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華中科技大學数学中心
Center for Mathematical Sciences

Newsletter, Spring 2025

華中科技大學 数学中心
Center for Mathematical Sciences

华中科技大学数学中心简介

在建设世界一流大学的征程中，数学学科的作用异常重要。华中科技大学高瞻远瞩，于2013年成立数学中心。华中科技大学数学中心一方面倡导数学不同分支之间的相互交叉，激发新的合作研究，催生新的研究领域和研究群体。另一方面引领数学与工科、理科，医科及其它学科之间的合作研究，实现交叉创新、 合作共赢。

作为我校国际交流与合作的平台，数学中心大力推动与发展“跨学科应用数学”合作研究。我们的跨学科合作研究领域包括数学与地球科学（物理海洋学和气候动力学）的交叉研究，以及数学与生命科学（计算和定量生物学）的交叉研究。

华中科技大学数学中心积极开展前瞻性研究，立足华中、辐射全国、影响海外。数学中心将国际先进的人才培养模式和研究机构运行机制有机融入到我国建设一流大学与一流学科的伟大事业之中，努力成为培养和聚集一流人才的平台， 国际交流与合作的平台，科教运行机制以及人事体制改革试点的平台。

数学中心成员包括院士，国家特聘专家，外专千人计划专家，长江学者，青年学术英才，楚天学者，洪堡学者和华中学者。还有一批海内外知名访问学者，博士后，博士生，以及来自多个国家的留学生。数学中心设有李国平讲座教授，东湖讲座教授，东湖数学论坛，和郭友中数理科学讲座。

希望重要的数学发现萌芽于此，
希望新的研究领域和研究群体产生于此，
希望著名数学家和科学家在此留下足迹，
希望科技界更深刻地感受到数学的作用：
数学强，则科技强；科技强，则国家强！

数学中心官网

数学中心微信公众号

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短课 Mini-Course

报告题目：Differential Calculus in the space of measures

报告人：Dr. Song Xuanye

报告时间：8:00pm-10:00pm（Beijing）

腾讯会议：598-947-8447

密码：123456

Syllabus: Through the learning of this course, students will grasp knowledge and skill in the new notions about the differentiation on the space of measures, with applications in control problems. The special attention will be paid to the novel definition of the derivatives of the functions defined on the space of measures in order to deal with the challenges in the study of mean-field game/control problems.

Schedule		Outline
Mar. 9, 2025	Course 1	Metric Spaces of Probability Measures
Mar. 14, 2025	Course 2	Differentiation on the space of measures I
Mar. 16, 2025	Course 3	Differentiation on the space of measures II
Mar. 21, 2025	Course 4	Convex space of measures
Mar. 23, 2025	Course 5	Ito’s Formula along flow of measures
Mar. 28, 2025	Course 6	Applications to McKean-Vlasov SDEs
Mar. 30, 2025	Course 7	Applications to optimal control problem

Academic Achievement 学术成果

数学中心近期研究成果

➢ 高婷

发表论文：

1. Peng Zhang, Ting Gao, Jin Guo, Jinqiao Duan, Action Functional as an Early Warning Indicator in the Space of Probability Measures via Schrödinger Bridge, Vol 13(3), 2025. Quantitative Biology.

随机动力系统中两个亚稳态之间的临界转变和临界现象是一个重要问题。在这项工作中，我们结合了从薛定谔桥和最优传输中衍生的综合框架，扩展了传统的 Onsager-Machlup 作用函数的方法，以研究两个亚稳态不变集之间的演化转变动力学。我们将这种方法应用于 Morris-Lecar 模型，研究了 Morris-Lecar 模型中亚稳态和稳定不变集（极限环或同宿轨道）之间的过渡动态。此外，我们分析了 ADNI 数据库中的真实阿尔茨海默病数据，以探索指示从健康状态过渡到 AD 前状态的早期预警信号。该框架不仅扩展了过渡路径以涵盖不变集上两个指定密度之间的度量，还展示了复杂疾病中预警指标或生物标志物的潜力。

2. Peng Zhang, Ting Gao, Jin Guo, Jinqiao Duan, Sergey Nikolenko, Early Warning Prediction with Automatic Labelling In Epilepsy Patients. The ANZIAM Journal. Published online 2025:1-16. doi:10.1017/S1446181124000178

通过患者的脑电图数据，提出了一个元学习框架来改善对早期发作信号的预测。所提出的双层优化框架可以帮助自动标记发作早期的噪声数据，并优化主干模型的训练精度。研究表明，不仅通过元学习获得的发作预测精度得到了显著提高，而且生成的模型还捕捉到了单个主干模型无法学习的噪声数据的一些内在模式。因此，元网络生成的预测概率是一种非常有效的预警指标。

已接收论文：

Event-triggered adaptive control for stochastic systems

——Jiani Cheng, Ting Gao, Jinqiao Duan

Accepted by Philosophical Transactions A.

本研究重点解决数据驱动随机动态系统中的逆问题并设计闭环反馈控制策略。我们提出

了一种噪声鲁棒控制器，即噪声 NG-RC，它将下一代水库计算 (NG-RC) 与随机分析相结合，以实现多时间尺度随机系统中的自适应事件触发控制 (ETC)。我们开发了噪声 NG-RC 控制器并通过扩展的随机 LaSalle 定理建立了其渐近稳定性，为非线性随机轨迹调节提供了理论保证。为了验证所提出的控制器的有效性和鲁棒性，我们在不同的时间尺度、噪声类型和强度下对随机 Van der Pol 系统进行了数值实验。此外，为了将我们的方法扩展到实际应用，我们使用 EEG 数据重建癫痫发作的底层随机动力学，并利用噪声 NG-RC 控制器，有效、准确地引导系统朝着期望的轨迹运行，而且在样本效率和计算成本方面也明显优于传统的人工神经网络方法。这项工作为控制多时间尺度随机动态系统提供了一个强大且可扩展的数据驱动框架。

- **郇真**

通过一个等变 2-群胚的高阶 Inertia 群胚上的 2-向量丛构造 2-等变椭圆上同调。

已接收论文：

Twisted equivariant quasi-elliptic cohomology and M-brane charge

——Zhen Huan

Accepted by Advances in Theoretical and Mathematical Physics

- **林聪萍**

已接收论文：

Personalized Prediction of Gait Freezing Using Dynamic Mode Decomposition

——Zhiwen Fu, Congping Lin, Yiwei Zhang

Accepted by scientific reports

Freezing of gait (FOG) is a common severe gait disorder in patients with advanced Parkinson's disease (PD). The ability to predict the onset of FOG episodes early on allows for timely intervention, which is essential for improving the life quality of patients. Machine learning and deep learning, the current methods, face real-time diagnosis challenges due to comprehensive data processing requirements. Their "black box" nature makes interpreting features and classification boundaries difficult. In this manuscript, we explored a dynamic mode decomposition (DMD)-based approach together with optimal delay embedding time to reconstruct and predict the time evolution of acceleration signals, and introduced a triple index based on DMD to predict and classify FOG. Our predictive analysis shows 86.45% accuracy in classification, and an early prediction rate of 81.97% of all samples with an average early prediction time of 6.13 seconds. This DMD-based approach has the potential for real-time patient specific FOG prediction.

Celebrity Story 名人故事

"中国居里夫人"王明贞——清华大学第一位女教授

王明贞（1906 年—2010 年）是中国近代著名的物理学家，被誉为"中国统计物理学研究的奠基人之一"，同时也是中国物理学界杰出的女性科学家代表。她的学术生涯跨越近一个世纪，并培养了大批物理学人才。王明贞的研究虽然以物理学为核心，但其工作与数学（尤其是应用数学和概率论）深度交叉，她的贡献主要体现在统计物理学中的数学理论构建与随机过程分析，特别是在布朗运动理论、噪声理论等领域。

一、学术背景：数学基因的觉醒

王明贞出生于苏州一个学术氛围浓厚的家族，她的父亲王季同是清末民初的数学家和机电专家，其兄弟姐妹中多人成为知名学者（如哥哥王守竞是量子物理学家，妹妹王淑贞是中国现代妇女先驱者，杰出的妇科专家）。王明贞 1926 年考入南京金陵女子大学，后转入燕京大学物理系，1932 年获硕士学位。1938 年赴美国密歇根大学留学，1942 年获物理学博士学位，师从统计物理学家 G.E.乌伦贝克（George Uhlenbeck），这段经历成为她数学思维系统性训练的起点。

在密歇根大学的博士研究中，她直面爱因斯坦、朗之万等巨匠留下的经典难题——布朗运动的数学描述。这一问题的本质，是将微观粒子的随机运动转化为可定量分析的数学框架。王明贞的突破在于：用随机微分方程（SDEs）重构多自由度系统的统计规律，这需要深厚的概率论与微分方程功底。1942 年，她的博士论文《布朗运动的理论》一经发表即震动学界，其中提出的公式被后世称为"王明贞公式"。

二、数学与物理的共舞：三大核心贡献

1.布朗运动理论的数学重构

王明贞的博士论文超越了爱因斯坦的经典模型。她通过引入多体系统的随机微分方程，解决了传统理论中忽略粒子间相互作用的局限性。王明贞最著名的成果是她与导师乔治·乌伦贝克（George Uhlenbeck）合作提出的王-乌伦贝克理论（Wang-Uhlenbeck Theory）。该理论系统研究了布朗运动的统计规律，给出了粒子在流体中随机运动的数学描述。其核心是推广了爱因斯坦和斯莫卢霍夫斯基的早期工作，引入更复杂的随机过程模型，特别是针对非平衡态系统的动力学行为。

王明贞对统计物理学，尤其是对玻耳兹曼方程和布朗运动有深入系统的研究。她首

次独立地从福克-普朗克（Fokker-Planck）方程和克雷默（Kramers）方程中推导出自由粒子和简单谐振子的布朗运动。她通过精确求解描述概率密度演化的福克-普朗克方程，获得了布朗粒子位移方差的解析表达式（即“王明贞公式”），揭示了微观随机性与宏观扩散现象的内在联系。

2.噪声理论的数学奠基

20 世纪 40 年代，王明贞转向电子学中的噪声问题研究。她利用傅里叶分析与随机过程理论，首次建立了电路热噪声的定量模型：推导出噪声功率谱密度的普适公式，证明其与系统阻抗和温度的关系；通过严格的数学证明区分“白噪声”与“色噪声”，为通信工程中的信号处理奠定了理论基础。

这一工作被评价为“将工程问题提升为数学物理的典范”。

3.统计力学中的数学方法创新

在统计物理领域，王明贞的数学贡献体现为：

多体系统概率分布的统一框架：她将相空间积分与马尔可夫链理论结合，构建了适用于非理想气体的广义概率分布函数；

蒙特卡洛方法的理论铺垫：尽管受限于早期计算条件，但其建立的随机过程模型为后来的数值模拟提供了数学基础。

王明贞在博士论文中解决了长时间以来悬而未决的“阻尼谐振子问题”，通过数学推导证明了谐振子在随机力作用下的能量分布规律。这一成果需要结合概率论、微分方程和统计物理的深入分析，展现了她在数学建模与物理问题结合上的卓越能力。

三、数学工具的实际影响

王明贞的研究不仅停留在理论层面，更催生了跨学科的应用突破：

“王明贞公式”的工程应用：其布朗运动方差公式 $\left\langle x^2 \right\rangle = \frac{2kT}{\zeta} t$ 被直接用于微流控芯片设计、纳米颗粒扩散分析等领域；

生物物理与金融数学的启示：她发展的随机过程理论，为蛋白质折叠动力学研究、金融市场波动模型提供了数学语言；

开源科学计算的先驱性启发：她对复杂系统数学建模的追求，与当代开源工具（如 FEniCS、COMSOL）的核心思想不谋而合。

四、教学传承：数学思维的播种者

1955 年，王明贞归国任教于清华大学。在特殊历史时期历经磨难（包括六年冤狱），她仍坚持编写《统计物理学》讲义，其特点在于：

强调数学推导的严谨性：例如，从刘维尔定理出发推导系综理论，要求学生独立完成随机微分方程的求解；培养交叉学科视野：鼓励学生将泛函分析、群论等数学工具应用于物理问题。

她的弟子中涌现出多位中国统计物理与计算数学领域的领军人物。

五、科学遗产：跨越世纪的数学回响

2010 年，王明贞以 104 岁高龄辞世，但其科学遗产依然鲜活：

随机过程理论的里程碑：她的工作被写入《Handbook of Stochastic Methods》等经典著作，成为概率论教材的必读案例；

女性科学家的精神丰碑：作为 20 世纪少数在数学物理领域取得原创成果的女性，她证明了“数学不需要性别标签”；

交叉学科的永恒启示：她的一生昭示，重大科学突破往往诞生于数学与物理的深度对话中。

王明贞的科学生涯，是一部以数学为笔、以物理为墨的史诗。在布朗运动的随机轨迹中，在电路噪声的频谱曲线里，她用数学语言揭示了自然界的深层秩序。今天，当人工智能依赖随机梯度下降优化神经网络，当生物学家用朗之万方程模拟分子运动，我们依然能感受到这位女科学家留下的智慧印记——她不仅是数学与物理的摆渡者，更是一位用公式书写真理的诗人。

原文链接：

https://mp.weixin.qq.com/s/mf2YPTkoHfbtG8oQdlVtlQ

https://baike.baidu.com/item/%E7%8E%8B%E6%98%8E%E8%B4%9E/36805

Victor Pavlovich Maslov——俄罗斯数学物理学家

Victor Pavlovich Maslov（1930 年 6 月 15 日－2023 年 8 月 3 日）是苏联和俄罗斯著名的数学物理学家，在应用数学、量子力学渐近方法及辛几何等领域作出了开创性贡献。

于 1953 年毕业于莫斯科国立大学物理系，并于 1957 年和 1966 年分别在该校完成了硕士和博士学位论文答辩。1984 年，Maslov 越过通讯会员这一级别，直接成为俄罗斯科学院院士。他著有 700 多篇科学论文，其中包括 14 部专著。

从 1968 年到 1998 年，Maslov 担任莫斯科电子工程学院（Moscow Institute of Electronic Engineering）应用数学系（苏联首个）主任，该系由他创立。20 世纪 60 至 80 年代，苏联在这一知识领域的专家培训体系得以形成，这主要得益于他的贡献。从 1987 年到 2007 年，他担任俄罗斯科学院力学问题研究所（Ishlinsky Institute for Problems in Mechanics）自然灾害力学实验室（原名为力学数学方法实验室，由 P. Ya. Kochina 创立）主任。1992 年至 2016 年，他（接替 N. N. Bogolyubov）担任莫斯科国立大学物理学院量子统计与场论系主任。自那时起，他的学生便一直在这两个科学系工作。

Maslov 是《俄罗斯数学物理杂志》和《数学笔记》的主编，《理论与数学物理》和《不动点理论与应用杂志》的编委会成员，以及《De Gruyter 数学论述》系列的编委会成员。他曾任俄罗斯应用数学科学院科学委员会主席、俄罗斯理论与应用力学国家委员会成员、国际索尔维物理与化学研究所名誉会员。

他的工作开创了新的数学领域：几何量子理论、拉格朗日几何和热带数学。他的基本成果包括引入现代辛几何的关键对象：拉格朗日流形、Maslov 指数和 Maslov 类；在量子力学和辛几何中，他提出的 Maslov 指数，用于描述相空间中闭合路径的拓扑性质。这一概念在量子场论、几何光学及动力系统分析中至关重要，尤其在处理 WKB 近似（半经典近似）时不可或缺。引入了“Maslov 正则算子”，这是波和量子方程半经典渐近解理论的基本构造。他提出了在阴影域和隧道域中应用经典力学方程的复解来构造小波长或普朗克常数的指数衰减渐近性的概念。这一概念后来导致了复杂细菌理论和瞬子理论。在等离子体理论中，他获得并研究了考虑频率倍增的三波相互作用方程，推广了 Korteweg-de Vries 方程和三波过程方程。在流体力学和磁流体力学中，他得到并研究了快速振荡波的方程。Maslov 在统计力学和量子统计以及超导和超流体理论中发展了混沌理论。他的想法导致了幂等分析的产生，特别是，它允许人们将一类重要的非线性方程简化为线性方程，并导致了热带几何的出现（MSC-2020 分类中的 14T 热带几何），其

中特别包含“Maslov 去量化”一词。

Maslov 站在现代科学的前沿，多次参与解决国家面临的复杂问题。1986 年，他领导了一组数学家的工作，为切尔诺贝利核电站第四台受损机组的石棺设计进行了计算。在这项工作中产生的想法后来形成了整个数学研究领域的基础。

Maslov 曾获得苏联国家奖（1978 年）、列宁奖（1982 年）、俄罗斯联邦两项国家奖（1997 年和 2013 年）、德米多夫奖（2000 年）和俄罗斯科学院李雅普诺夫金质奖章。

Maslov 的成果深刻影响了现代数学物理的发展，其指数理论成为几何量子化的基石。2023 年逝世后，学界通过专题研讨会和论文特辑纪念他的学术遗产。Maslov 是 20 世纪数学物理领域的巨擘，其工作架起了经典与量子世界的桥梁，并在多学科中持续发挥影响力。

参考链接：

https://link.springer.com/article/10.1134/S0001434624110257

Popular Mathematics 数学热门话题

德国国家科学院

German National Academy of Sciences——Leopoldina

在德国科学与文化的辉煌星空中，德国国家科学院——利奥波第那（Deutsche Akademie der Naturforscher Leopoldina） 如同一座跨越四个世纪的灯塔，见证并引领着人类科学探索的进程。作为全球历史最悠久的自然科学与医学学术机构之一，利奥波第那不仅承载着德意志民族的科学精神，更在全球范围内塑造着科学政策的未来方向。

利奥波第那科学院成立于 1652 年，由四位年轻医生在神圣罗马帝国城市施韦因富特（Schweinfurt）创立，最初名为“利奥波第那自然探索者学院”（Academia Naturae Curiosorum），以神圣罗马皇帝利奥波德一世之名获得皇家特许。其成立初衷是为医学与自然科学研究建立交流网络，成为欧洲早期科学革命的推动者之一。

随着德国科学崛起，利奥波第那吸引了包括歌德、洪堡兄弟、罗伯特·科赫在内的顶尖学者。1878 年，科学院永久迁址哈勒（Halle），依托马丁·路德大学形成学术共生体。2008 年，德国政府正式赋予利奥波第那“德国国家科学院”地位，使其成为代表德国参与国际科学事务的核心机构，标志着其从传统学术组织向国家战略智库的转型。

德国国家科学院现有来自全球 30 多个国家的约 1700 名成员，涵盖自然科学、医学、工程学及社会科学领域，其中近 200 位为诺贝尔奖、菲尔兹奖得主。院士经由严格选举产生，终身荣誉制保障学术独立性。科学院下设 28 个学科部类，包括经典学部（如物理学、化学）与前沿交叉学部（如科学伦理、人工智能）。每个学部由院士组成的委员会领导，负责领域内战略研究规划。日常运作由主席团（Präsidium）统筹，现任主席为系统生物学家杰拉尔丁·劳克斯（Geraldine Rauch）。总部设于哈勒，柏林分部侧重政策对话与国际合作。

德国国家科学院主导“生物经济”“气候工程”等国家重大科研项目，整合高校、研究所与企业资源。发布权威科学评估，如《基因编辑技术的伦理边界》《全球健康与流行病防控》等，为学界提供方向指引。作为德国政府法定科学咨询机构，就气候变化、能源转型、数字化转型等议题提交建议报告。例如，其《碳中和路径研究》直接影响了德国《气候保护法》修订。在 COVID-19 疫情期间，牵头组建跨学科专家组，发布疫情

建模、疫苗分配策略报告，塑造欧洲防疫政策框架。

德国国家科学院建立 G7/G20 科学顾问机制，代表德国参与全球科技治理，推动签署《海洋塑料污染防治联合声明》等国际协议。德国国家科学院与中国科学院、工程院建立定期对话机制，联合发起“可持续城市发展”“清洁能源技术”合作项目，成为中德科学合作枢纽。

德国国家科学院以奖章、奖品和荣誉会员的形式颁发奖项，以表彰杰出的科学成就。该学院的最高荣誉——利奥波第那荣誉院士，是为那些因其科学成就和对学院的服务而特别值得尊敬的成员保留的。物理学家马克斯 •普朗克（1941 年）和维尔纳 •海森堡（1967 年）是获得这一荣誉的人之一。2010 年，前利奥波第那主席 Volker ter Meulen 被授予荣誉会员，以表彰他的工作导致利奥波第那被任命为德国国家科学院。荣誉赞助者的头衔授予非会员，但他们在各自的领域做出了重大贡献，使学院受益。贝特霍尔德•贝茨（1987 年）和沃尔夫冈•弗拉德•赫瓦尔德（1995 年）都曾获此殊荣。

面对 21 世纪科学发展的复杂挑战，德国国家科学院正聚焦三大方向：

1.数字化转型伦理：构建人工智能、大数据技术的全球治理框架；

2.行星健康（Planetary Health）：协调气候变化、生物多样性保护与人类健康研究；

3.科学民主化：通过公民科学（Citizen Science）项目促进公众参与知识生产。

从 17 世纪显微镜下的微观世界探索，到今日应对气候危机的全球行动，德国国家科学院始终站在科学与社会的交汇点。它不仅是德国科学荣耀的守护者，更是人类理性与协作精神的象征。在“后真相时代”的喧嚣中，德国国家科学院以其 370 年的厚重积淀，持续证明着科学共同体的力量——唯有以证据为基、以对话为桥，方能照亮人类前行的暗礁。这座科学殿堂将继续书写属于全人类的智慧史诗。

德国国家科学院数学院士名单（69 名）：

1. Werner Ballmann	2. Paul Biran	3. Jean-Michel Bismut
4. Erwin Bolthausen	5. Carl de Boor	6. Peter Bühlmann
7. Marc Burger	8. Noam Chomsky	9. Adrian Constantin
10. Joachim Cuntz	11. Wolfgang Dahmen	12. Ingrid Daubechies
13. Camillo De Lellis	14. Christopher Deninger	15. László Erdős
16. Hélène Esnault	17. Gerd Faltings	18. Hans Föllmer
19. Mariano Giaquinta	20. Friedrich Götze	21. Wolfgang Hackbusch
22. Martin Hairer	23. Ursula Hamenstädt	24. Günter Harder

25. Helmut Hofer	26. Annette Huber-Klawitter	27. Gerhard Huisken
28. Huybrechts Huybrechts	29. Jürgen Jost	30. Bernhard Korte
31. Klaus Krickeberg	32. Marc N. Levine	33. László Lovász
34. Wolfgang Lück	35. Svitlana Mayboroda	36. Stefan Müller
37. Werner Müller	38. Felix Otto	39. Jacob Palis
40. Michael Rapoport	41. Walter Schachermayer	42. Peter Schneider
43. Peter Scholze	44. Alexander Schrijver	45. Karl Sigmund
46. Wolfgang Soergel	47. Hans J. Stetter	48. Dietrich Stoyan
49. Volker Strassen	50. Catharina Stroppel	51. Michael Struwe
52. Alain-Sol Sznitman	53. László Székelyhidi	54. Ulrike Tillmann
55. Yuri Tschinkel	56. Maryna Viazovska	57. Eva Viehmann
58. Claire Voisin	59. Nanny Wermuth	60. Wendelin Werner
61. Anna Wienhard	62. Burkhard Wilking	63. Barbara Wohlmuth
64. Gisbert Wüstholz	65. Don Zagier	66. Eduard Zehnder
67. Günter M. Ziegler	68. Thomas Zink	69. Sara Anna van de Geer

德国国家科学院物理院士名单（98 名）：

1. Eduard Arzt	2. Ralf Bender	3. Gunnar Berg
4. Dieter Bimberg	5. Rainer Blatt	6. Klaus Blaum
7. Immanuel Felix Bloch	8. Eberhard Bodenschatz	9. Patrick Bruno
10. Alessandra Buonanno	11. Ignacio Cirac	12. Marileen Dogterom
13. Helmut Dosch	14. Persis S. Drell	15. Jochen Feldmann
16. Harald Fuchs	17. Hongjun Gao	18. Reinhard Genzel
19. Elisabeth Giacobino	20. Herbert Gleiter	21. Eva K. Grebel
22. Siegfried Großmann	23. Sibylle Günter	24. Peter Hänggi
25. Theodor W. Hänsch	26. Günther Gustav Hasinger	27. Stefan Hell
28. Thomas Henning	29. Rolf-Dieter Heuer	30. Catherine Heymans
31. Frank Jülicher	32. Guinevere Kauffmann	33. Ursula Keller
34. Wolfgang Ketterle	35. Tobias Kippenberg	36. Jürgen Kirschner
37. Klaus von Klitzing	38. Sir Peter Knight	39. Jörg P. Kotthaus
40. Ferenc Krausz	41. Kurt Kremer	42. Rolf-Peter Kudritzki

43. Max G. Lagally	44. Astrid Lambrecht	45. Paul Leiderer
46. Karl Leo	47. Gerd Leuchs	48. Hannes Lichte
49. Detlef Lohse	50. Daniel Loss	51. Ke Lu
52. André Maeder	53. Gernot Neugebauer	54. Stuart Parkin
55. Felicitas Pauss	56. Itamar Procaccia	57. Gisbert Frhr. zu Putlitz
58. Hans-Joachim Queisser	59. Helmut Rauch	60. Achim Richter
61. Monika Ritsch-Marte	62. Hans-Walter Rix	63. Ángel Rubio
64. Konrad Samwer	65. Roland Sauerbrey	66. Matthias Scheffler
67. Hans Joachim Schellnhuber	68. Wolfgang Schleich	69. Peter Schneider
70. Herwig Schopper	71. Bernard F. Schutz	72. Petra Schwille
73. Alexander Mikhailovich Sergeev	74. Christine Silberhorn	75. Uzy Smilansky
76. Joachim P. Spatz	77. Volker Springel	78. Johanna Stachel
79. Alexei Starobinsky	80. Rashid Sunyaev	81. Subra Suresh
82. Samuel C. Ting	83. J. Peter Toennies	84. Joachim Trümper
85. Viola Vogel	86. Grigory E. Volovik	87. Martin Wegener
88. Hans-Arwed Weidenmüller	89. Simon D. M. White	90. Roland Wiesendanger
91. Peter G. Wolynes	92. Jackie Y. Ying	93. Anton Zeilinger
94. Jie Zhang	95. Annette Zippelius	96. Martin Zirnbauer
97. Peter Zoller	98. Ewine van Dishoeck	

网页链接：

https://www.leopoldina.org/en/about-us/

在一位数学天才英年早逝后，她的思想获得了新的生命

Years After the Early Death of a Math Genius, Her Ideas Gain New Life

——Joseph Howlett

原文链接：
https://www.quantamagazine.org/years-after-the-early-death-of-a-math-genius-her-ideas-gain-new-life-20250303/

一个新的证明扩展了已故 Maryam Mirzakhani（第一位获得数学最高荣誉菲尔兹奖 Fields Medal 的女性）的工作，巩固了她作为异域数学领域先驱的遗产。

作为一名研究生，Maryam Mirzakhani（中）改变了双曲几何领域。但她在 40 岁时去世，当时她还没能回答许多令她感兴趣的问题。数学家 Laura Monk（左）和 Nalini Anantharaman 正在继续她的工作。

In the early 2000s, a young graduate student at Harvard University began to chart an exotic mathematical universe — one inhabited by shapes that defy geometric intuition. Her name was Maryam Mirzakhani, and she would go on to become the first woman to win a Fields Medal, math’s highest honor.

Her earliest work dealt with “hyperbolic” surfaces. On such a surface, parallel lines arc away from each other rather than staying the same distance apart, and at every point, the surface curves in two opposing directions like a saddle. Although we can picture the surface of a sphere or doughnut, hyperbolic surfaces have such strange geometric properties that they're impossible to visualize. But they're also important to understand, because such surfaces are ubiquitous in mathematics and even string theory.

Mirzakhani was an influential cartographer of the hyperbolic universe. While still in graduate school, she developed groundbreaking techniques that allowed her to start cataloging these shapes, before moving on to revolutionize other areas of mathematical research. She hoped to revisit her map of the hyperbolic realm at a later date — to fill in its details and make new discoveries. But before she could do so, she was diagnosed with breast cancer. She died in 2017, just 40 years old.

Two mathematicians have since picked up the thread of her work and spun it into an even deeper understanding of hyperbolic surfaces. In a paper posted online last month, Nalini Anantharaman (opens a new tab) of the Collège de France and Laura Monk (opens a new tab) of the University of Bristol have built on Mirzakhani's research to prove a sweeping statement about typical hyperbolic surfaces (opens a new tab). They have shown that surfaces once thought to be rare, if not impossible, are actually common. In fact, if you were to pick a hyperbolic surface at random, it essentially would be guaranteed to have certain critical properties.

"This is a landmark result," said Peter Sarnak (opens a new tab), a mathematician at Princeton University. "There'll be a lot more that will come out of this."

The work, which has not yet been peer reviewed, suggests that hyperbolic surfaces are even stranger and less intuitive than anyone had imagined. It also builds on Mirzakhani's titanic mathematical legacy, reigniting her dream to illuminate this universe of unimaginable shapes.

A Packed Thesis

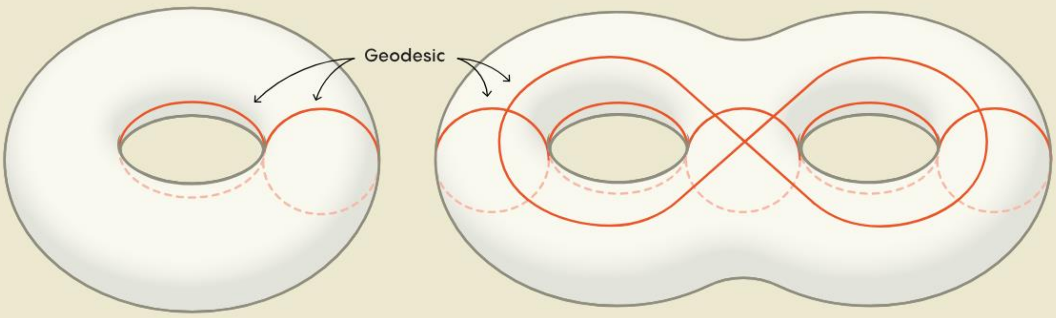
As a child growing up in Tehran, Mirzakhani, a voracious reader, hoped to one day write books of her own. But she also excelled in mathematics, and ultimately won two gold medals at the International Mathematical Olympiad, a prestigious competition for high school students. In 1999, after graduating from the Sharif University of Technology, she went to Harvard for graduate school. There she fell in love with hyperbolic geometry. An avid doodler, she enjoyed the challenge of trying to make sense of shapes that by definition could not be drawn.

"A hyperbolic surface is a bit like a puzzle that you can put together locally but you can't actually ever finish in our universe," said Alex Wright (opens a new tab), a mathematician at the University of Michigan and Mirzakhani's former postdoctoral fellow. That's because every piece of the puzzle is curved in the shape of a saddle. You can fit a few pieces together, but never in a way that fully closes the surface — at least not in our flat, three-dimensional space. This makes hyperbolic surfaces particularly difficult to study. Even basic questions about them remain open.

To get a handle on a hyperbolic surface, mathematicians study closed loops that live on it. These loops, called geodesics, come in all sorts of shapes; for a given shape, they carve out the shortest possible path from one point to the next as they return to their start. The more holes a surface has, the more varied and complicated its geodesics can get. By studying how many distinct geodesics of a given length there are on a surface, mathematicians can begin to understand what the surface looks like as a whole.

How Geodesics Illuminate Surfaces

To understand a surface, mathematicians study paths on it — called geodesics — that circle back to their starting point along the shortest possible trajectory.



Both of these shapes have infinitely many geodesics, so mathematicians instead count the number of geodesics up to a given length. This number grows as the number of holes in a surface increases.

Mirzakhani became obsessed with these circumnavigating curves. In discussions with colleagues, she brought them up constantly, her usual restraint evaporating. She often spoke breathlessly of geodesics and related objects as if they were characters in a story. "I remember when she would give talks, she would ask these two questions: How many curves are there, and where are they?" said Kasra Rafi (opens a new tab) of the University of Toronto.

While still in graduate school, she developed a formula that allowed her to estimate, for any hyperbolic surface, how many geodesics there were up to a given length. This formula not only allowed her to describe individual surfaces; it also enabled her to prove a famous conjecture in string theory (opens a new tab), and gave her insight into what kinds of hyperbolic surfaces it was possible to construct.

After completing her graduate degree, Mirzakhani went on to make major advances in geometry, topology and dynamical systems. But she never forgot the subject of her Ph.D. thesis.

She hoped to learn more about the creatures that lived in the hyperbolic zoo she had classified. In particular, she wanted to understand what a typical hyperbolic surface looked like. Often, mathematicians first study objects — graphs, knots, sequences of numbers — that they can construct. But their constructions are usually "not at all typical," said Bram Petri (opens a new tab) of Sorbonne University. "We tend to draw very special things." A typical graph, knot or sequence, selected at random, will look very different.

And so Mirzakhani began picking hyperbolic surfaces at random and studying their properties. "She had the perfect tools, so it was very natural," Wright said.

But she died before she could really pursue this line of inquiry. "She was really just developing the machinery," Monk said, "and then didn't have the time to use it."

Picking Up the Thread

Monk never thought she would be the one to pick up where Mirzakhani had left off. In fact, until she was in her early 20s, she had no intention of pursuing a career in mathematical research. She had planned to become a teacher since she was a child, when she would tutor fellow students to stave off her boredom in math classes. "I was pretty miserable at school," she said. "I would kind of keep myself busy by being the assistant teacher."

She enrolled in a master's program at Paris-Saclay University, one of three women in the

40-person cohort. Near its end, she learned that both of the other women were also planning to leave academia. The exodus made her question whether their plans reflected "our own individual choices and desires," she said, "or were we more affected than we realized by being in a setting where we were very much the exception." She felt a duty to the girls she had been planning to teach to become an example of a successful woman in mathematics.

So she decided to pursue a doctorate. "At least one of us has to do it," she told herself. "Otherwise it's quite sad." (Later, one of the other women also got a Ph.D.)

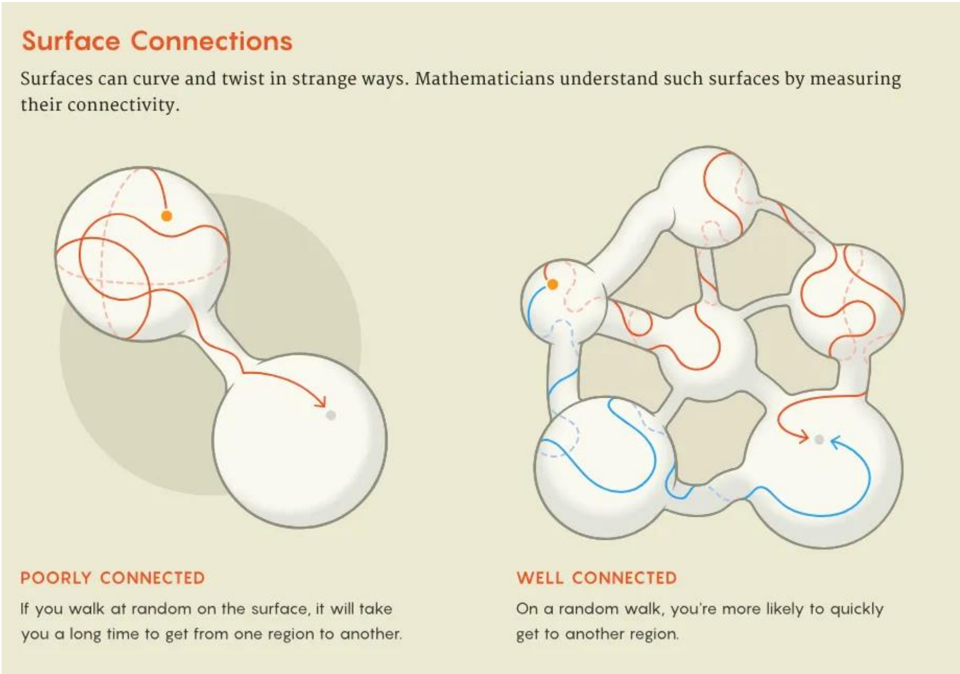
At the suggestion of one of her professors, Monk took a train to meet Nalini Anantharaman, a potential adviser who, like Mirzakhani, was an expert in multiple fields. In fact, Anantharaman had met Mirzakhani several times over her career — they were about the same age and interested in similar topics. Both also shared a passion for the humanities: Just as Mirzakhani had almost dedicated her studies to literature, Anantharaman had trained as a classical pianist, and hadn't been sure whether she would go into music or math.

In 2015, both mathematicians ended up visiting the University of California, Berkeley, for a semester. Mirzakhani's daughter and Anantharaman's son were close in age, and the two mathematicians occasionally met at a local playground, where they talked about motherhood while their children played.

Anantharaman knew that Mirzakhani had begun experimenting with random hyperbolic surfaces toward the end of her life. She was now hoping to build on that work.

One way to characterize a hyperbolic surface is to measure how connected it is. Imagine you're an ant walking on a surface in a random direction. If you walk for a while, are you equally likely to end up anywhere on the surface? If it's well connected, with plenty of possible paths between its various regions, then the answer is yes. But if it's poorly connected — like a dumbbell, which consists of two large regions attached by a single narrow bridge — you might instead spend a long time wandering on just one side before you find a way to cross to the other.

Mathematicians measure how connected a surface is using a number called the spectral gap. The bigger its value, the more connected the surface. Even though it's still impossible to imagine the surface, the spectral gap offers a way to think about its overall shape. “This is like a way of quantifying the sentence, ‘What does the surface look like?’” Rafi said.



While the spectral gap can theoretically be any value between 0 and 1/4, most of the hyperbolic surfaces that mathematicians have been able to construct have a relatively low spectral gap. It wasn’t until 2021 that they figured out how to build surfaces (opens a new tab) with any number of holes that had the highest possible spectral gap — that is, surfaces that were maximally connected.

But even though there are relatively few known hyperbolic surfaces with a high spectral gap, mathematicians suspect that they’re common. There is a vast and largely unexplored universe of hyperbolic surfaces. While mathematicians usually can’t construct individual surfaces in this universe, they hope to understand the general properties of a typical surface. And when they look at the population of hyperbolic surfaces as a whole, they expect that most have a spectral gap of 1/4.

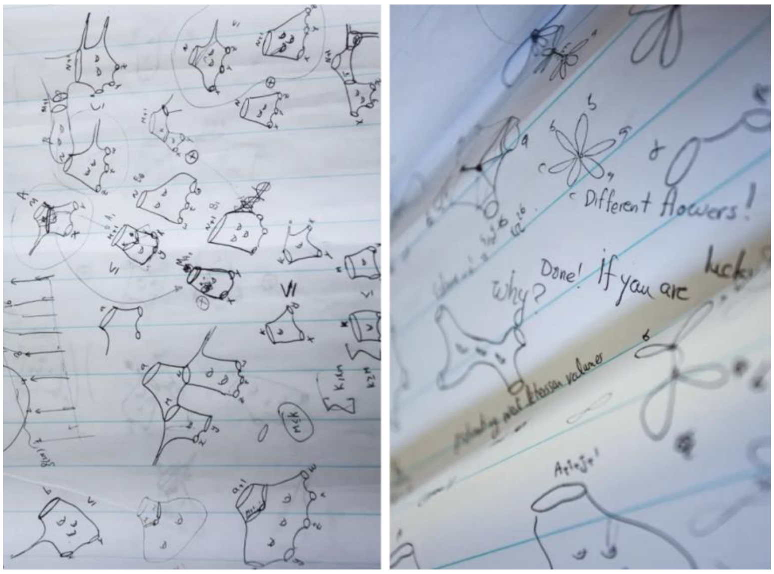
That’s the problem Anantharaman hoped to assign her new graduate student. Monk, eager to work closely with a female mentor and to set ambitious goals for herself — “if I’m going to do a Ph.D., I’ll really do it,” she remembers thinking — signed on.

Writing the Sequel

In 2018, just one year after Mirzakhani's death, Monk began her graduate studies with Anantharaman. Her first step was to learn everything she possibly could about Mirzakhani's work on hyperbolic surfaces.

It was known that if you could get an accurate enough estimate of the number of closed geodesics on a surface — those looped paths that Mirzakhani had studied so intensively — you would be able to compute the surface's spectral gap. Monk and Anantharaman needed to show that almost all hyperbolic surfaces have a spectral gap of 1/4. That is, the likelihood of picking a surface with an optimal spectral gap would approach 100% as the number of holes in the surface increased.

The pair started with the formula for counting geodesics that Mirzakhani had come up with during her Ph.D. The problem was that this formula underestimates the number of geodesics. It counts most, but not all, of them — it misses more complicated geodesics that cross themselves before returning to their start, like a figure eight encircling two holes.



But using Mirzakhani's limited formula, Monk and Anantharaman saw a way to prove a relatively large spectral gap. "It looked almost like a miracle," Anantharaman said. "It's still quite mysterious to me that it works so well."

What if she and Monk could sharpen Mirzakhani's formula to count the more complicated geodesics, too? Perhaps they could get their count to be accurate enough to translate into a spectral gap of 1/4, something that mathematicians before them had hoped to do, too.

Anantharaman suddenly remembered an email she had received from Mirzakhani just a couple of years before she died, posing a series of questions about the relationship between the spectral gap and counting geodesics. “At the time, I didn’t really know why she was asking all these questions,” Anantharaman said. But now she wondered whether Mirzakhani might have been planning to take a similar approach.

Monk spent part of her time in graduate school figuring out a way to extend Mirzakhani’s formula to more complicated geodesics. While doing so, she also wrote long, detailed descriptions of key concepts that Mirzakhani had not fully explained in her original papers. “I feel like some of her ideas were just put on the table for someone to kind of explain them to the community because she didn’t have a chance to do it,” she said.

By 2021, Monk had figured out how to count up all sorts of geodesics that had previously been inaccessible. She and Anantharaman knew that, with some additional work, they could probably use their new formula to get a better estimate of the spectral gap. But rather than publishing a partial result, they were determined to achieve the full 1/4 goal.

Then they got stuck.

Revisiting the Tome

There was one particularly gnarly type of geodesic that kept getting in their way. These geodesics would wind around the same region of a surface for a long time, forming convoluted tangles. The tangles appeared only on a small number of ornery surfaces, but when they did, they appeared in droves. If Monk and Anantharaman included them in their total count, it would throw off the computation they needed to perform to translate the count into the spectral gap — giving them an output smaller than 1/4.

The situation seemed hopeless, Monk said.

Her dejection only deepened when two independent teams published papers a couple of months apart in which they proved a spectral gap (opens a new tab) of 3/16 (opens a new tab). The news didn't bother Anantharaman; she only cared about getting to 1/4. "When I start working on something, I kind of fall in love with a distant goal," she said — apparently a trait she shared with Mirzakhani.

But Monk, still in the last year of her Ph.D. and needing a result that would let her finish her thesis, wondered if they should have settled for less. "I was a bit disheartened that we hadn't thought of doing that," she said.

Alex Wright, who was on one of the teams that achieved the 3/16 result, understood her perspective. "It's pretty unusual for a graduate student to be working on a problem that ambitious," he said. And it didn't seem as if anyone was going to figure out a way to achieve 1/4.

But Anantharaman had an idea: to turn to a different area of math, called graph theory, for inspiration. Remember that Anantharaman and Monk were trying to show that most hyperbolic surfaces are as connected as possible. Two decades earlier, the mathematician Joel Friedman (opens a new tab) proved that most graphs — collections of vertices and edges that appear all over mathematics — have this property.

But Friedman's result was not easy to translate. "Its an infamously hard result with a super long proof that resisted simplification," Wright said.

Anantharaman had tried to read Friedman's proof when she and Monk began their project. But like so many other mathematicians, she found it impenetrable. "At the time, I really didn't understand it at all," she said. Now she returned to it in search of new clues.

She found them. Certain steps of the proof looked familiar, like a graph-theoretic analog of what she and Monk had been trying to do with their hyperbolic surfaces. In fact, she realized, Friedman had encountered complicated paths between vertices in his graphs that, like her tangled geodesics, prevented him from getting the best estimate of the spectral gap. But somehow he had found a way to deal with these paths, and Anantharaman couldn't quite understand how.

In May 2022, she and Monk organized a workshop and invited Friedman to speak about his work. “They really needed a technique that was deep in the bowels of my proof,” he said.

He had essentially found a way to prove that he could remove the graphs with problematic paths from his calculations entirely. After speaking with Friedman, Monk and Anantharaman realized they could do the exact same thing. There was a lot of work left to do: It would be difficult to convert Friedman’s method into something that would work for hyperbolic surfaces. But their doubts were assuaged. “It was very exciting,” Monk said. “At this point, it was quite clear that we could finish.”

A Growing Legacy

In early 2023, the two mathematicians wrote a paper that sketched out what they had done so far. In it, they proved a record 2/9 spectral gap (opens a new tab). “That felt like a very nice intermediate step,” Monk said.

The following year, they adapted Friedman’s methods (opens a new tab), and wrote up a plan for how they would use it to get to 1/4 (opens a new tab). Last month, they finally completed the proof (opens a new tab), showing that a randomly selected hyperbolic surface is likely to have the maximal spectral gap. The result tells mathematicians more about hyperbolic surfaces than they have ever known. Other researchers now hope to use the pair’s techniques to answer other major questions, including one about important surfaces in number theory and dynamics.

This kind of work “instantly creates an avalanche of results that go together,” said Anton Zorich (opens a new tab), a mathematician at the Institute of Mathematics of Jussieu in Paris.

It also allowed Monk and Anantharaman to gain a deep familiarity with Mirzakhani’s research. Although Monk has still never watched any of Mirzakhani’s recorded lectures or heard her voice — preferring her to remain “a bit of a mystery in my mind,” she said — she feels as if she knows Mirzakhani through her proofs. “When you read the works of someone in detail, you end up understanding things beyond the sheer content of the work, about how they were thinking,” Monk said.

She’s honored to have been able to extend Mirzakhani’s legacy, and mathematicians are excited to see what that legacy will bring next.

“I’m sad she can’t see it,” Wright said of his former mentor.

Zorich agreed. “She was supposed to be there to appreciate this,” he said. “I have no doubt she would be extremely happy.”

增强女性在学术界的话语权

Empowering Female Voices in Academia

女性在塑造学术思想方面发挥了至关重要的作用，但她们的贡献在学术经典中往往被低估。在一个多样性和包容性被视为进步支柱的时代，学术界仍在努力解决系统性的性别差异问题。尽管女性占全球博士毕业生的近一半，但她们在高级教师和领导阶层的比例却在减少，这一现象被直截了当地称为“leaky pipeline”。在庆祝国际妇女节和妇女历史月之际，De Gruyter 出版社强调各学科女性学者、作家和编辑的杰出工作。这本编辑过的书收录了来自不同学科的女科学家的文章，放大了女性在学术领域的斗争、胜利和变革潜力。

统计数据描绘了一幅发人深省的画面：全世界只有 30%的研究人员是女性（联合国教科文组织，2023 年）。欧洲 STEM 领域的全职教授职位中，女性仅占 24%（欧盟 She Figures 报告）。性别偏见在同行评审、资金分配和引用率方面持续存在，往往使女性学者处于边缘地位。这些结构性的不平等不仅扼杀了个人的职业生涯，也使学术界本身陷入贫困。

增强女性在学术界的话语权要通过严谨的学术研究和生活经验的结合来应对这些挑战。女性科学家、社会科学家和人文学者的个人文章揭示了她们如何应对制度性性别歧视、文化刻板印象以及专业和护理角色的“双重负担”。他们的故事突显了系统性排斥的人力成本。这本书强调了种族、阶级和地理如何加剧了性别差异。例如，美国学术界的黑人女性面临种族和性别工资差距，而全球南方学者经常与知识生产中的殖民遗产作斗争。除了批评之外，该工作还提出了可操作的策略：实施同行评议盲审，遏制偏见。扩大育儿假和育儿支持。为早期职业研究人员创建导师网络。通过回顾被忽视的先驱们的历史——从 Rosalind Franklin（DNA 研究）到 Wangari Maathai（环境行动主义）——文本重新构建了学术界的集体记忆，以表彰女性的贡献。

De Gruyter 出版社超越了单纯的宣传，这是对重新构想学术界未来的呼吁。当学术界赋予女性声音时：多样化的团队产生更具创新性和社会相关性的成果（Nature，2022）。女性领导者的知名度激励着下一代。数据驱动的批评迫使政府和大学采取公平的做法。De Gruyter 推动了一场运动，在这场运动中，才能，而不是性别，决定了学术成功。

网页链接：

https://cloud.newsletter.degruyter.com/FemaleVoicesinAcademia?utm_source=marketingcloud&utm_medium=email&utm_campaign=collection%20&utm_term=FemaleVoices#hss

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数学正在发生日新月异的变化。不仅数学内部各分支相互交融，共同推动数学向更高层次发展，而且科学与工程问题牵涉到越来越深的数学课题，对数学提出了重大挑战，激发了新的数学理论和方法的创立，从而推动数学本身的发展。数学也一直在背后推动着科学和工程技术的进步，为现代科学和高新技术的发展奠定坚实基础。世界强国必须是数学强国，数学弱国不可能是现代化强国，而现代高科技竞争同时包含数学研究的竞争。华中科技大学数学中心顺应科学发展趋势于2013年在武汉成立了。

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（2）努力推动数学与科学、工程、医学之间的交叉研究；建立数学家和科学家之间的广泛联系，从而达到合作共赢；

（3）聚集一流人才，培养优秀学生，做出一流学术研究，引领学科发展，服务国家和社会。

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