Wu (NYCU)	D
2022 NCTS Workshop on Dynamical Systems	2022/05/26-2022/05/28	NCTS+ Online	Jung-Chao Ban (NCCU) Chih-Hung Chang (NUK) Kuo-Chang Chen (NTHU) Cheng-Hsiung Hsu (NCU)	D
Fourth NCTS PDE Symposium	2022/8/31	NTHU	Chun-Hsiung Hsia (NTU) Jin-Cheng Jiang (NTHU) Kung-Chien Wu (NCKU)	D
2022 The Winter Workshop on the Probability and Related Fields	2022/11/19	NCTS	Jyy-I Hong (NCCU) Gi-Ren Liu (NCKU)	D
NCTS Conference on Fractional Integrals and related phenomena in Analysis	2022/12/19-2022/12/23	NCTS+ Online	Chun-Yen Shen (NTU) Daniel Eli Spector (NTNU) Cody Stockdale (Clemson U)	D
2022 NCTS Math-Phys Joint Workshop on Machine Learning	2022/03/05	NCTS	Jiunn-Wei Chen (NTU) Pochung Chen (NTHU) Dimitrios Giataganas (NSYSU) Wei-Fan Hu (NCU) Tsung-Ming Huang (NTNU) Ming-Cheng Shiue (NYCU) Weichung Wang (NTU)	E

Workshop Title	Date	Venue	Organizers	Group
2022 Conference on Advanced Topics and Auto Tuning in High-Performance Scientific Computing	2022/03/29-2022/03/30	NCKU	Ray-Bing Chen (NCKU) Min-Hung Chen (NCKU) Takahiro Katagiri (Nagoya U) Matthew M. Lin (NCKU) Yu-Yu Liu (NCKU) Yu-Chen Shu (NCKU) Reiji Suda (The UoT) Chern-Shuh Wang (NCKU)	E
Opportunities and Challenges in Numerical Algebra (9)	2022/04/09	Online	Tsung-Ming Huang (NTNU) Ren-Cang Li (UT Arlington) Tiexiang Li (SEU) Linzhang Lu (XMU) Xiang Wang (NCU, CN)	E
2022 NCTS Student Workshop on Scientific Computing	2022/04/29	Online	Wen-Lin Chiou (FJU) Wei-Fan Hu (NCU) Tsung-Ming Huang (NTNU) Yung-Ta Li (FJU) Matthew M. Lin (NCKU) Ming-Cheng Shiue (NYCU) Weichung Wang (NTU) Suh-Yuh Yang (NCU)	E
Opportunities and Challenges in Numerical Algebra (10)	2022/05/08	Online	Tsung-Ming Huang (NTNU) Ren-Cang Li (UT Arlington) Tiexiang Li (SEU) Linzhang Lu (XMU) Xiang Wang (NCU, CN)	E
Opportunities and Challenges in Numerical Algebra (11)	2022/05/28	Online	Tsung-Ming Huang (NTNU) Ren-Cang Li (UT Arlington) Tiexiang Li (SEU) Linzhang Lu (XMU) Xiang Wang (NCU, CN)	E
Opportunities and Challenges in Numerical Algebra (12)	2022/06/25	Online	Tsung-Ming Huang (NTNU) Ren-Cang Li (UT Arlington) Tiexiang Li (SEU) Linzhang Lu (XMU) Xiang Wang (NCU)	E
2022 NCTS South-Taiwan Workshop on Scientific Computations, Differential Equations and Application	2022/08/17-2022/08/18	NCYU	Chun-Yueh Chiang (NFU) Chen-Chang Peng (NCYU) Chern-Shuh Wang (NCKU)	E
2022 NCTS Workshop on Computational Mathematics and Scientific Computing for Young Researchers	2022/08/26-2022/08/27	NCKU	Wei-Fan Hu (NCU) Tsung-Ming Huang NTNU) Matthew M. Lin (NCKU) Ming-Cheng Shiue (NYCU) Suh-Yuh Yang (NCU)	E

Workshop Title	Date	Venue	Organizers	Group
NCTS Student Mini-Symposium in Applied Mathematics	2022/1/20	Online	Chia-Chieh Jay Chu (NTHU) Yueh-Cheng Kuo (NUK) Te-Sheng Lin (NCTU) Shih-Feng Shieh (NTNU) Je-Chiang Tsai (NTHU)	F
Meet physicians, mathematicians and statisticians, part 3	2022/6/18	NCTS	Yu-Ting Lin (VGHTPE) Hau-Tieng Wu (Duke U)	F
URP/RA Winter Research Report	2022/02/10	NCTS+ Online	Yuan-Chung Sheu (NYCU)	Others
2022 NCTS Spring Day	2022/03/21	NCTS	Yng-Ing Lee (NTU)	Others
URP/RA Summer Research Report	2022/06/27	NCTS+ Online	Yuan-Chung Sheu (NYCU)	Others

4.2 Seminar Talks

Seminar Title	Date	Group
NCTS Number Theory Seminar	1/7, 1/14, 1/21, 2/25, 3/10, 3/24, 4/14, 4/22, 7/1, 7/8, 8/5, 10/28, 11/3, 11/10, 11/17, 11/24	A
Taipei Postdoc Seminar	1/5, 3/2, 3/16	A
NCTS Seminar in Algebraic Geometry	1/21, 1/21, 3/11, 3/16, 3/17, 4/28, 5/3	B
NCTS Seminar in Birational Geometry	1/7, 2/25, 3/25, 4/1, 4/15, 4/29	B
Online Seminar on Algebraic and Complex Dynamics	10/11, 10/18, 10/25	B
Seminar of Algebraic Geometry in East Asia	1/14, 2/11, 2/25, 3/25, 4/8, 4/22, 5/6, 5/20, 6/3, 6/17, 7/1, 9/30, 10/14, 10/28	B
Seminar on Arithmetic Geometry and Algebraic Groups	4/15	B
Taipei Postdoc Seminar	2/16, 9/28, 10/26	B
AS-NCTS Seminar on Geometry	1/14, 3/18, 4/8, 4/29, 6/10	C
NCTS Differential Geometry Seminar	1/6, 3/3, 3/17, 3/31, 4/14, 4/28, 5/12, 5/26, 8/16, 9/29, 10/6, 10/13, 10/26	C
NCTS International Geometric Measure Theory Seminar	1/19, 3/16, 5/18, 7/20, 9/21, 11/23	C
Taipei Postdoc Seminar	1/19, 4/20	C
European-Asian Joint Webinar on Dynamical Systems	3/22, 4/5, 4/19, 5/3, 5/17, 5/31,10/7, 10/21	D
Korea-Taiwan-Vietnam Joint Seminar in Combinatorics and Analysis	2/24, 3/11, 3/24, 4/8, 4/22, 5/4, 5/11, 5/31, 6/14, 9/9, 9/16, 10/14, 10/28	D
NCTS Nonlinear PDE and Analysis Seminar	3/3, 3/9, 3/17, 3/31, 5/12, 5/26, 6/1, 7/28, 8/11, 9/14, 9/28, 10/12	D
NCTS Probability Seminar	3/2, 3/16, 4/13, 9/19, 10/3, 10/17	D
NCTS Seminar on Dynamical Systems	1/4, 3/2, 3/9, 3/16, 3/23, 3/30, 4/13, 4/20, 4/27, 5/4, 6/1, 6/8	D
NCTS Webinar on Nonlinear Evolutionary Dynamics	2/24, 3/3, 3/10, 3/24, 3/31, 4/14, 5/5, 5/12, 5/19, 6/2, 6/9, 9/15, 9/22, 9/29, 10/6, 10/13, 10/20, 10/27	D
Taipei Postdoc Seminar	5/18	D
NCTS Math-Phys Machine Learning Seminar	4/12	E
NCTS Seminar on Scientific Computing	8/29	E
Taipei Postdoc Seminar	10/12	E
NCTS Seminar on Gene Network Analysis	2/23, 3/16, 4/13, 5/4, 7/21, 7/29, 10/19	F
NCTS Seminar on Mathematical Biology	4/15, 4/22, 4/29, 5/13, 5/27	F
Taipei Postdoc Seminar	4/6, 5/4	F

Program A	Speaker	Affiliation	Title of Talk
2022-11-24	Papikian, Mihran	Pennsylvania State University	Drinfeld-Stuhler Modular Varieties and Arithmetic Applications (IV)
2022-11-17	Papikian, Mihran	Pennsylvania State University	Drinfeld-Stuhler Modular Varieties and Arithmetic Applications (III)
2022-11-10	Papikian, Mihran	Pennsylvania State University	Drinfeld-Stuhler Modular Varieties and Arithmetic Applications (II)
2022-11-03	Papikian, Mihran	Pennsylvania State University	Drinfeld-Stuhler Modular Varieties and Arithmetic Applications (I)
2022-10-28	Shen, Chun-Yen	National Taiwan University	Sum Product Estimates and Their Applications
2022-08-05	Namikawa, Kenichi	Tokyo Denki University	An Integrality of Critical Values of Rankin-Selberg L-functions for GL(n+1)×GL(n)
2022-07-08	Lee,Yu-Sheng	Columbia University	Euler Systems and CM Congruences
2022-07-01	Lo, Chi-Heng	Purdue University	On the Intersection of Local Arthur Packets for Classical Groups
2022-04-22	Wong, Peng-Jie	NCTS	Square-free orders for elliptic curves modulo p
2022-04-14	Gezmis, Oguz	NCTS	Drinfeld Modular Forms of Higher Rank and Their Derivatives
2022-03-24	Fang, Jiangxue	Capital Normal University	Special Values of Drinfeld Modules
2022-03-16	Harada, Ryotaro	University of the Ryukyus	On Some Linear Independence Results for Special Values of Thakur Hypergeometric Functions
2022-03-10	Matsuzuki, Daichi	Nagoya University	Integral expressions and recursive formulas of multiple zeta functions in positive characteristic
2022-03-02	Chen, Harrison	Institute of Mathematics , Academia Sinica	Traces of Convolution Categories
2022-02-25	Wei, Fu-Tsun	National Tsing Hua University	Function Field Analogue of Shimura's Conjecture on Period Symbols
2022-01-21	Chen, Shih-Yu	Academia Sinica	On Deligne's Conjecture for Symmetric Fifth L-functions of Modular Forms
2022-01-14	Yun, Zhiwei	Massachusetts Institute of Technology	Special Cycles for Unitary Shtukas and Modularity
2022-01-07	Yu, Chia-Fu	Academia Sinica	The Gauss Problem for Central Leaves
2022-01-05	Peng, Jun-Wen	NCTS	Rigid Geometry: Berkovich Spaces, Perfectoid Spaces, and their Application on Arithmetic Dynamics

Program B	Speaker	Affiliation	Title of Talk
2022-10-28	Tanaka, Hiromu	The University of Tokyo	TBA
2022-10-28	Hung, Bao Viet Le	Northwestern University	TBA
2022-10-26	Chou, You-Cheng	Academia Sinica	TBA
2022-10-25	Tayou, Salim	Harvard University	TBA
2022-10-18	Whang, Junho Peter	Seoul National University	Periodic Points for Systems of Varieties
2022-10-14	Huy, Dang Quoc	Vietnam Institute for Advanced Study in Mathematics	Deforming Cyclic Covers in Towers
2022-10-14	Chen, Yen-An	NCTS	Foliated MLD and LCT
2022-10-11	Favre, Charles	École Polytechnique	B-divisors and Dynamical Degrees
2022-09-30	Quek, Ming Hao	Brown University	Around the Motivic Monodromy Conjecture for Non-degenerate Hypersurfaces
2022-09-30	Liu, Yuchen	Northwestern University	Wall Crossing for K-moduli Spaces
2022-09-28	Sultani, Nawaz	Academia Sinica	Gromov-Witten Invariants of Non-convex Orbifolds
2022-07-01	Thang, Nguyên Tât	Vietnam Academy of Science and Technology	Contact Loci and Motivic nearby Cycles of Nondegenerate Singularities
2022-07-01	Cuong, Dô Viêt	Vietnam National University	On the Moduli Spaces of Parabolic Higgs Bundles on a Curve
2022-06-17	Lu, Xin	East China Normal University	Sharp Bound on the Abelian Automorphism Groups of Surfaces of General Type
2022-06-17	Li, Qifeng	Academy of Mathematics and Systems Science	Deformation Rigidity of Wonderful Group Compactifications
2022-06-03	Takagi, Shunsuke	The University of Tokyo	Deformations of Klt and Slc Singularities
2022-06-03	Park, Euisung	Korea University	On the Rank of Quadratic Equations of Projective Varieties
2022-05-20	Esnault, Hélène	Freie Universität Berlin	Recent Developments on Rigid Local Systems
2022-05-20	Zhang, Tong	East China Normal University	Noether-Severi Inequality and Equality for Irregular Threefolds of General Type
2022-05-06	Matsui, Hiroki	Tokushima University	Spectra of Derived Categories of Noetherian Schemes
2022-05-06	Khan, Adeel	Academia Sinica	Microlocalization and Donaldson-Thomas Theory
2022-05-03	Benozzo, Marta	University College London	Iitaka Conjecture for Anticanonical Divisors in Positive Characteristics
2022-04-29	Mukherjee, Jayan	Brown University	Deformations and Moduli of Irregular Canonical Covers with $K^2=4p_g-8$
2022-04-28	Bell, Renee	University of Pennsylvania	Monodromy of Tamely Ramified Covers of Curves
2022-04-22	Yin, Qizheng	Peking University	Perverse-Hodge Symmetry for Lagrangian Fibrations

Program B	Speaker	Affiliation	Title of Talk
2022-04-22	Hwang, Jun-Muk	Institute for Basic Science	Partial Compactification of Metabelian Lie Groups with Prescribed Varieties of Minimal Rational Tangents
2022-04-15	Harbater, David	University of Pennsylvania	Bounding Cohomology Classes over Semi-global Fields
2022-04-15	Chen, Meng	Fudan University	On Explicit Birational Geometry of Higher Dimensional Varieties
2022-04-08	Hacon, Christopher	The University of Utah	Boundedness of Polarized Calabi-Yau Fibrations and Generalized Pairs
2022-04-08	Ngô, Bảo Châu	Vietnam Institute for Advanced Study in Mathematics	On the Functional Equation of Automorphic L-functions
2022-04-01	Jiang, Zhi	Fudan University	Cohomological Support Loci and Pluricanonical Systems of Irregular Varieties
2022-03-25	Hu, Yong	Shanghai Jiao Tong University	Algebraic Threefolds of General type with Small Volume
2022-03-25	Zhou, Yang	Fudan University	Wall-crossing for K-theoretic Quasimap Invariants
2022-03-25	Ishii, Shihoko	The University of Tokyo	A Bound of the Number of Weighted Blow-ups to Compute the Minimal Log Discrepancy for Smooth 3-Folds
2022-03-17	Lorenzo, Vicente	Universidade de Lisboa	Group Actions on Horikawa Surfaces
2022-03-11	Latyntsev, Alexei	University of Oxford	Quantum Vertex Algebras and Cohomological Hall Algebras
2022-02-25	Park, Jinhyun	Korea Institute for Advanced Study	On Motivic Cohomology of Singular Algebraic Schemes
2022-02-25	Ho, Quoc	The Hong Kong University of Science and Technology	Revisiting Mixed Geometry
2022-02-25	Lee, Yongnam	Korea Advanced Institute of Science and Technology	Total dual VMRT and its Application to the Bigness of the Tangent Bundle of Fano Threefolds
2022-02-16	Mikami, Ryota	Academia Sinica	Log-concavity and Matroids
2022-02-11	Brivio, Iacopo	NCTS	Invariance of Plurigenera in Positive and Mixed Characteristic
2022-02-11	Chen, Hsin-Ku	National Taiwan University	Classification of Three-dimensional Terminal Divisorial Contractions to Curves
2022-01-21	Singh, Rahul	University of Pittsburgh	Counting Parabolic Principle G-bundles with Nilpotent Sections over P^1
2022-01-21	Hekking, Jeroen	KTH Royal Institute of technology	Derived Blow-ups Using Rees Algebras and Virtual Cartier Divisors
2022-01-14	Nguyen, Xuan Viet Nhan	Basque Center for Applied Mathematics	Smooth Approximation in Polynomially Bounded o-minimal Structure
2022-01-14	Nguyen, Kien Huu	K. U. Leuven	Exponential Sums Modulo p^m for Deligne Polynomials
2022-01-07	Andreatta, Marco	Università di Torino	Lifting from an Ample Section The Case of Weighted Blow-ups

Program C	Speaker	Affiliation	Title of Talk
2022-11-23	Song, Antoine	California Institute of Technology	The spherical Plateau problem: existence, uniqueness, stability
2022-10-20	Liao, Wei-Hung	National Yang Ming Chiao Tung University	Convergence Analysis of Dirichlet Energy Minimization for Spherical Conformal Parameterizations
2022-10-13	Nie, Xin	Shing-Tung Yau Center of Southeast University	Higgs Bundles, Minimal Surfaces and Pseudo-hyperbolic Spaces
2022-10-06	Evans, Chris	Queen Mary University of London	Lagrangian Mean Curvature Flow in the Complex Projective Plane
2022-09-29	Choi Beomjun	Pohang University of Science and Technology	Liouville Theorem for Surfaces Translating by Sub-affine-critical Powers of Gauss Curvature
2022-09-21	Székelyhidi Gábor	Northwestern University	Minimal Hypersurfaces with Cylindrical Tangent Cones
2022-08-16	Lee, Kuan-Hui	University of California, Irvine	Generalized Ricci Flow
2022-08-16	Pan, Chung-Ming	Institut de Mathématiques de Toulouse	Singular Gauduchon Metrics
2022-07-20	Bellettini, Costante	University College London	Hypersurfaces with Prescribed-mean-curvature: Existence and Properties
2022-06-10	Shi, Ziming	Rutgers University	Sobolev Differentiability Properties of Logarithmic Modulus of Real Analytic Functions
2022-05-26	Edelen, Nicholas	University of Notre Dame	Degeneration of 7-dimensional Minimal Hypersurfaces with Bounded Index
2022-05-18	Pigati, Alessandro	New York University	(Non-)Quantization Phenomena for Higher-dimensional Ginzburg-Landau Vortices
2022-05-12	Franz, Giada	ETH Zürich	Equivariant Min-max Theory to Construct Free Boundary Minimal Surfaces in the Unit Ball
2022-04-29	Sutti, Marco	NCTS	Numerical Optimization on Matrix Manifolds
2022-04-28	Yeon, Eungbeom	Pusan National University	Existence and Uniqueness Results on Free Boundary Minimal Surfaces via Weierstrass Representation Formula
2022-04-20	Harvie, Brian	NCTS	Static Manifolds and Quasi-local Mass in General Relativity
2022-04-14	Wang, Yi-Sheng	Academia Sinica	Characteristic Diagram of a Handlebody-knot
2022-04-08	Huang, Che-Hung	Purdue University	Plurisubharmonicity of the Dirichlet Energy
2022-03-31	Kwong, Kwok-Kun	University of Wollongong	On an Inverse Curvature Flow in Two-dimensional Space Forms
2022-03-18	Lye, Jørgen Olsen	University of Oldenburg	Yamabe Flow on Singular Spaces
2022-03-17	Takahashi, Ryosuke	Kyushu University	J- Equation on Holomorphic Vector Bundles
2022-03-16	Steinbrüchel, Simone	University of Leipzig	A Regularity Theorem for Area-minimizing Currents at Higher Multiplicity Boundary Points
2022-03-03	Lee, Kuan-Hui	University of California, Irvine	The Stability of Generalized Ricci Solitons
2022-01-19	Wood, Albert	NCTS	Gluing Constructions in Geometric Analysis
2022-01-19	Minter, Paul	University of Cambridge	A Structure Theory for Branched Stable Hypersurfaces
2022-01-14	Zhao, Kai-Wei	University of California, Irvine	On Blowup of Regularized Solutions to Jang Equation and Constant Expansion Surfaces
2022-01-06	Lin, Yu-Shen	Boston University	Torelli Theorem of ALH^* Gravitational Instantons

Program D	Speaker	Affiliation	Title of Talk
2022-10-28	Yoo, Semin	Korea Institute for Advanced Study	Weak Bruhat Interval Modules of the 0-Hecke Algebras for Genomic Schur Functions
2022-10-27	Church, Kevin	Canadian Imperial Bank of Commerce	The Unreasonable Effectiveness of Computer-assisted Proofs in Nonlinear Dynamics
2022-10-21	Li, Ruofan	South China University of Technology	Rational Numbers in $\times b$-invariant Set
2022-10-20	Giletti, Thomas	University of Lorraine	Propagation in a Shifting Environment
2022-10-17	Lam, Wai Kit	National Taiwan University	A Brief Introduction to First-passage Percolation (IV)
2022-10-14	Smorodinsky, Shakhar	Ben-Gurion University	A Solution to Ringel's Circle Problem (1959)
2022-10-13	Poláčik, Peter	University of Minnesota	On the Quasiconvergence Property of Solutions of Semilinear Parabolic Equations on the Real Line
2022-10-12	Kwon, Bongsuk	Ulsan National Institute of Science and Technology	Plasma Solitary Waves and Related Problems
2022-10-07	Huang, Nai-Zhu	National Chengchi University	On the Mixing Properties of the Markov Tree-shifts
2022-10-06	Girardin, Léo	Université Claude Bernard Lyon 1	Non-local Pulling in Reaction-diffusion Equations
2022-10-03	Lam, Wai Kit	National Taiwan University	A Brief Introduction to First-passage Percolation (III)
2022-09-29	de Rijk, Björn	Karlsruher Institut für Technologie	Nonlinear Stability and Asymptotic Behavior of Periodic Wave Trains in Reaction-diffusion Systems against C^2_{ub}-perturbations
2022-09-28	Nguyen, Van Tien	National Taiwan University	Finite-time Blowup Solutions to the Keller-Segel System
2022-09-22	Liao, Xian	Karlsruher Institut für Technologie	Conserved Energies for the One-dimensional Cubic Nonlinear Defocusing Schrödinger Equation with Nonzero Boundary Conditions at Infinity
2022-09-19	Lam, Wai Kit	National Taiwan University	A Brief Introduction to First-passage Percolation (II)
2022-09-16	Holmsen, Andreas	Korea Advanced Institute of Science and Technology	Some Recent Results on Geometric Transversals
2022-09-15	Du, Yihong	University of New England	Propagation Dynamics of the Fisher-KPP Nonlocal Diffusion Equation with Free Boundary
2022-09-14	Kawagoe, Daisuke	Kyoto University	On Strong Convergence of an Elliptic Regularization with the Neumann Boundary Condition Applied to a Boundary Value Problem of a Stationary Advection Equation

Program D	Speaker	Affiliation	Title of Talk
2022-09-09	Roche-Newton, Oliver	Johannes Kepler Universität Linz	Counting Arcs in F_q^2
2022-08-11	Lai, Chen-Chih	Columbia University	Free Boundary Problem for a Gas Bubble in a Liquid, and Asymptotic Stability of the Manifold of Spherically Symmetric Equilibria
2022-07-28	Tsai, Tai-Peng	University of British Columbia	Weak and Mild Solutions to the Navier-Stokes Equations in Wiener Amalgam Spaces with Spacetime Integral Bounds
2022-06-14	Duc, Khanh Nguyen	State University of New York at Albany	A Murnaghan-Nakayama Rule for Grothendieck Polynomials of Grassmannian Type
2022-06-09	Vassena, Nicola	Free University of Berlin	Is Genericity Always Generic on Biochemical Networks?
2022-06-08	Tsai, Cheng-Yu	National Chengchi University	On Metric Invariants of Entropy Type (I)
2022-06-02	Monobe, Harunori	Osaka Metropolitan University	Singular Limit of a Three-component Lotka-Volterra Competition System
2022-06-01	Lin, Cheng-Pu	Academia Sinica	Introduction to the Theory of the Incompressible Navier-Stokes Equation (III)
2022-06-01	Wang, Jing-Wei	National University of Kaohsiung	Tame Systems and Scrambled Pairs under an Abelian Group Action (II)
2022-05-31	Oum, Sang-il	Korea Advanced Institute of Science and Technology	Building the Hierarchy of Graph Classes
2022-05-31	Pyörälä, Aleksi	University of Oulu	Normal Numbers in Self-conformal Sets
2022-05-26	Lin, Cheng-Pu	Academia Sinica	Introduction to the Theory of the Incompressible Navier-Stokes Equation (II)
2022-05-19	Ei, Shin-Ichiro	Hokkaido University	Pattern Formation Problems Related to Networks
2022-05-18	Jeong, Seonghyeon	NCTS	Introduction to the Optimal Transportation Problem and the Monge-Ampere Equation
2022-05-17	He, Yubin	Université Paris-Est Créteil Val de Marne	Uniform Approximation Problems of Expanding Markov Map
2022-05-12	Chiba, Hayato	Tohoku University	The Generalized Spectral Theory and its Application to Neuronal Dynamics
2022-05-12	Lin, Cheng-Pu	Academia Sinica	Introduction to the Theory of the Incompressible Navier-Stokes Equation (I)
2022-05-11	Oh, Changkeun	University of Wisconsin–Madison	Decoupling Inequalities for Quadratic Forms
2022-05-05	Shimojo, Masahiko	Tokyo Metropolitan University	Spreading and Extinction of Solutions to the Logarithmic Diffusion with a Logistic Reaction
2022-05-04	Pham, Huy Tuan	Stanford University	A Proof of the Kahn-Kalai Conjecture
2022-05-04	Wang, Jing-Wei	National University of Kaohsiung	Tame Systems and Scrambled Pairs under an Abelian Group Action (I)
2022-05-03	Song, Kunkun	Hunan Normal University	On the Fourier Transform of Coin-tossing Type Measures
2022-04-27	Zhang, Zongfan	Sichuan University	Mixing via Sequence Entropy (II)
2022-04-22	Tran, Tuan	Institute for Basic Science	Exponential Decay of Intersection Volume and Applications
2022-04-20	Zhang, Zongfan	Sichuan University	Mixing via Sequence Entropy (I)

Program D	Speaker	Affiliation	Title of Talk
2022-04-19	Wu, Zhi-Yi	University of Oulu	Some Facts in Fractal Spectral Measure Theory
2022-04-14	Ma, To Fu	University of Brasília	On Semilinear Lamé Systems with Time-dependent Delays
2022-04-13	Lam, Wai Kit	National Taiwan University	A Brief Introduction to First-passage Percolation
2022-04-13	Huang, Nai-Zhu	National Chengchi University	Commutativity and Noncommutativity of Topological Sequence Entropy (II)
2022-04-08	Mohammadi, Ali	Institute for Research in Fundamental Sciences	Energy Estimates over Finite Fields and Applications
2022-04-05	Shang, Lei	Université Paris-Est Créteil Val de Marne	On Fast Points of Engel Expansions
2022-03-31	Lessard, Jean-Philippe	McGill University	Computer-assisted Proofs of Existence of Periodic Motions in Fluids
2022-03-31	Hong, Guo-Dong	NCTS	An Introduction of Weak Convergence (III)
2022-03-30	Huang, Nai-Zhu	National Chengchi University	Commutativity and Noncommutativity of Topological Sequence Entropy (I)
2022-03-24	Chemnitz, Dennis	Free University of Berlin	Upper and Lower Bounds for the Frequencies of Delayed Non-homogeneous Oscillators
2022-03-24	Palsson, Eyvindur Ari	Virginia Tech	Triangles and Triangle Averaging Operators
2022-03-23	Lai, Guan-Yu	National Yang Ming Chiao Tung University	Set of Sequence Entropies for a Given Space (II)
2022-03-22	Wu, Wanlou	Université Paris-Est Créteil Val de Marne	Approximation Property on Entropy for Surface Diffeomorphisms
2022-03-17	Hong, Guo-Dong	NCTS	An Introduction of Weak Convergence (II)
2022-03-16	Li, Jhih-Huang	National Taiwan University	統計物理系統在大尺度下的行為：SLE 曲線 (4)
2022-03-16	Lai, Guan-Yu	National Yang Ming Chiao Tung University	Set of Sequence Entropies for a Given Space (I)
2022-03-11	Das, Shagnik	National Taiwan University	Schur's Theorem for Randomly Perturbed Sets
2022-03-10	Morita, Yoshihisa	Ryukoku University	Front Propagation and Blocking for Reaction-Diffusion Equations on Unbounded Metric Graphs
2022-03-09	Roychowdhury, Prasun	Indian Institute of Science Education and Research (IISER) Pune, India	Criticality Theory and Poincare-Hardy-Rellich Inequality
2022-03-09	Wu, Yu-Liang	University of Oulu	Topological Sequence Entropy (II)
2022-03-03	Hong, Guo-Dong	NCTS	An Introduction of Weak Convergence (I)
2022-03-03	Walther, Hans-Otto	Justus-Liebig-Universität Gießen	Differential Equations with State-dependent Delays and their Solution Manifolds
2022-03-02	Li, Jhih-Huang	National Taiwan University	Large-scale Behaviors of Systems from Statistical Mechanics: SLE Curves (3)
2022-03-02	Wu, Yu-Liang	University of Oulu	Topological Sequence Entropy (I)
2022-02-24	Iosevich, Alex	University of Rochester	Point Configurations from a Universal Standpoint
2022-02-24	Chiba, Hayato	Tohoku University	Bifurcation of the Kuramoto Model on Networks Based on the Generalized Spectral Theory
2022-01-04	Hu, Zhangnan	South China University of Technology	On the Intersection of Dynamical Covering Sets with Fractals

Program E	Speaker	Affiliation	Title of Talk
2022-10-12	Sutti, Marco	NCTS	Computing Geodesics on the Stiefel Manifold
2022-08-29	Sutti, Marco	NCTS	Federated Learning on Riemannian Manifolds
2022-04-12	Su, Cheng-Fang	National Yang Ming Chiao Tung University	Quantum Variational Algorithms and Their Application in Biomedicine

Program F	Speaker	Affiliation	Title of Talk
2022-10-19	Suzuki, Takashi	Osaka University	Computational Biology Reveals Dual Signaling Pathways Inside the Cell
2022-07-29	Yan, Ching-Cher Sanders	Academia Sinica	Stochastic Simulations for Gene Expression: the Gillespie Algorithm and the Burst Langevein Algorithm
2022-07-21	Yan, Ching-Cher Sanders	Academia Sinica	Gene Expression Noise in a Single Cell: Source Discrimination, Propagation and Description
2022-06-10	Sasmal, Sourav Kumar	Birla Institute of Technology and Science	Mathematical Modeling on Ecology and Epidemiology
2022-05-27	Wang, Xiunan	University of Tennessee	A Hypothesis-free Bridging of Disease Dynamics and Non-pharmaceutical Policies
2022-05-13	Shuai, Zhisheng	University of Central Florida	Impact of Hotspot Arrangements on Disease Invasion
2022-05-04	Kim, Jinsu	Pohang University of Science and Technology	Reaction Networks for a Graphical Description of Biochemical Systems: Stability of Stochastic Reaction Networks and its Application
2022-05-04	Lin, Jia-Wei	National Yang Ming Chiao Tung University	Structure-preserving Methods for Computing Complex Band Structures of Three Dimensional Photonic Crystals
2022-04-29	Wang, Hao	University of Alberta	Stoichiometric Theory and Innovative Analysis
2022-04-22	Lam, King-Yeung	Ohio State University	The Nonlocal Selection of Spreading Speed in Shifting Environments
2022-04-15	Lou, Yijun	The Hong Kong Polytechnic University	Stage Structured Models with Seasonal Stage Durations
2022-04-13	Kim, Jinsu	Pohang University of Science and Technology	Reaction Networks for a Graphical Description of Biochemical Systems: Three Milestones and Recent Issues in the Stochastic Reaction Network Literature
2022-04-06	Yen, Peter	National Sun Yat-sen University	Investigating and Understanding Extreme Events in the Financial Market Using Methods Based on “Algebraic Topology”
2022-03-16	Kim, Jinsu	Pohang University of Science and Technology	Reaction Networks for a Graphical Description of Biochemical Systems: Stochastic Modeling and Related Issues
2022-02-23	Kim, Jinsu	Pohang University of Science and Technology	Reaction Networks for a Graphical Description of Biochemical Systems: Deterministic Modeling and the Deficiency Zero Theorem

4.3 TMS and Other Courses

4.3.1 TMS Courses

Program A	Dates	Organizers	Lecturers
Taiwan Mathematics School: Introduction to Drinfeld Modules and Drinfeld Modular Varieties	2022-02-15 / 2022-06-15	Yang, Yi-Fan (NTU)	Chia-Fu Yu (Academia Sinica)
Taiwan Mathematics School: Analytic Number Theory	2022-02-15 / 2022-06-14	Yang, Yi-Fan (NTU)	Yi-Fan Yang (NTU) Peng-Jie Wong (NCTS)
Program C			
Taiwan Mathematics School: Real Analysis II	2022-02-18 / 2022-06-17	Ho, Nan-Kuo (NTHU)	Ulrich Menne (NTNU)
Taiwan Mathematics School: Geometry and Quantum Field Theory	2022-02-16 / 2022-06-01	Ho, Nan-Kuo (NTHU)	Siye Wu (NTHU)
Program E			
Taiwan Mathematics School: Machine Learning for PDEs	2022-02-18 / 2022-03-25	Huang, Tsung-Ming (NTNU)	Wei-Fan Hu (NCU) Ming-Cheng Shiue (NYCU)

4.3.2 Other Courses

Program A	Dates	Organizers	Lecturers
NCTS Short Course on Representation Theory: Minicourse on Double Affine Hecke Algebras	2022-10-18 / 2022-12-6	Lai, Chun-Ju (AS)	Wille Liu (Academia Sinica)
NCTS Short Course on Representation Theory: Mini Course on Whittaker Modules and Categories for Lie Algebras and Lie Superalgebras	2022-04-01 / 2022-04-29	Chen, Chih-Whi (NCU) Peng, Yung-Ning (NCU) Lai, Chun-Ju (AS)	Chih-Whi Chen (National Central University)
Program B			
A Modern Introduction to Algebraic Stacks	2022-10-31 / 2023-01-16	Lee, Yng-Ing (NTU)	Adeel Khan (Academia Sinica)
NCTS Winter Short Course on Algebraic Geometry	2022-01-11 / 2022-01-26	Yu, Chia-Fu (AS)	Chia-Fu Yu (Academia Sinica)
Program C			
Introduction to Holonomy and G-structures	2022-03-15 / 2022-05-10	Ho, Nan-Kuo (NTHU)	Jesse Madnick (NCTS)
Program D			
Fractals in Diophantine Approximation	2022-08-08 / 2022-08-24	Chang, Chih-Hung (NUK), Ban, Jung-Chao (NCCU)	Meng Wu (University of Oulu), Lingmin Liao (Université Paris-Est Créteil)
MSRI-NCTS Joint Summer School: Recent Topics in Well Posedness	2022-07-18 / 2022-07-29	Chen, Jungkai (NTU), Giga, Yoshikazu (The UoT) Schonbek, Maria (UC, Santa Cruz) Yoneda, Tsuyoshi (The UoT)	Lorenzo Brandolese (Université Claude Bernard Lyon 1), Sylvie Monniaux (Aix-Marseille University), Tsuyoshi Yoneda (The University of Tokyo)
Distinguished Lecture: Random Matrix Theory and Applications to Statistics	2022-07-12 / 2022-07-12	Tsui, Mao-Pei (NTU)	Horng-Tzer Yau (Harvard University)
Distinguished Lecture: Curvature Equation from the Aspect of Integrability	2022-07-11 / 2022-07-12	Lee, Yng-Ing (NTU)	Chang Shou Lin (National Taiwan Univeristy)
Introduction to Decoupling Inequalities	2022-04-20 / 2022-05-18	Shen, Chun-Yen (NTU)	Zane Kun Li (Indiana University Bloomington)
Program E			
NCTS Winter Course: Parallel Finite Element Method using Supercomputer	2022-02-10 / 2022-02-20	Chen, Pochung (NTHU), Huang, Tsung-Ming (NTNU), Kao, Ying-Jer (NTU), Wang, Weichung (NTU)	Kengo Nakajima (The University of Tokyo)

Program F			
NCTS Phys-Math Joint Summer School on Quantum Information Science 2022	2022-08-22 / 2022-08-24	Hsieh, Ming-Lun (NTU), Goan, Hsi-Sheng (NTU), Chen, Jiunn-Wei (NTU)	Shin-Liang Chen (National Chung Hsing Univeristy), Yuan Chung Cheng (National Taiwan University), Ming-Lun Hsieh (National Taiwan University), Hao-Wei Huang (National TsingHua University), Matthew M. Lin (National Cheng Kung University)
2022 NCTS Summer Course on Mathematical Biology	2022-08-01 / 2022-08-05	Wang, Feng-Bin (CGU), Cheng, Chang-Yuan (NPU), Wu, Chang-Hong (NYCU)	Chang-Yuan Cheng (National Pingtung University), Yukihiko Nakata (Aoyama Gakuin University), Naveen K. Vaidya (San Diego State University), Feng-Bin Wang (Chang Gung University), Chang-Hong Wu (National Yang Ming Chaio Tung University)

4.4 List of Visitors

Arrival date	Departure date	Days of visit	Name	Program	Affiliation	Country
2022/1/1	2022/3/31	90	Ryotaro Harada	A	University of the Ryukyus	Japan
2022/1/1	2022/1/21	21	Ju-Yi Yen	D	University of Cicinnati	USA
2022/4/9	2022/6/21	74	Zane Kun Li	D	Indiana University Bloomington	USA
2022/5/12	2022/7/15	65	Hau-Tieng Wu	F	Duke University	USA
2022/5/30	2022/8/12	75	Chi-Heng Lo	A	Purdue University	USA
2022/6/7	2022/9/13	99	Hung Chiang	A	Columbia University	USA
2022/6/20	2022/7/16	27	Horng-Tzer Yau	D	Harvard University	USA
2022/7/2	2022/8/24	54	Mu-Tao Wang	C	Columbia University	USA
2022/7/6	2022/7/31	26	I-Hsun Chen	D	Brown University	USA
2022/7/9	2022/8/14	37	Tai-Peng Tsai	D	University of British Columbia	Canada
2022/7/11	2022/7/31	21	Brice Franke	D	Université de Bretagne Occidentale	France
2022/7/18	2022/8/26	40	Kuan-Hui Lee	C	University of California, Irvine	USA
2022/7/18	2022/8/21	35	Yung-Chang Hsu	D	Purdue University	USA
2022/7/29	2022/8/17	20	Lan-Hsuan Huang	C	University of Connecticut	USA
2022/8/5	2022/8/19	15	Ju-Yi Yen	D	University of Cincinnati	USA
2022/8/26	2022/9/23	29	Ryotaro Harada	A	University of the Ryukyus	Japan
2022/8/26	2022/9/23	29	Yoshinori Mishiba	A	University of the Ryukyus	Japan
2022/9/1	2022/10/31	61	Daichi Matsuzuki	A	Nagoya University	Japan
2022/9/12	2023/1/12	111	Camille Laurent-Gengoux	C	Université de Lorraine	France
2022/9/23	2022/12/23	92	Mihran Papikian	A	Pennsylvania State University	USA
2022/11/1	2022/12/31	61	Chao-Ming Lin	C	University of California, Irvine	USA
2022/10/5	2022/12/25	82	Yerko Torres	B	Pontificia Universidad Catolica, Santiago	Chile
2022/11/24	2023/1/9	38	Hau-Tieng Wu	F	Duke University	USA
2022/12/26	2023/1/2	6	Yu-Shen Lin	C	Boston University	USA
2022/12/26	2023/1/14	6	Guangliang Chen	F	San Jose State University	USA

4.5 Publications

4.5.1 Publications of Key Members

Journal Name	2021 ACK (60)	2021 AFF (56)	2022 ACK (35)	2022 AFF(45)	To Appear (17)
ACM Transactions on Mathematical Software	1				
Acta Mathematica Sinica		1			
Advances in Applied Mathematics and Mechanics	1				
Advances in Geometry		1			
Advances in Mathematics	1	1	1	2	
Algebra & Number Theory					1
Anal. PDE		1			
Annales de l'Institut Fourier (Grenoble)		1			
Annali della Scuola Normale Superiore di Pisa	1	1			
Annals of Mathematical Sciences and Applications			1		
Applicable Analysis	2		1		1
Applied Mathematics Letters			1		
Archiv der Mathematik			1	1	
Archive for Rational Mechanics and Analysis		1			
ARS MATHEMATICA CONTEMPORANEA				1	
Bull. Inst. Math. Acad. Sin.		1			
Bulletin of the Australian Mathematical Society				1	
Calculus of Variations and Partial Differential Equations	1				
Chaos, Solitons and Fractals	1	1			
Communications in Contemporary Mathematics			1	1	1
Communications in Mathematical Physics				1	
Communications in Pure and Applied Analysis		1			
Comptes Rendus Mathématique	1	1			
Computer Physics Communications	1		1		
Deep-Sea Research I.				1	
Discrete and Continuous Dynamical Systems - Series B	4		2		2
Displays			1		
Diversity		1			
Doc. Math.	1	1			
Duke Math. Jour.		1			
Ecography	1	1			
Ecology and Evolution	1	1			
Ecology Letters	1	2			
Electronic Journal of Probability			1	1	
Ergodic Theory and Dynamical Systems	1				
FEMS Microbiology Ecology				1	
Forum of Mathematics, Sigma					1

Journal Name	2021 ACK	2021 AFF	2022 ACK	2022 AFF	To Appear
Frontiers in Marine Science	1	1			
Geometriae Dedicata		1			
Geometric and Functional Analysis			1		
Hokkaido M. J.				1	
IEEE Transactions on Circuits and Systems I		1		1	
IMA J. Numer. Anal.	1				
Indagationes Mathematicae			1	1	
Indiana Univ. Math. J.		1			
International Journal of Mathematics			1	1	
International Journal of Number Theory				1	1
International Mathematical Research Notices	2	2	1		
Inventiones Mathematicae	1				
Inverse Problems	1				
J. Atmos. Sci.	1				
J. Geo. Res.			1		
J. Knot Theory Ramification		1			
J. Math. Fluid Mech.	2		1		
J. Pure Appl. Algebra			1	1	
J. Theor. Nombres Bordeaux		1			
Journal of algebra and application				1	
Journal of Algebraic Combinatorics		1			
Journal of Clinical Sleep Medicine	1	1			
Journal of Computational and Applied Mathematics	1				
Journal of Computational Physics	1				
Journal of Differential Equations	2	1	1	2	
Journal of Functional Analysis		1			
Journal of Geometric Analysis	2	2	1	1	
Journal of Geometry and Physics		1			
Journal of Mathematical Analysis and Applications	2				
Journal of Mathematical Biology	1				
Journal of Mathematical Physics	1	3			
Journal of Number Theory			1	2	
Journal of Scientific Computing	2		2		
Journal of Statistical Computation and Simulation	1				
Journal of the Franklin Institute					1
Journal of Topology and Analysis		1		1	1
Mathematical Physics, Analysis and Geometry	1	1			
Mathematical Research Letters		1			1

Journal Name	2021 ACK	2021 AFF	2022 ACK	2022 AFF	To Appear
Mathematische Nachrichten			1	1	
Mathematische Zeitschrift	1	1			
Nagoya Math Journal				1	
Nature Communications			2	4	
Nonlinear Anal.	1			2	1
Nonlinearity	1	2			
Osaka J. Math.				1	1
Physical Review Fluids	1				
PLOS ONE	1	1			
Proc. Math. Camb. Phil. Soc.				1	1
Proceedings of AMS			1		1
Proceedings of the Royal Society of Edinburgh		1			
Progress in Oceanography		1			
PRX QUANTUM		1			
Pure and Applied Analysis		1			
Quantum Information Processing			1		
Real Analysis Exchange			1	1	
Real World Applications	1				
Research in Number Theory	1	1		1	
Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales. Serie A. Matemáticas				1	
Revista Matematica Iberoamericana		1			
RIMS Kokyuroku Bessatsu				1	1
Scientific Reports	2	1	1		
SIAM Journal on Applied Dynamical Systems	1	1			
SIAM Journal on Imaging Sciences	1				
SIAM Journal on Mathematical Analysis	1	1			
Statistics in Medicine	2				
Taiwanese Journal of Mathematics	1	1		1	
The Quarterly Journal of Mathematics		1			
Theoretical Computer Science			1	1	1
Tohoku Mathematical Journal					1
Topology and its Applications	1	1		1	
Transactions of the American Mathematical Society		1	1	1	
Transformation Groups			2	2	

4.5.2 Publications of Postdoctoral Fellows

Author	Title	Journal	To Appear	ACK	AFF	Year
Junsik Bae	Linear Stability of Solitary Waves for the Isothermal Euler-Poisson System	Arch Rational Mech Anal 243 (2022) 257-327			Y	2022
Iacopo Brivio	Lifting globally F-split surfaces to characteristic zero	arXiv:2208.03690				2022
Iacopo Brivio	Invariance of plurigenera for some varieties with good minimal models	arXiv:2112.11257				2021
Chun-Wei Chang	Comments on identifying causal relationships in nonlinear dynamical systems via empirical mode decomposition	Nature Communications 13, 2860			Y	2022
Chun-Wei Chang	Causal networks of phytoplankton diversity and biomass are modulated by environmental context	Nature Communications 13, 1140.			Y	2022
Chun-Wei Chang	Reconstructing large interaction networks from empirical time series data	Ecology Letters 24: 2763–2774			Y	2021
Shih-Hsin Chen	Synchronization of Heterogeneous Forced First-Order Kuramoto Oscillator Networks: A Differential Inequality Approach	IEEE Transactions on Circuits and Systems I: Regular Papers, Vol. 69 (2021), No. 2, pp. 757–770			Y	2021
Jia-Yuan Dai	Ginzburg–Landau Patterns in Circular and Spherical Geometries: Vortices, Spirals, and Attractors	SIAM J. Applied Dynamical Systems Vol. 20, No. 4, pp. 1959–1984		Y	Y	2021
Jia-Yuan Dai	Ginzburg-Landau spiral waves in circular and spherical geometries	SIAM Journal on Mathematical Analysis, 53 (1), p. 1004–1028		Y	Y	2021
Jia-Yuan Dai	Ginzburg-Landau Patterns in Circular and Spherical Geometries: Vortices, Spirals, and Attractors	arXiv:2110.07104				2021
Simon-Raphaël Fischer	Curved Yang-Mills-Higgs gauge theories in the case of massless gauge bosons	Journal of Geometry and Physics, 162, article 104104, 2021				2021
Simon-Raphaël Fischer	Infinitesimal gauge transformations induced by Lie algebroid connections, in thecontext of Yang-Mills-Higgs gauge theory,	arXiv:2108.11061				2021
Ser-Wei Fu	Cylinder curves in finite holonomy flat metrics	Journal of Topology and Analysis (2021) https://doi.org/10.1142/S1793525321500308			Y	2021
Ser-Wei Fu	Flat grafting deformations of quadratic differentials on surfaces	Geom. Dedicata (2021) 214:119-138			Y	2021
Andrea Galasso	Equivariant fixed point formulae and Toeplitz operators under Hamiltonian torus actions and remarks on equivariant asymptotic expansions	Int. J. of Mathematics, Vol. 33, No. 2 (2022)		Y	Y	2022

Author	Title	Journal	To Appear	ACK	AFF	Year
Andrea Galasso	Functional calculus and Quantization commutes with reduction for Toeplitz operators on CR manifolds	arXiv:2112.11257				2021
Andrea Galasso	Equivariant Asymptotics of Szegö kernels under Hamiltonian SU(2) × S1 actions	arXiv:2205.01779				2022
Andrea Galasso	Commutativity of quantization with conic reduction for torus actions on compact CR manifolds	arXiv:2103.09485				2021
Andrea Galasso	Toeplitz operators on CR manifolds and group actions	arXiv:2103.05836				2021
Andrea Galasso	Equivariant fixed point formulae and Toeplitz operators under Hamiltonian torus actions	arXiv:2008.08269				2021
Andrea Galasso	On the singularities of the Szegő kernels on CR orbifolds	arXiv:2009.03579				2021
Oğuz Gezmiş	On Drinfeld modular forms of higher rank and quasi-periodic functions	Transactions of the American Mathematical Society, 375 (2022), 2387-2416			Y	2022
Oğuz Gezmiş	Trivial multiple zeta values in Tate algebras	Int. Math. Res. Not., vol. 2022, no. 18, pp 14319–14383				2022
Oğuz Gezmiş	Special values of Goss L-series attached to Drinfeld modules of rank 2	Journal de Théorie des Nombres de Bordeaux, 33(2021), no.2, 511-552			Y	2021
Brian Harvie	The Limit of the Inverse Mean Curvature Flow on a Torus.	Proc. Amer. Math. Soc. 150 (2022), 3049-3061.				2022
Brian Harvie	Inverse Mean Curvature Flow of Rotationally Symmetric Hypersurfaces	arXiv:2207.08107				2022
Brian Harvie	The Mass of the Static Extension of Small Spheres.	arXiv:2103.15713				2022
Brian Harvie	On the Uniqueness of Static Metric Extensions for CMC Bartnik Data	arXiv:1612.05241v3				2021
You-Hung Hsu	Exceptional collections, t-structures, categorical actions-sl2 case	arXiv:2103.17093				2021
You-Hung Hsu	A categorical action of the shifted q=0 affine algebra	arXiv:2009.03579				2021
Seonghyeon Jeong	Local Holder regularity of solutions to generated Jacobian equations	Pure and Applied Analysis 3-1 (2021), 163–188			Y	2021
Jesse Madnick	The Second Variation of Null-Torsion Holomorphic Curves in the 6-Sphere	Journal of Geometric Analysis (2022) 32: 395		Y	Y	2022
Jesse Madnick	The Mean Curvature of Special Lagrangian 3-Folds in SU(3)-Structures with Torsion	J. Geom. Phys. 162 (2021) 104090			Y	2021

Author	Title	Journal	To Appear	ACK	AFF	Year
Jesse Madnick	The Mean Curvature of First-Order Submanifolds in Exceptional Geometries with Torsion	Ann. Glob. Anal. Geom. (2021) 59: 27-67				2021
Jesse Madnick	Cohomogeneity-One Lagrangian Mean Curvature Flow	arXiv:2208.01574				2021
Jesse Madnick	A Variational Characterization of Calibrated Submanifolds	arXiv:2207.04275.				2022
Jesse Madnick	Free-Boundary Problems for Holomorphic Curves in the 6-Sphere	arXiv:2105.10562		Y	Y	2021
Jesse Madnick	Associative Submanifolds of Squashed 3-Sasakian Manifolds	arXiv:2103.17093				2021
Sanghyuck Moon	On the topological solutions with vortices and antivortices for the Maxwell-Chern-Simons O(3) sigma model on a torus	Journal of Differential Equations 309 (2022) 1-29			Y	2022
Sanghyuck Moon	Bubbling solutions of mixed type for a general non-abelian Chern-Simons-Higgs system of rank 2 over a torus	Nonlinear Analysis 214 (2022) 112552			Y	2022
Sanghyuck Moon	Nonlinear Schrödinger systems with mixed interactions: locally minimal energy vector solutions	Nonlinearity 34 (2021) 6473–6506			Y	2021
Sanghyuck Moon	Partly clustering solutions of nonlinear Schrödinger systems with mixed interactions	J. Funct. Anal. Volume 280 (2021) 108987			Y	2021
Sanghyuck Moon	Least energy solution for a scalar field equation with a singular nonlinearity	Proc. Roy. Soc. Edinburgh Sect. A, 151 (2021), 93-109			Y	2021
Sanghyuck Moon	Non-Abelian Chern-Simons-Higgs system with indefinite functional	arXiv:2109.15078				2021
Changningphabi Namoijam	Algebraic relations among hyperderivatives of periods and logarithms of Drinfeld modules	arXiv:2008.07490				2022
Changningphabi Namoijam	Hyperderivatives of periods and quasi-periods for Anderson t-modules	work in progress				2022
Changningphabi Namoijam	On Transcendence of special values of Goss L-functions attached to Drinfeld modules	work in progress				2022
Bin Nguyen	A new infinite family of irregular algebraic surfaces with canonical map of degree 8.	Archiv der Mathematik 119 (2022), 147–153		Y	Y	2022
Bin Nguyen	New examples of canonical covers of degree 3	Mathematische Nachrichten, Volume 295, Issue 3, (2022), pp. 450-467		Y	Y	2022
Bin Nguyen	Some examples of algebraic surfaces with canonical map of degree 20	Comptes Rendus - Mathématique, Volume 359 (2021) no. 9, pp. 1145-1153		Y	Y	2021

Author	Title	Journal	To Appear	ACK	AFF	Year
Bin Nguyen	Some infinite sequences of canonical covers of degree 2	Advances in Geometry, Volume 163, Issue 1, pp 143–148 (2021)			Y	2021
Bin Nguyen	Some algebraic surfaces with canonical map of degree 10, 12, 14.	arXiv:2207.04275				2022
Bharathwaj Palvannan	Codimension two cycles in Iwasawa theory and tensor product of Hida families.	Mathematische Annalen (2022) 383: 9–75			Y	2022
Yasuhiro Terakado	The discriminant of a hypersurface in weighted projective space	International Journal of Number Theory (2023),Published 18 August 2022, Online First.	Y		Y	2022
Yasuhiro Terakado	Hecke eigensystems of automorphic forms (mod p) of Hodge type and algebraic modular forms	Mathematische Annalen. (2022) 382: 69-102				2022
Yasuhiro Terakado	Canonical subgroups of generalized Drinfeld modules	Research in Number Theory (2021) 7:8				2021
Kazuki Tokimoto	Local Langlands correspondence for regular supercuspidal representations of GL(n)	International Mathematics Research Notices, no. 3, 2007-2073 (2021)				2021
Chien Hsun Wang	Stability conditions and braid group actions on affine A type quivers	Journal of algebra and application Vol. 21, No. 09, 2250174 (2022)			Y	2022
Kuan-Hsiang Wang	On non-local nonlinear elliptic equations involving an eigenvalue problem	Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales. Serie A. Matemáticas, 116:45 (2022)			Y	2022
Kuan-Hsiang Wang	Ground states for a linearly coupled indefinite Schrodinger system with steep potential well	Journal of Mathematical Physics, 62, 081505 (2021)			Y	2021
Kuan-Hsiang Wang	On indefinite Kirchhoff-type equations under the combined effect of linear and superlinear terms	Journal of Mathematical Physics, 62, 031505 (2021)			Y	2021
Kuan-Hsiang Wang	An eigenvalue problem for nonlinear Schrodinger-Poisson system with steep potential well	Communications on Pure and Applied Analysis, 20, pp 1497-1519			Y	2021
Yi-Sheng Wang	Geometric realization and its variants	Hokkaido M. J. 51(2) (2022)			Y	2022
Yi-Sheng Wang	Unknotting annuli and handlebody-knot symmetry	Topology Appl. 305 (2022)			Y	2022
Yi-Sheng Wang	Rigidity and symmetry of cylindrical handlebody-knots	Osaka J. Math.	Y		Y	2022
Yi-Sheng Wang	A table of n-component handlebody links of genus n+1 up to six crossings	Proc. Math. Camb. Phil. Soc.	Y		Y	2022

Yi-Sheng Wang	Resolution of singular fibers of an S^1-manifold	J. Topol. Anal.	Y		Y	2022
Yi-Sheng Wang	A complete invariant for closed surfaces in the three-sphere	J. Knot Theory Ramifications 30, 6 (2021)			Y	2021
David Wen	Higher Dimensional Elliptic Fibrations and Zariski Decomposition	Comm. in Contemporary Mathematics Vol. 24, No. 04, 2150024 (2022)			Y	2022
Peng-Jie Wong	Primes in the Chebotarev density theorem for all number fields	Journal of Number Theory 241 (2022) 700-737			Y	2022
Peng-Jie Wong	On Stark's class number conjecture and the generalised Brauer-Siegel conjecture	Bulletin of the Australian Mathematical Society 106 (2022), 288-300			Y	2022
Peng-Jie Wong	Counting zeros of the Riemann zeta function	Journal of Number Theory 235 (2022), 219-241			Y	2022
Peng-Jie Wong	Refinements of strong multiplicity one for GL(2)	Mathematical Research Letters	Y		Y	2022
Peng-Jie Wong	Counting zeros of Dedekind zeta functions	Mathematics of Computation Volume 91, Number 333, January 2022, pp 277–293				2021
Peng-Jie Wong	Almost all primes satisfy the Atkin-Serre conjecture and are not extremal	Research in Number Theory (2021) 7:31		Y	Y	2021
Peng-Jie Wong	Fourier coefficients of automorphic L-functions over primes in ray classes	arXiv:2208.10622				2022

4.6 Undergraduate Research and Summer Research Program

4.6.1 URP

NCTS URP 2021 (2021.10.1-2022.6.30)

主題名稱	指導老師	學員 1	學員 2	學員 3
1. 光學相位重建問題	陳鵬文 (中興大學)	王淑瑄 (中興應數四)		
2. Riemann-Hilbert 方法在可積系統的應用	黃信元 (交通大學)	姜鈞 (中山應數四)		
3. Bispectral analysis and its applications	吳浩樞 (Duke U.) 沈俊嚴 (台灣大學)	顏逸儒 (台大數學四)	張詠信 (台大數學四)	
4. Algebraic number theory towards local-global principles in arithmetic geometry	李庭諭 (台灣大學)	劉耀聰 (台大數學三)	李永丞 (台大數學三)	
5. Topics in Poisson geometry	廖軒毅 (清華大學)	張華炘 (清大數學二)		
6. Data Science with Application to Sleep Stage Automatic Scoring	劉聚仁 (成功大學)	邱能泰 (陽明交大醫學四)	郝嘉誠 (陽明交大電機三)	曾以諾 (成大數學四)
7. On Arithmetic of Multinorm One Tori 多重範一代數環面算術研究	余家富 (中研院)	洪梵雲 (台大數學四)	黃俊皓 (台師大數學三)	
8. On K3 surfaces: moduli spaces, automorphism groups and fibrations	陳榮凱 (台大數學)	陳沅蓁 (台大數學三)	蘇品丞 (台大物理五)	陳毅鴻 (台大數學四)
9. Combinatorial aspects of non-commutative probability theory and its application in data science	黃皓瑋 (中山大學)	蕭明 (台大數學二)	周子涵 (政大應數三)	

NCTS URP 2022

主題名稱	指導老師	學員 1	學員 2	學員 3
Heat and Bergman Kernels Asymptotics in Complex Geometry	蕭欽玉 (中研院數學所)	台大數學四 蔡以心		
L∞ algebra and its applications	廖軒毅 (清華數學)	清華理學院學士班四 劉思承	清華數學三 呂建德	清華數學三 翁麟翔
Denoising and Stiching of Images and Surfaces	樂美亨 (師大數學)	中央數學四 林固德	師大數學四 黃靖恩	
同步化問題中的隨機微分方程以及時滯微分方程	夏俊雄 (台大數學)	台大資工四 蔡仲恩		
Association of indoor temperature, humidity, and air pollutants with cognition and frailty in older adults	程蘊菁 (台大流行病學及預防醫學)	台大公衛三 陳姍萱	台大公衛三 黃映潔	
Algebraic geometry and analytic geometry (GAGA)	卓士堯 (清華數學)	清大數學四 吳沂騰	清大數學四 林俊廷	
異質性材料熱傳問題及電導係數求解問題的數學模型	曾昱豪 (高雄大應數)	高雄大應數四 李玉萱	高雄大應數三 曾柏翰	高雄大應數二 劉書伶
The connective constant of the self-avoiding random walk on planar lattices	方向 (中央數學)	中央數學四 吳念潔		

4.6.2 USRP

NCTS USRP 2022

主題名稱	指導老師	助教	學員 1	學員 2	學員 3	學員 4	旁聽
1) Comparison of Various Methods in Deformation Quantization	廖軒毅 (清大數學) 蕭欽玉 (中研院)	張晉嘉	清華數學二 張華炘	台大數學三 蔡以心	清大學士班三 劉思承	台大物理三 廖威宇	-
2)Two-Dimensional Random Walk	陳隆奇 (政大應數)	李柏駿	陽交大應數二 黃鈺誠	政大應數二 黃奕銘	高師大數二 徐丙忠	-	-
3) Noise Analysis in Reaction Network System	蔡志強 (清大數學)	洪士薰	東吳數學三 謝尚庭	中央大氣四 陳冠宏	-	-	-
4) Solitons and Inverse Scattering Transform	黃信元(陽交大應數)		台大大氣二 郭叡	中原應數二 顏巧雯	政大應數四 胡傳宇	-	-
5) Quantum Computation and Quantum Information with Applications	黃皓瑋 (清大數學) 林敏雄 (成大數學)	李冠群	中山應數二 劉芹榕	中正數學三 高志宏	彰師大數學二 吳家侑	中央數學三 李昀浩	東吳數學三 王靖騰
6) Numerical Methods for Image and Geometry Processing	樂美亨 (台師大數學)	廖家緯	臺師大數學三 黃靖恩	中央數學三 林固德	臺師大數學四 蔡育儒	-	-
7) Planar Statistics Physics and Bernoulli Percolation	李志煌 (台大數學) 林偉傑 (台大數學)	盧德倫 馬宗儀 張恒宇	中正數學三 洪偉傑	陽交大電機三 郝嘉誠	陽交大應數四 蘇彥維	陽交大應數三 蘇士紘	台大外文二 徐樂融
8) Topics in Boltzmann Equation	吳恭儉 (成大數學)	張慧慈	成大數學三 王凱立	中正數學三 朱威愷	-	-	-
9) Toric Varieties and Weighted Projective Spaces	陳榮凱(台大數學) 賴青瑞(成大數學) 陳正傑(中央數學)	陳延安 王士欣 簡瑋辰	台大數學四 鄭容濤	台大數學四 吳以理	台大數學四 陳毅鴻	台大數學四 黃建順	清大數學碩二 施政邦