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

Newsletter, Summer 2024

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

地址：中国湖北武汉珞喻路1037号
华中科技大学创新研究院（恩明楼）8楼
邮编：430074
网页：mathcenter.hust.edu.cn
电邮：mathcenter@hust.edu.cn

Huazhong University of Science and Technology
1037 Luoyu Road, Wuhan, China
Postal Code : 430074
Web : mathcenter.hust.edu.cn
E-mail : mathcenter@hust.edu.cn

目 录

奋斗者，启航吧！

——致 2024 届毕业生

段金桥　2024 年 5 月 1 日

亲爱的毕业生们：

你们好！

今天你们到达了人生的一个重要的里程碑！你们毕业了！能与你们一起分享这个喜悦的时刻，我深感荣幸。我向你们表示最热烈的祝贺和最诚挚的祝福！

你们正站在人生的一个新起点上。一个更大的舞台正等着你们隆重登场。

这是一个波澜壮阔的时代！我们中华民族正式开启了重返世界巅峰的新征程。奋斗者，启航吧！

这也是一个希望和挑战并存的时代，你们面临着无数的可能性。追梦人，出发吧！

我们正处于新的科学革命的前夜！量子力学已经诞生 100 年了。DNA 双螺旋结构发现至今也有 70 年了。上一批激动人心的数学理论框架也建立在几十年前吧。当前机器学习、人工智能似乎要解放全人类了，但数学和科学创新永远不过时！

在这个重要的新起点上，我想与大家分享一些关于未来、梦想和坚持的思考。

首先，我想对即将进入高校/科研院所工作或做博士后的同学们说：在当前大环境下，你们将会面临激烈的竞争，可能会遭遇挫折和困难。但是，请你们相信，只要你们坚持努力、永不放弃，就一定能够找到属于自己的舞台。

那些看似轻松的工作，往往并不如你所想象的那么轻松。那些今天看似容易通过考核的岗位，明天会如何？今天看起来艰难的路，可能正好把你们带到柳暗花明的又一村！只有通过不断的努力和奋斗，你们才能在这个社会中立足。勇敢地去追求你们的梦想吧！

在未来中外科学竞争激烈的十年甚至二十年里，你们必将对推动科技进步、服务国家发展起到重要作用。这是时代赋予你们的巨大机遇呀！没有凤凰的时代，只有时代的凤凰！因此，愿你们珍惜这个机会，充分发挥自己的才智和潜力，为中外科技竞争做出伟大的贡献以回报时代给予你们的机会。我期待未来在助力我们国家科学、经济、技术腾飞的成就榜上，看到诸位的名字。

其次，我想对继续深造、攻读博士学位的同学们说：祝福你们成为时代的宠儿。我国有博士学位人数只占比 0.078%呀。你们是幸运的，你们有机会接受最优质的教育，探索科学的边界。但这份幸运同时也意味着巨大的时代责任。

我知道，攻读博士学位是一项艰苦而漫长的任务。但是，请你们相信，这个过程必将是你们人生中最为宝贵的一段经历。知识、智慧和创新将与你们为伴。你们也将

会体验到科学创新的乐趣和成就感。

同时，我也希望你们能够注重培养自己的综合素质。除了专业知识外，你们还应该关注社会热点、了解国家与国际大事、关心人民疾苦，把论文写在祖国的大地上。

接下来，我想对即将进入企业的同学们说：恭喜你们！在如今竞争激烈的就业市场里，你们突出重围，顺利进入到社会大讲堂，开始你们充满希望的新生活。同时，我依然想叮嘱你们，学历只代表过去。在你们的周围，有来自全国甚至全世界各地名校的佼佼者们。我希望你们可以认真地做一份周全的宏观职业规划：工作一年后、五年后、十年后你们应该取得什么样的职业成就？

我们这个时代刚刚发生了深刻的变革。在职场上，真正重要的是你们的核心能力、人生态度和持续学习的决心。你们未来的领导们更看重的是你是否“有理想、有追求、有上进心”。因此，我希望你们能够放下对学历的执着，转而关注如何提升自己的综合素质和解决问题的能力。

最后，我想再多叮嘱几句。

1. **人生没有捷径可走。**在这个充满诱惑的世界里，许多人在寻找捷径，希望能够轻松地达到目标。那些看起来容易的路，往往充满了坎坷和险阻；而那些容易得到的东西，往往并不值得我们去追求。其实，任何值得去的地方，都没有捷径可走。因此，我希望你们能够保持一颗谦虚、进取的心，不断努力前行、永不放弃。无论你们将来走到哪里，无论你们遇到什么困难和挑战，都要相信自己、相信未来、相信数学、科学和计算的力量。
2. **“志不强者智不达”。**跑步的经验与教训：当我把目标定为 10000 米时，跑到 5000 米时还很轻松。而但当我把目标定为 5000 米时，跑到 3000 米时就想放弃。
3. **做一名终身学习者。**然后，你的编制和铁饭碗就在你手中。
4. **始终保持一颗感恩的心。**珍惜身边的每一个人和每一次机会。
5. **坚持就是胜利。**困难是常态。容易的事情不值得你去为之奋斗！但你碰到困难的时候，到大江大湖大海边或大山大草原里去健走 42.2 公里（马拉松）。但你迷茫的时候，到附近的抗日烈士陵园瞻仰。

亲爱的同学们，你们即将离开熟悉的校园，踏上新的人生征程，书写属于你们自己的辉煌人生。愿你们在追求梦想的过程中，也能够收获幸福和快乐。

祝福你们！

News 新闻

非线性与随机动力系统研讨会

5 月 11 日，华中科技大学数学中心成功举办“非线性与随机动力系统”线上研讨会。本次研讨会由数学中心高婷副教授组织。数学中心主任段金桥教授、华中科技大学吴付科教授、刘继成教授、王湘君教授、杨美华教授、孙旭教授、刘显明副教授为本次研讨会顾问委员。

来自国内高校和科研院所的 60 余位专家学者线上参会，共同探讨非线性与随机动力系统领域的最新研究成果和发展趋势。

本次研讨会不仅为专家学者们提供了一个交流学术思想、分享研究成果的平台，也为非线性与随机动力系统领域的发展注入了新的活力和动力。相信在不久的将来，该领域将迎来更加辉煌的成就。

非线性与随机动力系统研讨会

腾讯会议号：349-268-431　2024 年 5 月 11 日

5 月 11 日上午	**主持人：高婷**	
时间	**报告人**	**报告题目**
9:00-9:30	罗德军	2D Smagorinsky-Type Large Eddy Models as Limits of Stochastic PDEs
9:30-10:00	武伟娜	SVI solutions to stochastic nonlinear diffusion equations on general measure spaces
10:00-10:30	邵井海	Optimal control problem for stochastic processes with Holder coefficients
10:30-11:00	原三领	Environmental stochasticity driving the extinction of top predators in a food chain chemostat model
11:00-11:30	周国立	Global well-posedness and backward uniqueness of stochastic 3D Burgers equation in L^2(T^3; R^3)
11:30-12:00	束琳	负曲率流形上的 Brown 运动
5 月 11 日下午	**主持人：高婷**	
时间	**报告人**	**报告题目**
14:30-15:00	黎定仕	Pullback measure attractors for non-autonomous stochastic reaction-diffusion equations on thin domains
15:00-15:30	储继峰	Sharp bounds of nodes for Sturm-Liouville operators
15:30-16:00	舒级	Dynamics of stochastic fractional Ginzburg-Landau equations driven by nonlinear noise
16:00-16:30	孙景瑞	Long-Time Behavior of Optimal Control for Stochastic LQ Problems
16:30-17:00	周建军	Viscosity Solutions to Second Order Path-Dependent HJB Equations
17:00-17:30	张祥	Differential Galois groups vs integrability of differential systems near a periodic orbit

数学与健康赋能——第二届松山湖数学论坛

——By 陈建宇

2024 年 6 月 15 日，第二届松山湖数学论坛在广东东莞松山湖科学城如期举行，专家学者齐聚松山湖，为生命健康领域科研发展“精准把脉”。

这次论坛以“数学赋能，健康同行”为主题，田刚、徐宗本、汤涛、方复全、汤超、罗智泉、Paolo Piccione 等 10 位国内外院士及上百位国内数学领域、医学领域知名专家学者及企业代表，围绕数学在生命健康领域的应用、最新研究成果及未来发展趋势等议题展开深入探讨，推动数学与数据科学方法用于解决人类健康难题。期间，广东省动力系统与神经系统交叉研究重点实验室也正式揭牌，段金桥教授担任实验室主任。

图 1 松山湖数学论坛现场

此次论坛由大湾区大学（筹）与松山湖管委会联合主办。东莞市委副书记、市长吕成蹊，副市长黎军，副市长陈庆松，广东省科技厅实验室与平台基地处四级调研员彭丹，东莞市有关部门、松山湖管委会相关负责人，大湾区大学（筹）相关院系专家学者等出席论坛。

聚焦“数学+”发展模式 引领生命健康领域技术发展

松山湖数学论坛是由大湾区大学（筹）与松山湖管委会联合发起主办的高水平学术会议，论坛旨在打造粤港澳大湾区数学前沿探索及学科交叉的学术交流平台，通过邀请海内外高水平学者及学术新秀进行思想交流，促进数学及相关领域探索新的研究方向，推动数学与其他学科的深度交叉融合，提升粤港澳大湾区的数学研究水平。

“我召集松山湖数学论坛的初衷，就是希望数学学科能够进一步聚焦‘数学+’的发展模式，推动数学与其他学科的深度融合。”中国科学院院士、大湾区大学（筹）校长田刚在开幕式致辞中表示，松山湖数学论坛作为大湾区具有典型代表性的学术平台，必将为推进大湾区乃至全国的基础研究发展作出重要贡献，数学与生命健康两者的有机结合，将为大湾区相关行业的未来发展注入新的活力。

图 2 动力系统与神经系统交叉重点实验室揭牌

广东省动力系统与神经系统交叉研究重点实验室以数学基础学科为主要支撑，与计算机科学、脑科学、生物医学工程等领域交叉融合，探究脑疾病复杂演化机理，构建多模态脑数据的脑疾病动力系统模型，搭建脑疾病的辅助诊疗智慧平台，实现对脑疾病的演化机制解析、早期预警等，引领智慧医疗技术发展突破。

论坛由大会报告、主题报告两部分组成。论坛以“数据与生命科学”为主题，围绕“医学图像处理与分析”、“生命科学数据分析与大数据”、“流行病学与疾病建模”、“数据伦理和隐私保护”等多个议题进行。

论坛上，多位院士专家就各自研究领域作高水平主题报告，从数学与数据科学方法对医学领域的融合赋能角度，带来行业前沿观察。 中国科学院院士、国家基金委交叉科学部主任、北京大学讲席教授汤超带来题为《发育的精确性和鲁棒性》的主题报告，针对胚胎发育中的精确性和鲁棒性进行数学物理建模和理论分析，为细胞周期、细胞命运决定、干细胞重编程等生物问题提供了新的定量的视角。

中国科学院院士、西安交通大学教授徐宗本则以《大模型的极限理论：解读智能涌现现象》为题，分享数学在人工智能发展，特别是提高算法创新能力上的独特作用和价值。

此外，加州大学欧文分校数学、发育与细胞生物学杰出教授聂青，密歇根州立大学数学、电气与计算机工程、生物化学与分子生物学讲席教授魏国卫等多位专家，围绕各自研究领域作主题报告，为公众带来更多数学在生命健康领域的创新应用，挖掘科学前沿的理论与技术突破，共话跨学科融合发展未来。

华中科技大学数学中心高婷副教授也在大会作主题报告，题为《随机动系统与脑科学：预警控制与隐私安全》

数学中心 2024 届毕业生悟道——国情报告

从「提高生活水平」到「共享改革发展成果」

——陈建宇

中华优秀传统文化中的“不患寡而患不均”，“损有余补不足”等思想蕴含着共享的意蕴。马克思恩格斯曾指出，“所有人共同享受大家创造出来的福利”，“生产将以所有的人富裕为目的”。

马克思恩格斯在《共产党宣言》中明确指出，“无产阶级的运动是绝大多数人的、为绝大多数人谋利益的独立的运动”。社会主义的本质是让广大人民群众共享改革发展成果。

“天下大同”“等贵贱均贫富”等中华传统文化思想，反映了千百年来中国人民对理想社会的追求和向往。共享发展理念以不断满足人民群众对美好生活的向往为价值导向，以实现全体人民共同富裕为价值目标，超越了中华传统文化中的均贫富思想。

一、中国的经济发展与社会变革

近年来，中国的经济发展速度令人瞩目。作为全球第二大经济体，中国在多个领域展现了强大的竞争力。然而，在此过程中，我们也面临着一些亟待解决的问题和挑战。以下是对中国国情的观察和分析，并与西方发达国家（以美国为例）进行对比，提供具体数据和见解。

经济增长与结构调整

根据国家统计局的数据，2023 年中国的 GDP 增长率约为 5.5%，而美国的 GDP 增长率为 2.1%。尽管中国的经济增速依然高于美国，但增长模式的可持续性引发了广泛关注。中国的经济增长更多依赖于投资和出口，而内需尚未完全释放。相比之下，美国的经济结构相对平衡，消费占 GDP 的比重高达 70%。

城市化与区域发展

中国的城市化进程仍在快速推进。2023 年，中国城市化率达到 64%，而美国已超过 80%。这意味着中国在未来的城市化过程中，仍有大量的人口将从农村迁移至城市，这不仅带来了经济发展的机遇，也提出了城市规划、基础设施建设和社会保障方面的挑战。

科技创新与产业升级

在科技创新方面，中国取得了显著进步。2023 年，中国的研发投入占 GDP 的比重达到 2.4%，虽然略低于美国的 2.8%，但在具体领域，如人工智能、5G 技术和新能源，中国已成为全球领导者。例如，中国在 2023 年部署了超过 120 万个 5G 基站，而美国仅为 40 万个。

然而，在核心技术和高端制造业方面，中国依然存在较大差距。以半导体产业为例，中国依赖进口的芯片比例高达 80%，而美国在高端芯片制造和设计上具有绝对优势。

社会保障与民生福祉

在社会保障方面，中国与美国有明显的不同。中国的基本医疗保险覆盖率已超过 95%，基本养老保险参保人数达到 9.97 亿，但保障水平相对较低，特别是农村和中小城市的居民。而美国尽管社会保障体系完善，但医疗费用高昂，约 9%的居民没有医疗保险。

二、环境保护与可持续发展

环境保护是中国近年来重视的领域。2023 年，中国的森林覆盖率提高到 23.2%，空气质量显著改善，PM2.5 年均浓度下降至 33 微克/立方米。然而，中国仍是全球最大的二氧化碳排放国，2023 年排放量约为 98 亿吨，占全球总量的 27%。相比之下，美国的排放量为 50 亿吨，但人均排放量仍高于中国。

三、结论与反思（悟道）

中国的经济发展成就举世瞩目，但与发达国家相比，仍有许多领域需要提升。首先是经济结构的调整和内需的释放；其次是科技创新和核心技术的突破；第三是社会保障体系的完善和保障水平的提高；最后是环境保护和可持续发展的全面推进。

在未来的发展道路上，我们可以借鉴西方发达国家的成功经验，结合中国自身的国情，走出一条具有中国特色的发展道路。这不仅需要政府的政策引导，更需要全社会的共同努力和创新驱动。

国家的发展或者是落后其实最受影响的是我们这一代年轻人，社会的蛋糕需要所有人共享，而我们现在所拥有的一切便利和生活都是基于国情发展来实现的。我认为公民与国家之间是相辅相成的关系。

国情报告：中国与德国的比较分析

——方程

一、引言

中国，作为世界上人口最多的国家，近年来在经济、科技、文化等方面取得了举世瞩目的成就。德国，作为欧洲的经济强国，以其精湛的工艺、强大的制造业和先进的科技水平闻名于世。本报告旨在通过数据分析，具体而深入地比较两国的国情，以期在对比中寻求启示，促进两国间的交流与合作。

二、经济比较

1.经济增长率

近年来，中国经济保持中高速增长，年均增长率保持在 6%以上，成为全球经济增长的重要引擎。而德国作为欧洲经济稳定的代表，其经济增长率也稳定在 1.5%至 2.5%之间，显示出稳健的发展态势。

2.产业结构

中国正逐步从依赖传统制造业向高新技术产业和现代服务业转型，高新技术产业增加值占 GDP 比重逐年上升。德国则以其强大的制造业闻名，尤其在汽车、机械、电子等领域拥有世界领先的技术和市场份额。

3.贸易与投资

中国是全球最大的商品出口国之一，同时也是吸引外资最多的发展中国家。德国作为欧洲最大的经济体，其贸易和投资也呈现出强劲的增长势头，特别是在对华贸易和投资方面，两国之间的经贸往来日益密切。

三、科技比较

1.研发投入

中国在研发投入上不断增加，研发投入占 GDP 比重逐年提高，已成为仅次于美国的全球第二大研发投入国。德国在科研方面也有着悠久的历史和雄厚的实力，其研发投入占 GDP 比重也保持在较高水平。

2.创新成果

中国在科技领域取得了多项重要创新成果，包括在 5G 通信、人工智能、新能源汽车等领域取得了突破性进展。德国则在精密制造、环保技术、生物医药等领域拥有世界领先的技术和成果。

四、社会比较

1.人口结构

中国正面临人口老龄化问题，劳动力人口比重逐年下降，而德国作为较早进入老龄化的国家，其养老保障体系和劳动力市场政策相对成熟。

2.教育水平

中国在普及义务教育和高等教育方面取得了显著成就，国民整体受教育水平不断提高。德国则以其高质量的教育体系和职业教育闻名于世，为经济发展提供了源源不断的高素质人才。

五、结论与启示

通过与中国和德国的比较分析可以看出，两国在经济发展、科技创新、社会进步等方面都取得了显著成就。同时，两国在产业结构、人口结构、教育水平等方面也存在一定的差异和互补性。因此，加强两国间的交流与合作具有重要意义。未来，两国可以在科技创新、产业合作、人才培养等方面加强合作与交流，共同推动世界经济的繁荣与发展。同时，中国也可以从德国的发展经验中汲取启示，进一步完善自身的制度建设和政策体系，推动经济社会的持续健康发展。

国情报告（从经济角度分析）

——冯灵羽

中国的 GDP 在过去几十年间实现了高速增长，从 2000 年的 1.2 万亿美元增长到 2022 年的约 17.7 万亿美元（美国的 GDP 长期以来位居全球第一，2022 年约为 25.5 万亿美元）。中国经济的高速增长得益于改革开放、工业化进程和经济全球化。2022 年，中国 GDP 增速为 3%左右（美国 GDP 增速为 2.1%左右），低于以往高增速的水平，主要是受到了疫情及国际形势的影响。2024 年是疫情后经济恢复的第二年，当前经济运行面临困难挑战，主要是国内需求不足，重点领域风险隐患较多，外部环境复杂严峻。

中国 GDP 的构成中，第一产业（农业）占比约为 7%，第二产业（工业）占比约为 39%，第三产业（服务业）占比约为 54%。而美国 GDP 的构成中，农业占比非常小，仅约 1%，工业占比约为 18%，服务业则占据绝对主导地位，占比约为 81%。近年来，随着我国经济结构调整，服务业在 GDP 中的占比逐渐上升，反映出经济的转型升级。然而，制造业依然是中国经济的重要支柱。中美两国经济结构存在显著差异。我国依然处于工业化和城市化进程中，制造业在经济中占据重要地位，未来需要进一步提升服务业和高技术产业的比重，实现经济的高质量发展。相比之下，美国经济已进入后工业化阶段，服务业和高科技产业占据主导地位，经济更加依赖创新和消费驱动。

在全球经济体系中，中美两国的经济互动密切，相互依存度高。中美贸易摩擦和技术竞争在一定程度上影响了两国经济的稳定性和预期。美国对华加征关税的政策会影响一些出口到美国市场的企业，造成企业经营成本增加、竞争力下降和订单减少等结果。对于特定行业如电动汽车行业，虽然关税有所提高，但中国车企通过拓展非美国市场、优化产能布局等方式来应对关税带来的压力。同时，我国政府也在积极引导企业进行产业结构调整和优化升级，以适应复杂多变的国际市场竞争环境。美国在信息技术、金融服务、医疗健康等领域具有全球领先的优势。因此，美国的芯片出口管制措施和技术封锁，在一定程度上阻碍了中国在人工智能领域的发展。但这种限制也增加了中国自主研发和创新的挑战。面对外部技术的封锁和压力，我国需要更加努力地进行科技研发和创新，以实现技术突破和产业升级。国家如此，个人更是如此。我们应该不断学习和提升自我，掌握核心技能，培养创新思维，为国家的科技进步贡献自己的力量。只有共同努力，才能赢得未来的竞争。

Academic Achievement 学术成果

数学中心近期研究成果

➢ 付建勋

4-6 月，投向 Ergodic Theory and Dynamical Systems 的文章返还了修改意见，本人针对所提问题修改了文章；其他工作正常推进。

➢ 高婷

发表论文：

Fourier neural operator based fluid-structure interaction for predicting the vesicle dynamics

——Wang Xiao, Ting Gao, Kai Liu, Jinqiao Duan, Meng Zhao

Physica D: Nonlinear Phenomena, Volume 463, July 2024, 134145.

提出了一种基于傅里叶神经算子的流固耦合求解器，用于高效模拟 FSI 问题，其中基于有限差分方法的固体求解器与傅里叶神经算子无缝集成，使用浸入边界法预测不可压缩流动，并进行了理论上的收敛性分析以及数值计算模拟。

已接收论文：

Early Warning Prediction with Automatic Labeling in Epilepsy Patients

——Peng Zhang, Ting Gao, Jin Guo, Jinqiao Duan, Sergey Nikolenko

Accepted by ANZIAM.

通过患者的脑电图数据，我们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。我们的研究表明，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。

投稿论文：

Action Functional as an Early Warning Indicator in the Space of Probability Measures via Schrödinger Bridge

——Peng Zhang, Ting Gao, Jin Guo, Jinqiao Duan

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。

- **郇真**

继续基础数学的研究。

- **刘超**

继续写手头主要文章《Emergences of nonlinear Jeans-type instabilities for quasilinear wave equations》，这个问题已经做四年，简化到一大类高度复杂不满足 null condition 的拟线性波方程上来做，目前有一定进展。同时合作的非线性 GL 不稳定性也有初步轮廓。

- **林聪萍**

“otally asymmetric simple exclusion process on a dynamic lattice with local inhomogeneity”revision 中

- **徐海涛**

对有限的非线性格点系统中局部态（包括边缘态）的出现机制进行讨论，将在位势的非线性结果推广到更常见的 FPU 类型，将一维格点系统推广至二维情形。

- **殷钶**

Y. Li, Y. Yang, K. Yin, Y. Duan, and J. Yuan, “The truncated variational model for image labeling and graph partitioning,” Inverse Problems and Imaging, online first, 2024, doi: 10.3934/ipi.2024022.

- **赵蒙**

研究了非同心圆情形下多界面扩张，针对不同的流体粘性和界面的相对位置，研究了界面的动力学和演化过程；还研究了细丝在 Stokes 流中的褶皱现象及其物理机制。

- **张一威**

与瑞典隆德大学 Tomas Persson 教授、江苏师范大学吴万楼博士、北京中国石油大学胡张楠博士合作研究了双曲情况下的收缩靶的分形维数问题，文章提交至 arxiv:https://arxiv.org/abs/2405.02582

Celebrity Story 名人故事

2024 年邵逸夫数学科学奖得主——南非数论大家 Peter Sarnak

彼得·萨纳克（Peter Sarnak）于 1953 年在南非约翰内斯堡出生，拥有南非和美国双重国籍，现为美国普林斯顿高等研究院数学戈帕·普拉萨德讲座教授及美国普林斯顿大学数学尤金·希金斯讲座教授。1980 年师从保罗·科恩（Paul Cohen）于美国斯坦福大学获得数学博士学位。他是美国国家科学院院士、美国艺术与科学院院士、英国皇家学会院士。2019 年获得西尔维斯特奖（英国皇家学会），2014 年获得沃尔夫奖。担任《Annals of Mathematics》等多个国际期刊编委。

2024 年邵逸夫数学科学奖颁给彼得·萨纳克（Peter Sarnak），以表彰他将数论、分析学、组合学、动力学、几何学和谱理论结合在一起，发展出薄群的算术理论和仿射筛法。

邵逸夫奖是 2002 年由香港著名的电影制作人邵逸夫先生创立的奖项，旨在表彰在学术及科学研究或应用上取得突破性成果，并对人类生活产生深远影响的科学家，首届的颁奖礼在 2004 年举行。邵逸夫奖设有三个奖项，分别为天文学奖、生命科学与医学奖、数学科学奖。国际著名数学家、清华大学讲席教授丘成桐与美国芝加哥大学教

授弗拉基米尔·德林费尔德（Vladimir Drinfeld）共同获得了 2023 年度邵逸夫奖数学科学奖，以表彰他们对数学物理、算术几何、微分几何和凯勒几何的贡献。

获奖理由

如果一个自然数大于 1，除了 1 和它本身以外不再有其他因数的自然数，那么这个自然数就被称为素数。例如，2 是素数，但 4 = 2×2 不是素数。欧几里得定理（大约公元前 300 年）断言，除 0 和 1 以外的任何自然数都是素数的乘积，并且有无限多个素数。素数分布的研究是数论中的一个核心问题。

自古希腊以来，寻找素数一直是数论的中心主题。人们寻找多项式函数 f(x)，使得对于无穷多个整数 x，f(x)都是素数。欧几里得定理指出 f(x) = x 是这样的一个函数。人们可以通过要求 f(x)的值是殆素数 (具有有限个素因子的自然数)来扩大这个问题，也就是说，对于无穷多个整数 x, f(x)是有限个素数的乘积。例如，孪生素数猜想等价于 f(x) = x(x+2)是无穷多个整数 x 的两个素数的乘积。中国数学家陈景润（1973 年），使用布伦的组合筛法，证明了这个函数对于无穷多个整数 x 至多有 3 个素数因子。人们还可以通过要求 x 位于整数的稀疏子集中来限制 x 的集合。对于具有整数系数的任何多项式，都可以提出类似的问题，无论它有多少个变量。

萨纳克率先在稀疏子集中寻找多项式的殆素数值，这些稀疏子集是由薄群产生的轨道。薄群是具有“恰到好处”属性的算术群的子群：它既不太大（具有无穷指数），也不太小（与算术群具有相同的 Zariski 闭包）。薄群在纯数学和应用数学中非常自然地出现。例如，整数阿波罗尼奥斯圆填充的对称群就是一个薄群。此外，还有许多克莱因群，或者更一般地说，微分方程的单值群，都是薄群。

扩展图是计算机科学中广泛使用的高度连接的稀疏图。萨纳克预见到了如何利用薄群的有限商群的扩展特性来产生殆素数，并开发了仿射筛法。萨纳克与布尔甘（Bourgain）和甘布尔德（Gamburd）合作，利用某些薄群建构出扩展图。这一构造依赖于萨纳克和薛（Xiaoli Xue）之前的基础工作，他们展示了有限线性群的最小维数与扩展图之间的关系。

萨纳克与布尔甘和甘布尔德合作，得到了薄群轨道上的整数向量的精确计数和均匀分布结果，当对它们施加给定的多项式函数时，它们取殆素数值。

萨纳克与戈尔塞菲迪（Golsefidy）合作，证明了在某些自然假设下，一个整数多项式函数在薄群轨道的 Zariski 稠密子集中会产生殆素数。

萨纳克将组合和遍历的理论方法引入到丢番图问题中，产生了深远的影响。他原创而深刻的见解启动了一个庞大的研究计划，将数论、组合学、分析学、动力学、几何学和谱理论结合在一起。

网页链接：

https://www.shawprize.org/laureates/2024-mathematical-sciences/?type=Contribution

Popular Mathematics 数学热门话题

根号 2 如何成为一个数

How the Square Root of 2 Became a Number

By Jordana Cepelewicz

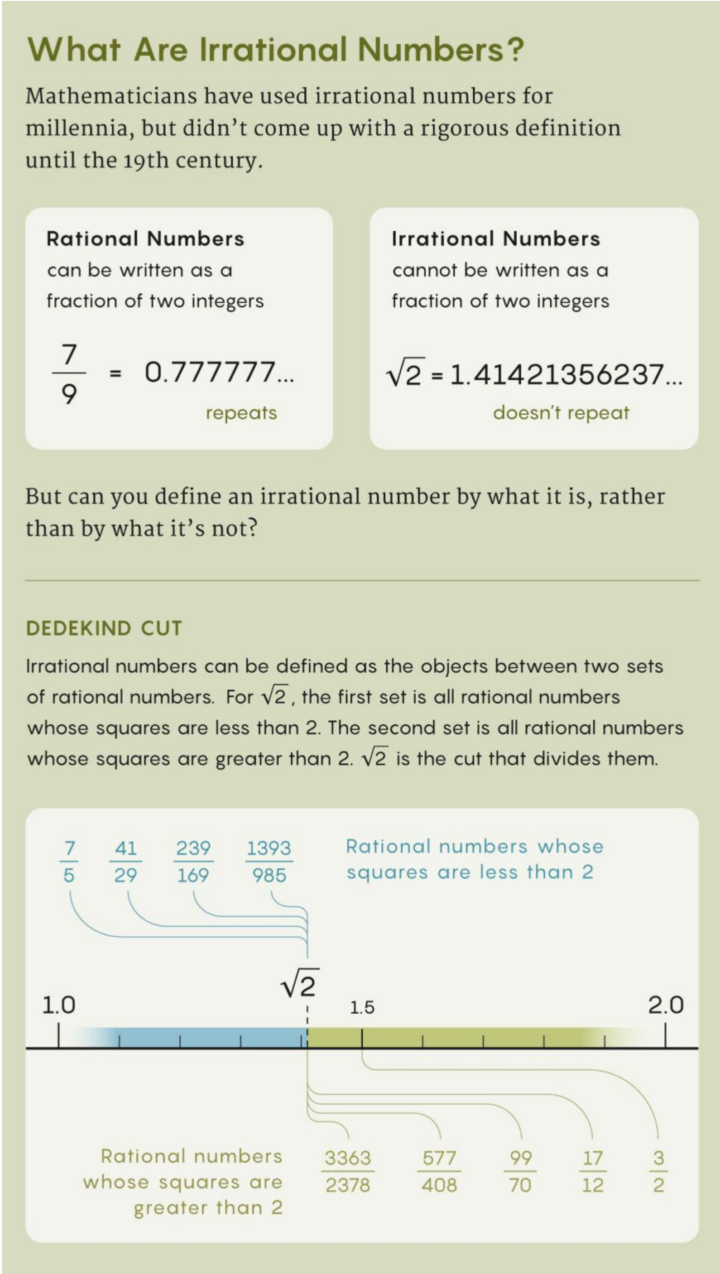
有用的数学概念，比如数轴，在被严格定义之前可能会存在上千年。$\sqrt{2}$的发展历程悠久，在数学史上具有重要意义。

The ancient Greeks wanted to believe that the universe could be described in its entirety using only whole numbers and the ratios between them — fractions, or what we now call rational numbers. But this aspiration was undermined when they considered a square with sides of length 1, only to find that the length of its diagonal couldn't possibly be written as a fraction.

The first proof of this (there would be several) is commonly attributed to Pythagoras, a 6th-century BCE philosopher, even though none of his writings survive and little is known about him. Nevertheless, "it was the first crisis in what we call the foundations of mathematics," said John Bell, a professor emeritus at Western University in London, Ontario.

That crisis would not be resolved for a long time. Though the ancient Greeks could establish what $\sqrt{2}$ was not, they didn't have a language for explaining what it was.

For millennia, this sufficed. Renaissance mathematicians manipulated what they came to call irrational numbers while trying to solve algebraic equations. The modern notation for square roots came into use in the 16th and 17th centuries. But still, there was something slippery about them. Does $\sqrt{2}$ exist in the same way that 2 does? It wasn't clear.



Mathematicians continued to live with that ambiguity. Then, in the mid-1800s, Richard Dedekind, among others, realized that calculus — which had been developed 200 years earlier by Isaac Newton and Gottfried Leibniz — stood on a shaky foundation. A reserved but gifted mathematician who worked slowly and published relatively little, Dedekind was preparing to teach his students about continuous functions when he realized that he couldn't give a satisfactory explanation of what it meant for a function to be continuous.

He hadn't even seen functions properly defined. And that, he argued, required a good understanding of how numbers worked — something mathematicians seemed to have taken for granted. How, he asked, could you know for sure that $\sqrt{2}$ multiplied by $\sqrt{3}$ equals $\sqrt{6}$? He wanted to provide some answers.

And so he introduced a way to define and construct the irrational numbers using only the rationals. Here's how it works: First, split all the rational numbers into two sets, so that all of the fractions in one set are smaller than those in the other. For instance, in one group, collect all rationals that, when squared, are less than 2; in the other, put all rationals whose squares are greater than 2. Exactly one number plugs the hole between these two sets. Mathematicians give it the label $\sqrt{2}$. For Dedekind, then, an irrational number is defined by a pair of infinite sets of rational numbers, which create what he called a cut. "It's a very lovely idea," said Ian Stewart of the University of Warwick. "You can pin down the missing irrational numbers not by describing them, but by describing the gap in which they have to sit."

Dedekind showed that you can fill in the entire number line this way, rigorously defining for the first time what are now called real numbers (the rationals and the irrationals combined).

At around the same time that Dedekind introduced his cuts, his friend and collaborator Georg Cantor also began to think about irrational numbers. The overlap made their relationship complicated. "They were good friends, and they hated each other. They cooperated, and they ignored each other," said Leo Corry, a historian of science who is the president of the Open University of Israel.

Cantor came up with a different definition of irrational numbers. He expressed each in terms of sequences of rational numbers that approached, or "converged" to, a particular irrational value. Though Cantor's irrational numbers initially looked different from Dedekind's, later work proved that they are mathematically equivalent.

Cantor's work led him to ask how many numbers exist. The question might at first seem strange. There are infinitely many whole numbers — you can always keep adding one more. Presumably, that's as big as a set of numbers can get. But Cantor showed that, paradoxically, though the number of fractions is the same as the number of integers, there are demonstrably more irrational numbers. He was the first to realize that infinity comes in many sizes.

The number line was more crowded, and weirder, than anyone had imagined. But mathematicians were only able to see that after a change in perspective.

Dedekind's cuts are arguably the beginning of modern mathematics. "It's really the first point in the history of mathematics where mathematicians actually know what they're talking about," Stewart said. Dedekind and others used his definition to prove major theorems in calculus for the first time — which allowed them not just to strengthen the edifice that Leibniz and Newton had built, but to add to it. Dedekind's work enabled mathematicians to better understand sequences and functions. Emmy Noether, a prolific mathematician who helped shape the field of abstract algebra in the early 20th century, is said to have told her students that "everything is already in Dedekind."

A formal definition of $\sqrt{2}$ opened new horizons for exploration beyond the topics in calculus that initially motivated Dedekind. As Stewart put it, "After Dedekind, mathematicians started to realize that you can invent new concepts altogether. … The whole idea of what mathematics is about becomes much broader and more flexible."

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数学罗塞塔石碑

A Rosetta Stone for Mathematics

By Kevin Hartnett

1940 年，安德烈 • 韦伊给他的妹妹西蒙写了一封信，概述了他在三个不同的数学领域之间进行翻译的愿景。80 年后，它仍然激发了该领域许多最激动人心的发展。

In 1940, from a jailhouse in Rouen, France, André Weil wrote one of the most consequential letters of 20th-century mathematics. He was serving time for refusing to join the French army, and he filled his days in part by writing letters to his sister, Simone, an accomplished philosopher living in London.

In a previous letter, Simone had asked André to tell her about his work. With war all around, André began his reply cautiously, warning his sister that past a certain point "you will understand nothing of what follows." Over the next 14 pages, he sketched his idea for a "Rosetta stone" for mathematics. Following the example of the famous engraving by that same name — a trilingual text that made ancient Egyptian writing legible to Western readers through translation into Ancient Greek — Weil's Rosetta stone linked three fields of mathematics: number theory, geometry, and, in the middle, the study of finite fields.

Other mathematicians had proposed ideas in this direction, but Weil was the first to spell out an exact vision. His letter presaged the Langlands program, a major initiative in contemporary mathematical research.

"You have three worlds that don't directly communicate with each other, but there are certain features they have in common, and experience shows some questions on one side can be interpreted appropriately in another," said Brian Conrad of Stanford University.

The first element of Weil's Rosetta stone was number theory, the charismatic heart of mathematical inquiry for millennia. The central concern of number theory is the integers, or positive and negative whole numbers, and functions that rely on them. Number theorists try to prove results about things like how the prime numbers are distributed, using tools that can be drawn from all manner of esoteric branches of mathematics. They also study mathematical worlds called number fields that generalize some important properties of the integers.

On the other side of Weil's Rosetta stone was geometry. He was thinking in particular about shapes such as spheres, doughnuts and multi-holed pretzels. These shapes are the solution sets of certain equations that have two variables, like $y^2 = x^3 - x$. Those solutions can be taken to be "complex" numbers, which have both a "real" part — the types of numbers people use in everyday life — and an "imaginary" part, which is a real number multiplied by the square root of -1, written as i.

Because these shapes are the geometric embodiment of solutions to polynomial equations, they have a structure that can be exploited using techniques from complex analysis, a form of calculus. This structure allows for a richer set of theorem-proving tools, beyond those immediately available to number theorists.

This was clear to 19th-century mathematicians, and it motivated them to imagine how nice it would be to prove theorems about "Riemann surfaces" — the shapes that Weil was interested in — that they could in turn translate into theorems in number theory. But many things are nice that aren't true, and Weil acknowledged to his sister that the theory of Riemann surfaces "is too far from the theory of numbers. One would be totally obstructed if there were not a bridge between the two."

Then he came to the main point of his letter: He was building such a bridge. He wrote, "Just as God defeats the devil: this bridge exists."

The bridge that Weil proposed is the study of finite fields — small number systems that resemble the real numbers in having two smoothly working operations like addition and multiplication. They achieve this by taking the circular form found on a clock, with a prime number of hours. Say you had a clock with only 11 hours; starting at 10 o'clock and adding two hours, you'd end up at 1 o'clock. (The number of hours on the clock has to be prime for division to work the way it should.)

Finite fields are a place where number theory and geometry begin to blend.

To see how, take a finite field with two elements: zero and 1. You can write polynomials — functions that combine sums and products of fixed exponents — in this field. Their coefficients — the numbers in front of the variables — have to be either zero or 1, as in these two polynomials:

Example A: $0x^3 + 1x^2 + 0x + 1$

Example B: $1x^3 + 1x^2 + 1x + 0$

These polynomials can be represented by their coefficients alone, which form a string of zeros and ones. Whole numbers can also be encoded as strings of zeros and ones, in what is called binary form, where they are expressed as sums of powers of 2. The number 1 is equal to 2^0, 2 is 2^1, 3 is $2^1 + 2^0$, and so on. In binary, therefore, the first three whole numbers are 00, 01 and 10.

Over the finite field with two elements, the coefficients and whole numbers of polynomials are both encoded as strings of zeros and ones. So the polynomial in example A corresponds to the number 5, since its coefficients, 0101, are the number 5 written in binary, and the polynomial in example B corresponds to the number 14, since 1110 is the number 14 written in binary.

They have other similarities too. Some whole numbers are prime, meaning that their only factors are 1 and themselves, and others are composite, meaning that they are products of multiple prime numbers. This same distinction between prime and composite applies to polynomials. Some polynomials can be factored as the product of smaller polynomials that themselves cannot be factored. These smaller polynomials, known as irreducible polynomials, are the prime numbers of the polynomial world. Polynomials are closely related to ideas from geometry, yet over the finite field with two elements, their arithmetic becomes loosely analogous to the arithmetic of whole numbers — opening up the possibility that in this setting, visual intuition can be applied to questions in number theory.

Writing to his sister, Weil declared that "the analogy with number fields is so strict and obvious that there is neither an argument nor a result in arithmetic that cannot be translated almost word for word to the function [or finite] field.” He allowed, though, that the distance between Riemann surfaces and finite fields is greater. Polynomials can be expressed and factored over finite fields, but importing the full machinery of complex analysis into finite fields was another matter. Yet Weil asserted confidently, “The distance is not so large that a patient study would not teach us the art of passing from one to the other.” Then he described his grand ambition:

My work consists in deciphering a trilingual text {[cf. the Rosetta Stone]}; of each of the three columns I have only disparate fragments; I have some ideas about each of the three languages: but I know as well there are great differences in meaning from one column to another, for which nothing has prepared me in advance. (Text in brackets and braces added by the translator.)

That was in 1940. Over the next decade, Weil developed precise methods that deciphered vast expanses of his Rosetta stone. He also made a series of conjectures about the relationship between number theory and geometry. The most audacious of these was a finite-field version of the Riemann hypothesis, one of the most important open questions in mathematics, which pertains to, among other things, how prime numbers are distributed. (He proved a one-dimensional case of this version.)

“When you convert intuition into something tangible, that’s when it becomes valuable,” said Edward Frenkel of the University of California, Berkeley.

In the late 1950s and early 1960s, Alexander Grothendieck made foundational contributions to the field of algebraic geometry in pursuit of Weil’s conjectures. In 1973 Pierre Deligne used Grothendieck’s techniques to prove Weil’s finite-field version of the Riemann hypothesis in higher dimensions.

Weil’s Rosetta stone has also guided progress in the Langlands program, a grand project to unify disparate fields of mathematics. The project began in 1967 when its founder, Robert Langlands, described his idea in a letter to Weil, expressing a desire to connect different branches of inquiry within number theory itself. Later, in the early 1980s, Alexander Beilinson and Vladimir Drinfeld defined a geometric version of the Langlands program, expanding Langlands’ vision to encompass a connection between number theory and geometry.

Over the last few years, some of the most important advances in the Langlands program have involved translations between the original number-theory vision of Robert Langlands and the later geometric version. These translations follow the approaches set out in Weil's Rosetta stone.

In 2021 Laurent Fargues and Peter Scholze finalized work on the Fargues-Fontaine curve, which provided one of the first direct translations between the geometric version of the Langlands program and the number-theory version. In recent months, Frenkel, Pavel Etingof and David Kazhdan have sharpened the link between the two versions. They redefined the geometric Langlands program in terms more consistent with Langlands' initial vision, yielding a more exact translation between the two.

For Frenkel, the impact of Weil's Rosetta stone encapsulates the way mathematics develops. Some new ideas emerge as the logical outgrowth of things that are already known. But others — and often the most important ones — are wholly original.

"These ideas seem to come from thin air; they're not tangible, not easily traceable," Frenkel said. But Weil's idea, he notes, was more than a dream. "Everybody has a dream," Frenkel said. "Not only did Weil articulate the dream in the letter, he then converted that dream into something concrete."

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奇怪的弯曲形状打破了 50 年的几何猜想

Strangely Curved Shapes Break 50-Year-Old Geometry Conjecture

By Jordana Cepelewicz

科学家们发现了一种奇异弯曲的形状，这些形状打破了半个世纪前的几何学猜想。这一发现不仅挑战了我们对几何形态的传统认知，也为数学领域的研究开辟了新的方向。通过对这些独特形状的探索，科学家们或许能够解锁更多关于空间、形状和维度的奥秘，为未来的数学研究和应用奠定坚实的基础。

Mathematicians have disproved a major conjecture about the relationship between curvature and shape.

In an old Indian parable, six blind men each touch a different part of an elephant. They disagree about what the elephant must look like: Is it smooth or rough? Is it like a snake (so thinks the man touching the trunk) or a fan (as the man touching the ear proposes)? If the blind men had combined their insights, they might have been able to give a correct account of the nature of the elephant. Instead, they end up fighting.

For decades, topologists have hoped to avoid falling into a similar trap. They thought they could characterize mathematical shapes by synthesizing numerous local measurements. But newly discovered, paradoxically curved spaces show that this isn't always possible. “Things can be much more wild than what we thought,” said Elia Bruè of Bocconi University in Italy, who worked with two other mathematicians to demonstrate this.

Topologists stretch and compress the shapes they study. An infinitely thin rubber band, from a topological perspective, is equivalent to a circle, because you can easily deform it into a circular shape. Topologists tend to characterize shapes according to their global properties: Do they have holes, like a doughnut? Do they go on forever, like an infinite plane, or are they “compact” like the surface of a sphere? Do their “straight” lines go on indefinitely — making them what mathematicians call “complete” — or are there dead ends?

But as with the elephant in the parable, it can be hard to directly perceive the global nature of topological shapes. And so mathematicians want to understand their relationship to local geometric properties, like curvature. What can you say about a shape's global topology, given information about how it curves at every point?

In 1968, John Milnor, a renowned mathematician then at Princeton University, conjectured that an average sense of a complete shape's curvature was enough to tell us that it couldn't have infinitely many holes. For the next 50 years, many results supported his claim. "You were tempted to believe it was true, because it was true in so many realistic cases," said Jeff Cheeger of the Courant Institute of Mathematical Sciences at New York University. "And how in God's name could you construct a counterexample to it?"

In this area of mathematics, said Vitali Kapovitch of the University of Toronto, "the Milnor conjecture was probably the biggest open problem."

And so in 2020, Bruè and two colleagues set out to prove it. They ended up finding a counterexample instead — and built an entirely new kind of topological shape in the process. "It's fantastic work," Cheeger said. "A landmark."

A Holey Grail of Topology

To understand Milnor's conjecture, it helps to first consider how topologists and geometers think about curvature.

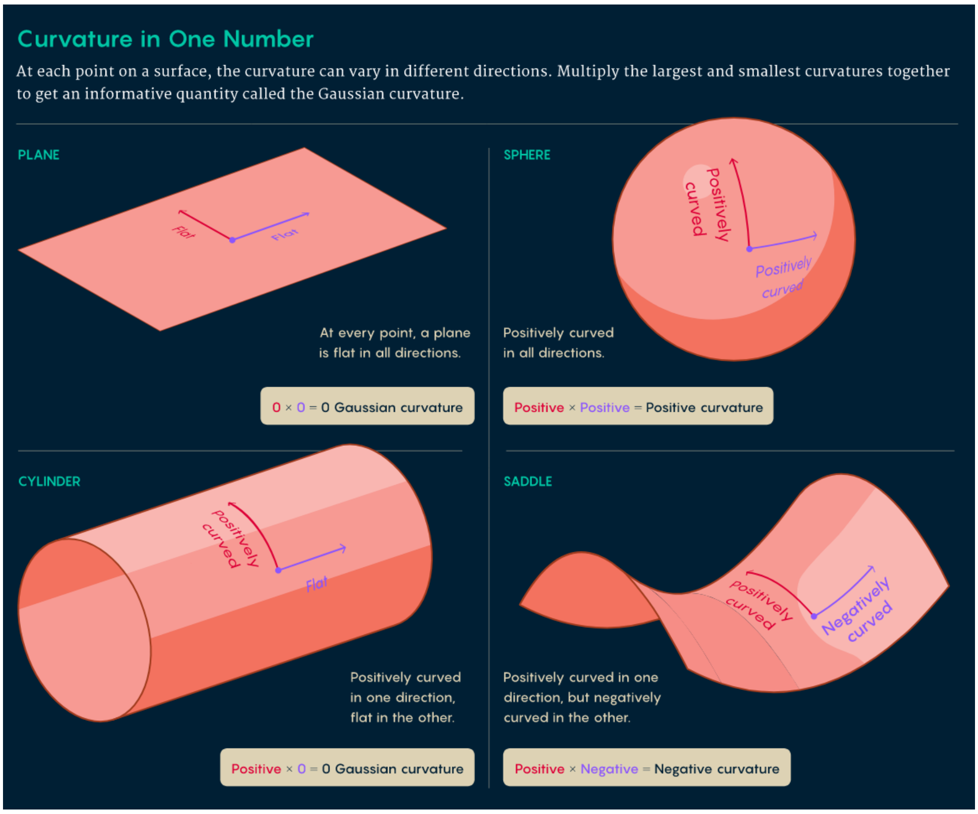
Both study manifolds — spaces that look flat when you zoom in on them. A tiny ant on the surface of a sphere, doughnut or other two-dimensional manifold will perceive its immediate neighborhood to be no different from a two-dimensional plane. But if the ant moves a little bit in any direction, it might notice that the space begins to shift, or curve. The idea of a locally flat manifold generalizes easily into higher dimensions. But curvature is tougher to define.

Take, for example, the simplest case: a one-dimensional object such as a circle. Surprisingly, these one-dimensional spaces cannot, in a mathematical sense, be intrinsically curved. A one-dimensional geometer walking along a circle, unable to perceive more than one dimension, would think she was traveling in a straight line — and would be surprised to find herself retracing her steps.

But if you embed a circle in a two-dimensional plane, it's apparent that it has constant, positive extrinsic curvature. (The relevant distinction here is between intrinsic and extrinsic curvature: what you can see if you're stuck inside the space, versus what you can see from outside it.)

Smaller circles bend more quickly as you move around them, and therefore have higher extrinsic curvature; bigger circles have lower curvature. (A straight line, in this sense, is like an infinitely big circle. Its curvature is zero, indicating that it's completely flat.) We can also apply this definition to more complicated shapes that have changing curvature, by considering how big a circle you would need to match the shape at any given point. In this way, curvature is a local property: Every point on a manifold has an associated curvature.

For a surface — a two-dimensional manifold — there are many ways to place circles so that they match the surface's curves. At a given point, you can measure curvature in any direction by placing an appropriately sized circle in that direction. But, surprisingly, it's possible to define the surface's curvature at that point with just one number. If you find the directions that give you the biggest and smallest curvature values, and multiply those values together, you get a number called the Gaussian curvature. This number summarizes information about how the surface bends in a useful way. Even more surprisingly, the Gaussian curvature turns out to be an intrinsic property: It doesn't depend on any higher-dimensional background space the surface might be placed into. In this sense, paradoxically, cylinders are not intrinsically curved, though spheres are.

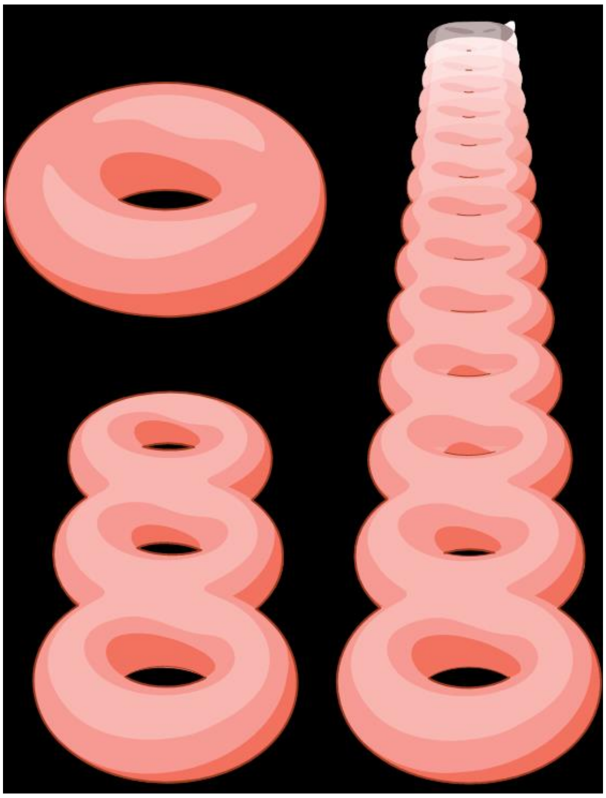


This number also helps mathematicians draw conclusions about the space's topology.

Say, for instance, that the Gaussian curvature is positive at every point on a two-dimensional manifold. Then topologists can prove that it can't have holes, like a doughnut. (It's either the standard surface of a sphere or one other, more complicated possibility.) If, on the other hand, the Gaussian curvature is zero at every point, there are solutions both with and without holes: The manifold could lie flat, like an infinite plane, but it might also be a cylinder or a Möbius strip. A cylinder, unlike the infinite plane, has a hole in the middle. And Möbius strips are different from cylinders because of the twist they contain.

In three or more dimensions, it's generally no longer possible to capture useful information about curvature with a single number. Mathematicians instead keep track of the curvature using "tensors," which can be thought of as arrays of numbers that transform according to particular mathematical rules. There are several different ways to describe a manifold's curvature using tensors, but one of the most important is something called the Ricci tensor. Like Gaussian curvature, it distills essential information into a (comparatively) simpler form.

Unlike numbers, tensors can't be neatly sorted into order — but like numbers, they can be categorized as "nonnegative" if they satisfy a certain property. In 1968, Milnor conjectured that complete manifolds whose Ricci tensor is nonnegative at every point can't have an infinite number of holes (as shown below to the right).



Manifolds with one hole (upper left), three holes (lower left) and an infinite number of holes (right).

More than half a century later, Bruè, along with Aaron Naber of Northwestern University and Daniele Semola of the Swiss Federal Institute of Technology Zurich, would prove him wrong.

Things Fall Apart

When Milnor posed his conjecture, mathematicians were just starting to explore the effects of Ricci curvature, which crops up over and over again throughout math and physics. “People knew very little at that point in time about anything, except that you could define it,” Naber said.

“We were in the wilderness at that time, on some arid plain with a few trees,” Cheeger said.

In the ensuing decades, mathematicians filled in this picture, constructing examples and developing a more concrete theory. All the evidence seemed to point to Milnor’s conjecture being true.

The conjecture is exceedingly easy to prove for one-dimensional manifolds. It has been known to be true in two dimensions since the 1930s. And in 2013, it was proved for three-dimensional manifolds. If you impose some additional constraints — assuming, for instance, that you’re always working with a manifold that’s closed and bounded, like a sphere, or whose volume grows at a particular rate — Milnor’s conjecture holds in all dimensions. And in 1978, a mathematician named Mikhael Gromov showed that if a different, more detailed measure of curvature is always nonnegative, then the manifold must have only a finite number of holes.

“Basically, you assume anything at all, and it becomes true,” Naber said.

Over the years, Naber tried several times to prove the conjecture in full generality — for all possible dimensions, without making any of those extra assumptions. He failed. Later, at a conference in 2019, he met Bruè and Semola, both then graduate students at the Scuola Normale Superiore in Pisa, and the three of them started working together on a different problem. By November 2020, they’d solved that problem, and Bruè and Semola had gotten their doctorates. So the three of them decided to make a new attempt to prove Milnor’s conjecture.

They kept at it for more than two years. “We tried all the tricks that we knew,” Semola said.

“We spent just an embarrassing amount of time trying to prove it,” Naber said. This included writing up an 80-page proof that turned out to be incorrect — “the most I’ve personally ever written before something broke down.”

But it broke down in a way that the mathematicians found informative. “When we realized that the strategy was flawed, that got us to the point that we started believing that maybe there was room for building a counterexample,” Semola said.

From there, things proceeded more smoothly. In a matter of months, the trio figured out how to construct a strange seven-dimensional manifold. They built it by gluing together infinitely many seven-dimensional pieces in subtle and intricate ways, assembling the entire manifold they needed bit by bit. All the while, they had to make sure that the Ricci curvature always stayed nonnegative. And they had to avoid accidentally satisfying any of the many properties for which Milnor’s conjecture was already known to be true. The mathematicians ended up with what they called a smooth fractal snowflake — an infinite and delicate self-similar structure.

t had nonnegative Ricci curvature at every point. And it had an infinite number of holes. They had disproved Milnor’s conjecture.

“It’s more complicated than all the previous constructions” of manifolds with nonnegative Ricci curvature, said Guofang Wei of the University of California, Santa Barbara.

Bruè, Naber and Semola, all geometers, later shared their work with several topologists, who informed them that, to their surprise, they’d created a new topological space entirely. And it wasn’t because there was something special about seven dimensions. Using similar techniques, the trio was able to build analogous counterexamples in higher-dimensional spaces (which they said was easy), as well as in six dimensions (which was hard). Nobody yet knows if a counterexample exists in four or five dimensions.

Because nonnegative Ricci curvature is a condition that appears often in math and physics, “one would hope that you have a certain amount of innate control over these things,” Naber said. But it turns out that shapes with nonnegative Ricci curvature are more flexible and less well behaved than mathematicians had expected — complicating their understanding of the relationship between local geometric properties and global topological ones.

Before the discovery of the new counterexamples, “you could sort of hope to really understand what the manifolds all look like,” said Ben Weinkove of Northwestern University. But now, “it’s just a Pandora’s box of possibilities.”

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男人世界里的女人——对女性数学家 Elisabetta Strickland 的采访

A woman in a man’s world——An interview with Elisabetta Strickland

By Ulf Persson

在当今的数学界，女性科学家的身影逐渐增多，她们以独特的视角和坚韧的毅力，为数学的发展注入了新的活力。EMS 杂志有幸邀请到了数学界一位杰出的女性代表——Elisabetta Strickland 女士，她不仅在学术上取得了显著成就，更在推动女性数学家发展方面发挥了积极作用。EMS 杂志的编辑 Ulf Persson，也是查尔姆斯理工大学（Göteborg，瑞典）的名誉教授，对 Elisabetta Strickland 女士进行了深度采访。

Elisabetta Strickland 的职业生涯充满传奇色彩。她的父母在二战期间结缘，父亲作为皇家空军军官在非洲服役，后因工作原因来到意大利，并与母亲相识相爱。这段跨越国界和文化的爱情故事，也为她的成长背景增添了一抹浪漫色彩。婚后，她的父母移居英国，然而母亲对阳光的渴望最终促使他们回到罗马，开启了新的生活篇章。

Elisabetta 在罗马长大，深受这座古老城市的文化熏陶。她的父亲在转行成为进出口商人后，也成功地在商界闯出一片天地。然而，对于 Elisabetta 来说，她的人生轨迹却与商业截然不同。她选择了数学这条道路，并在其中找到了自己的兴趣和追求。

作为一位女性数学家，Elisabetta 深知自己在学术界的角色和责任。她不仅致力于个人的学术发展，更积极参与推动女性在数学领域的进步。她的努力得到了广泛认可，并在数学界产生了深远影响。

本次采访深入了解了 Elisabetta 的学术背景、成长经历以及她对女性数学家的看法和建议。她的话语中充满了对数学的热爱和对未来的期待，也为我们揭示了女性数学家在学术道路上所面临的挑战和机遇。

EMS 杂志希望通过本次采访，能够激发更多女性对数学的兴趣和热爱，为数学界注入更多新鲜血液。同时也期待更多的女性数学家能够像 Elisabetta 一样，勇敢地追求自己的梦想，为数学的发展贡献自己的力量。

Elisabetta Strickland and I met at the Institut Mittag-Leffler in Stockholm in the fall of 1980 and have kept in touch ever since. (As a curiosity, we once had a photo exhibit together in Rome.) Hence, it was natural for me to include her in the ongoing series of interviews with women mathematicians, especially as she has taken a very active role in promoting women in mathematics.

Elisabetta Strickland, Rome 2011 (photo by Martina Lanini).

Ulf Persson: *Let us start from the start. Why not give us some family background?*

Elisabetta Strickland: You mean talking about my mother and father?

UP: *Go ahead!*

ES: My father was a Royal Air Force officer in the Second World War, in fact in Africa. Afterward he was sent to Italy when the allies liberated Rome, and they needed to find some Italian who was fluent in English to act as an interpreter. My mother was well-qualified for the job, and she applied. My father had to interview the applicants, and he fell in love with her right away.

UP: *It was mutual?*

ES: Yes, they got married soon thereafter and went to England.

UP: *How romantic. Just like that? No problems?*

ES: There were some forty Englishmen at the time who married Italian girls. And the priests did not demand them to convert to Catholicism as long as their spouses stayed Catholic and most importantly that their children were raised Catholic.

UP: *This makes sense, please continue.*

ES: My mother put up with England for a while, but then she realized that she could not live without the sun and went back to Rome.

UP: *And your father followed suit?*

ES: Naturally, did he have a choice? But then of course he had to face the problem of employment. How could he make a living? He ended up becoming a businessman, importer and exporter, that kind of thing.

UP: *Could you be more specific?*

ES: Why? It had to do with aluminium on the behest of someone who became a partner. Actually it took us to Venice where we lived for five years. At Lido to be more specific.

UP: *What time of life did that happen?*

ES: In my case between five and ten years of age.

UP: *But you returned to Rome.*

ES: Yes we did. I do not think that my mother could conceive of living anywhere else, nor can I by the way.

UP: *Anything else you could add?*

ES: My father was compelled to travel a lot, so in fact I did not see too much of him in my childhood. But he was not an absent father, he really took care of us.

UP: *And your mother was a present mother?*

ES: Very much so.

Elisabetta Strickland standing in Rome 1952 with her father Reginald Charles Strickland and her mother Esperia holding her baby sister Sara.

UP: *Your background does not explain your interest in mathematics.*

ES: I was a school girl, in fact an exemplary one, very studious, very serious and very successful. I won so many prizes, I was very proud of that.

UP: *So mathematics was only one among other subjects you excelled in?*

ES: You can say that, but the truth is that I had an excellent math teacher, very clever, it was a pity that he was stuck in life teaching in high school and not at university.

UP: *The intellectual quality of teachers at that time was typically quite high, after all there were few university positions, so sad as his case may have been, it was far from being unusual. But he clearly made a difference, in particular to you.*

ES: Yes, he taught me so much so when I started out at the university I already knew so much. What I particularly appreciate about him was his encouragement to solve problems in unconventional ways.

UP: *So you start university.*

ES: I started out as an engineering student.

UP: *Really?*

ES: Yes, I had this idea of wanting to build bridges. But it only lasted for a week. I was the only girl among one hundred and fifty or so students, and once when I dropped my pencil, all of them dived down to pick it up, begging me for my phone number, so we could get together. That was too much, and I fled to the math department where there were at least some women and hence some semblance of sanity.

UP: *So how was that?*

ES: First it was a four-year program, the first two years devoted to become mathematically literate, and then you had three options. Either doing research, with an academic career, or teach, or do applied mathematics and go out in the supposedly real world. There was never a question in my mind to consider anything beside the first alternative.

UP: *This is nice to know, but it does not address my question.*

ES: Fair enough. 1968 was as you must remember a special year when it came to students, and I was fully swept up in the movement. I was convinced that the educational system was rotten and had to be reformed, and I discovered in myself an affinity, maybe even a talent, for speaking publicly. I enjoyed it immensely, as I enjoyed that period. I flourished.

UP: *You also met your future husband Corrado de Concini at that time?*

ES: Not so fast. Yes, there was this guy de Concini who never bothered to show up at lectures, but had the audacity to ask me for notes. No doubt a very lazy guy.

Her husband Corrado de Concini in Ireland 2006.

UP: *So unlike the case of your parents, there was no love lost.*

ES: Love? It did not enter my mind. But I have to admit that when he handed back the notes he had annotated them with remarks that revealed that he was a very clever guy.

UP: *And you find cleverness in guys very attractive, trumping physical attraction?*

ES: Now you are at it again. Let me just point out that my opinion of the guy became more nuanced, and I saw him in a more favorable light. But that happens to most people when you get to know them better. And to put the topic to rest, de Concini's love interest was clearly elsewhere; he ended up married for some years, and I had a boyfriend who studied engineering, and we were supposed to get married. But I changed ideas.

UP: *Yes, I have some vague memory of that, as you bring it up. So what happened after the four years of basic university education?*

ES: In Italy there was not a tradition of obtaining Ph.D.'s. You just continued on your own writing papers and if you were lucky you obtained a university position, or else taught at school, or went out in the so-called 'real world.' But things started to change a little after 1968, e.g., de Concini decided to go to Warwick and get a Ph.D., actually with Lusztig as an advisor.

UP: *Let's talk about your career instead.*

ES: My mathematical career was rather straightforward. I spent my sabbaticals using a National Council of Research grant and a NATO grant. Then I applied successively for the three different levels of professorships, i.e., assistant, associate and full ones. I became full professor in 1987. The noteworthy thing was that I played according to the rules, much to the frustration of the Italian mathematical community. The rules being that each position was to be publicly announced and decided upon by a scientific community ostensibly arguing on strict scientific merits. The tradition in Italy, as opposed to Northern Europe, was that the appointments were made on a national basis, the powerful clique at each department deciding whom to get, the professor typically choosing their own successor. Traditions die slowly, and I was often approached and asked to withdraw my application, but I persevered as I had the legal right to apply and I stuck to it, and the appointed committees clearly took their duties seriously and did not bow down to departmental pressures.

UP: *You had to qualify for this positions writing papers and I doubt you were sitting put in* *your study in Rome. What did you do, and more specifically what kind of mathematics did you do? What kinds appeal to you, and what leaves you cold?*

ES: That was a lot of questions. Where should I begin? About mathematics, I must say that I do not like computations, so thus I was never interested in analysis…

UP: *Sorry, but what is the connection? Analysis is not about computations…*

ES: You should of course not take 'computations' literally, but proofs in analysis are very intricate involving clever estimates, you more often than not have no idea what is going on, the trees hiding the forest.

UP: *Yes, in analysis you get your hands dirty, and that does not appeal to you?*

ES: I prefer to keep my hands clean. I like abstract proofs based on concepts rather than, let me say, logical computations which do not leave you any wiser.

UP: *You prefer slick proofs.*

ES: You can put it that way. But algebra and geometry I find much more congenial than analysis.

UP: *Even commutative algebra?*

ES: Yes, I used commutative algebra in my work. But early on I got fascinated by group theory, in particular finite groups. But there was no group theory in Rome, so I commuted to Padua for some time. I was also recommended by Claudio Procesi to get into representation theory if my interest in groups was serious. Very good advice.

UP: *How come you were drawn to algebraic geometry?*

ES: How could I resist, I am Italian after all! As to your other question, I did go abroad to widen my horizons. In particular, I went to the Boston area. And I also had some interaction with Joe Harris, all of which gave me a nudge towards algebraic geometry. Griffiths in particular urged me to think of something in algebra which could be helpful for the varieties I was interested in at that times. I worked very hard, studying in the library day and night, I would not be able to summon such single-minded devotion now.

UP: *We have talked a lot about doing mathematics, but almost nothing about the mathematics which you have been doing. I think we have touched on this before, but when* *you do mathematics, is it always with a publication in mind, or do you think of something just for fun regardless whether it has a fair chance of 'paying' off or not.*

ES: I certainly take a professional attitude, I do not fool around, I always have a goal in mind, I feel I cannot waste time.

UP: *Do you collaborate a lot?*

ES: Not at all. I very much prefer to work alone, to talk mathematics to other people often gets me confused. This does not mean that I do not interact with other mathematicians, asking questions, getting new ideas, but the idea of actually working with someone solving a specific problem does not appeal to me at all. Too much of an interference.

UP: *So could we be a bit specific about your work without getting into technical details?*

ES: I will try. I did start out in finite group theory, but I left it for algebraic geometry, as I already told you.

UP: *What about finite group theory?*

ES: You are coming back to it. True, my first published paper, back in 1972, concerned semigroups, but it was just a short note. But throughout the 70s all my mathematical papers concerned finite groups, but getting into the 80s my future husband Corrado de Concini started to have a more significant influence. This was a period I have definitely put behind. I was just too isolated in Italy, to say nothing about Rome.

UP: *So back to algebraic geometry. What did you study?*

ES: More specifically I was studying special varieties with a lot of structure and hence there being much to play around with. And also with some interesting applications, inter-mathematical I should add.

UP: *Varieties as such?*

ES: Varieties of complexes, of projectors, flag-varieties, the conormal bundle of the determinantal variety, varieties related to symplectic vector spaces. Other examples are varieties given by G/P where G is a Lie group and P is a parabolic subgroup. The latter may not at first look very geometric, but you can talk about lines on them. This might give you an inkling of my taste.

UP: *What do you do with those varieties?*

ES: All kinds of things, like finding their defining equations. And then of course my interest in groups has not abated, much of what I do centers on groups, I am doing invariant theory.

UP: *Do you do it from a complex analytic point of view, working with truly continuous groups?*

ES: Not at all, I am very much interested in positive characteristics, and have generalized results by Hermann Weyl and George Kempf in 0 characteristic to positive. The methods are quite different and involve a lot of combinatorics.

UP: *Could you elaborate on the Weyl bit?*

ES: Sure. Am I allowed to be a little bit technical?

UP: *Go ahead.*

ES: Let V be a symplectic vector space. Consider for an integer N the algebra of endomorphisms of the tensor algebra $V^{\otimes N}$. Inside it, you find the spin algebra $S_p(V)$ and you are interested in its commutator. This can be described as the algebra generated by the symmetric group S_N acting on the tensor algebra by permutation on the factors, which turns out to be isomorphic to $K[S_N]/I$, where I is the ideal generated by the anti-symmetries on n+1 letters, where 2n is the dimension of V.

UP: *That was quite a mouthful. As you do things also in finite characteristics, are there interesting connections to finite group theory, in particular the work you used to do, and which might have been of some help?*

ES: It has more to do with representations of classical groups over finite fields of arbitrary characteristic.

UP: *What is the work you have been most proud of?*

ES: I do not know about being proud of, but the hardest work was in connection with so-called wonderful compactifications.

UP: *Which are not so wonderful, I gather. So without being technical could you elaborate?*

ES: No. Let me just say that those compactifications concern adjoint semisimple groups, in arbitrary characteristic mind you. There is nice geometry involved, some aspects of which I have been exploring. To be more specific, I have been looking at wonderful compactifications of symmetric varieties and their Chow rings and trying to compute some invariants thereof. The so-called ring of conditions, if you have heard about that?

UP: *No.*

ES: Anyway. It involves a lot of combinatorics.

UP: *Are you still active?*

ES: Yes, in fact I have just started a research project with a colleague M. Lanini studying the cohomology of a flag variety under a Poincaré–Birkhoff–Witt degeneration.

UP: *So you are after all collaborating.*

ES: I am not a fanatic, sometimes it is after all quite natural and convenient.

UP: *Could you tell me a little of your life as you became an established professor? When was that?*

ES: This was in connection with the birth of my son Guglielmo, who was born in 1988, as you should know…

UP: *Yes, on the very same day as my youngest daughter Alina…*

ES: I had got a full professorship at Roma Tor Vergata, a new university in the city, which had been founded just a few years earlier. The facilities were temporary and primitive, but a few years later they improved, though they were placed in the outskirts of Rome some 25 km from the center. I had to commute by metro and bus, which took me an hour and a half each way.

UP: *It must have been a nightmare? With a baby and everything.*

ES: Not at all. In many ways it was one of my most productive times. I sat and worked hard while in transit. I read papers, I wrote articles, you name it. Sometimes I was so immersed in what I was doing that I forgot to get off at the last stop, and had to be rescued in the dark by the cleaning staff of the Metro. From there on there was a bus to the university, and I was lucky if I got a seat, but was fun nevertheless mingling with students and colleagues.

UP: *Now we have not touched upon the issue of women and mathematics, as far as it is an issue at all.*

ES: What about it?

UP: *You have been active in it, sitting on many committees as I understand, such as the Women in Mathematics Committee of the European Mathematical Society. Do you enjoy such work?*

ES: It has nothing to do with enjoyment at all, it is just very important. I have really put in much effort, and it has been a lot of work during many years. So many committees, so many meetings. Of course, I have to admit that arranging meetings could be quite fun, but it amounts to a lot of work. But meetings are very important, and this of course goes beyond the issue of women in mathematics.

UP: *What is the major issue when it comes to women and mathematics?*

ES: It is representation, they are simply underrepresented in all kinds of respects, as editors of journals, in prize committees, in short whenever it comes to female influence and power. How come until Seoul there were no single female Fields medalist? I remember discussing the matter with Ragni Piene a year or so before.

UP: *As for underrepresentation, women are in great demand to sit on committees in order to meet the requirements, but that is not necessarily welcomed by women, many who feel obliged to participate unduly in such work which I assume consumes a lot of time and effort and thus is not always welcome, maybe even in some cases hampers their careers. Is not the basic problem that so few women go into mathematics, and actually why is that a problem?*

ES: It goes without saying this is an important cause. I would say that France has a long tradition of women doing mathematics and provides an example to all other countries. It is also true that a lot of women go into mathematics in Italy, but the majority does not have the ambition to go beyond teaching in high school; but that might change. The academic situation is much tougher now than forty years ago when we were young, and this holds both for women and men. As to committee work, as I said, I have committed a lot of time to it, and out of duty, not out of real pleasure. And I feel that it has not had the effect I had hoped for, so I have to admit to a great disappointment. I will not put the blame on some specific institutions, at least not publicly.

UP: *A question I often pose to women, at least to successful women, is whether they personally have felt any suppression; for feminists outside mathematics this is taken for granted due to the above-mentioned underrepresentation, but so far I have not met anyone* *who has admitted it. Would you be an exception?*

ES: Let me say that I am a tough lady, I might not look it, but I am. I am quite persistent, not to say stubborn, and I stick up for my rights, and I can argue forcefully for them, so maybe I am not the right person to ask.

UP: *Let me change track and ask you a personal question: Have you seen mathematics as a career or a calling? In other words, have you seen it as important to get ahead, or has this just been a nice but unintended consequence?*

ES: Mathematics is a competitive subject and I quickly realized what was needed. I have worked hard, being by necessity involved in competitions for work, you and your readers are probably familiar with the Italian system of Concorsi when you actually compete for positions nationwide, submitting your work to committees. There are three levels, roughly corresponding to assistant, associate and finally full professor. I have been very lucky that I was able to stay in Rome all the time. Only after reaching the upper level could I relax and have a child, it would have been impossible before that. And by the way, the matter of bearing children really puts women at a disadvantage, I am full of admiration for those successful women mathematicians who have managed to have had many children. Of course husbands can be helpful and supporting, but women cannot escape the concomitant duties unlike men, and even if the men go out of their way they cannot relieve you of more than half of the burden. But this is a digression, where were we…

UP: *Talking about the hard work involved in your career.*

ES: Oh yes. It also involves a lot of travel.

UP: *But that is the fun part, to be cynical for many of us, the most fun part.*

ES: Speak for yourself. Travel is unavoidable, you simply have to meet people, to get new ideas and outside stimulations; few indeed are those lone geniuses who are entirely self-sufficient. This is why I travel. And conferences are fun of course, at least the social part, but talking mathematics to people, that is what counts. And of course solving a problem is one thing, indispensable of course, but then you also have to sell your problem and solution and to convince people that what you have done is both clever and important. It is of course great if you have a mentor who explains those things to others, but for most of us you have to do that yourself, and that is quite a challenge.

UP: *So the social aspects of mathematics are important?*

ES: Very much so, as in all other ways of life. It is very important who you know and in what environment you work. Even if you may not be aware of it, you do absorb so much by mere osmosis. Getting ahead just on your own locomotion is not an option for most people. You need outside ideas, otherwise you dry up. This is something you just have to acknowledge.

UP: *So just reading the literature is no substitute?*

ES: Of course not, you need to know what to read, and what it really means. You may have an informal conversation with someone and learn more in half-an-hour than you would only learn from reading a paper for months if even that is enough.

UP: *Why is that? Is it because a paper is too complete, for the sake of documentation you have to include everything, which of course is a good thing, but not for conveying ideas? For the latter you need some motivation, given the right motivation and some key insight, things will fall into place, because most of a proof is just a matter of transportation, and as such rather tedious to read, as opposed to fill in the details.*

ES: Very true. I cannot but agree completely. However, I would like to add something important. You need to meet people in the flesh, it is not enough by e-mail, phone conversations and even zoom. I want to really hear the voices of the others, to become aware of gestures, expression of faces. All of those seemingly peripheral matters actually contribute and can make a difference. And not to forget only by engaging with a person face to face can you tell whether you are dealing with somebody intelligent or not.

UP: *Our common friend Fabrizio Catanese used to say that you can only gauge the worth of a mathematician by collaborating with him/her on a paper.*

ES: So true! I am so glad that you bring up Fabrizio. Discussing mathematics with him has been one of my most rewarding experiences. It is not so easy to have an interesting and fruitful conversation with a mathematician.

Fabrizio Catanese, in Bayreuth 2022 at the home of his colleague Jörg Rambau (photo by Jörg Rambau).

UP: *There has to be a common ground, and that is becoming harder and harder with the increased specialization of mathematics.*

ES: Of course you need common ground, that is obvious, but also some kind of chemistry. I have learned a lot of algebraic geometry from Fabrizio, because for one thing he knows a lot obviously, but what is much, much more important is that when he talks mathematics he is not only precise but also clear, and I find this a great help. Then of course from the perspective of algebra I have learned a lot from my husband Corrado and also from Procesi, but I want to emphasize Fabrizio, because most people would not realize that.

Her friend and colleague Claudio Procesi as member of the Abel Prize committee around 2006.

UP: *We have now spoken a lot on math and your mathematical career, but people may be curious about the individual Elisabetta Strickland, something that mathematical achievements seldom throw much light on. Was mathematics the only subject that really interested you at school?*

ES: By no means. Literature was my favorite subject. And also remember I was interested in all subjects in principle. I should also mention that I very much liked physics, but between that and mathematics my choice was mathematics.

UP: *So mathematics was special?*

ES: Only to the extent that I was lucky having such a wonderful math teacher.

UP: *But that also applied to your fellow schoolmates, so it must go deeper. What about literature, have you pursued that?*

ES: I am a reader of course, but most of all a writer; I have always loved to write, and so do you, I know, and I have kept on writing all my adult life. I have published several books, and I regularly contribute articles to various journals. One particular example, is that I edit a Newsletter for Women in academics and have to regularly come up with something. As to interests, I have always loved sailing and at one time in my life I submitted articles to various sailing magazines. They paid well.

Elisabetta Strickland sailing off the coast of Sardinia, 1977.

UP: *What are examples of your non-mathematical books?*

ES: I have written on female scientists, such as Mary Somerville, who among other things 'checkmated' Maxwell, but also on Emmy Noether who stood up to Einstein, and also Sophie Germain, who I claim, provocatively of course, founded mathematical physics and many more not so well known. And then of course on Maryam Mirzakhani, the first female Fields Medalist whose early death was so tragic and such a loss. If you want something less academic and more literary I can refer to I numeri nel cuore in which I, along with my colleagues Ciro Ciliberto and Fausto Saleri, collected some of our short stories, albeit with mathematical themes.

Elisabetta Strickland in Edinburgh.

UP: *What about your interest in photography?*

ES: That you know about of course, did we not have a photo exhibit together?

UP: *That was ages ago. But what about your interest?*

ES: I combined it with my sailing activities. I loved to take photos of sailboats, especially engaged in racing. One particular case was when I was hard up trying to shoot a really unconventional picture. I approached a guy with a helicopter and was able to convince him to give me a ride. I entered, he strapped me to the seat and took off. I was a bit apprehensive of course, never having been in a helicopter before, and so he opened the door on my side and turned the helicopter sideways, so I was staring into the void below me. Normally I would have been terrified, but I had a job to do, and I leaned out with my camera and shot several pictures from my unique vantage point. They made a splash, some of them even ended up on the cover of sailing magazines and I got a golden plate from Kodak for one of them.

The helicopter photo taken during the Sardinia cup, 1981.

UP: *You got to be famous.*

ES: I would not say that, but it certainly had the sweetness of fame, I was very proud. I have another anecdote to give you and your readers a taste of that life. One morning I decided to do something special coming to cover a sailing event. There was the Whitbread race in England. Somehow I managed to get there, I was a research scholar, so with little money at the time; and once there I had the problem of lodging. I discovered a boat with some young Danes and asked them whether I could sleep over in their boat. They responded with due enthusiasm, and we had a wonderful evening laughing, talking and drinking beer. Wonderful, magical times, nothing untoward happened. In the morning they took off for the race, and I was fit for fight.

UP: *Do you have any other hobbies?*

ES: What do you mean? Is not two such enough? True, I am interested in many things, but if I had not pursued a career in mathematics, I might have been an interior decorator. Such things amuse me a lot. Recently Corrado and I bought some property in Tuscany, which we have set up quite nicely, if for no other reason than to entice our son and his girlfriend, who are living in London, to visit us more often. It seems to work.

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Wuhan, China

Web: mathcenter.hust.edu.cn　　E-mail: mathcenter@hust.edu.cn

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数学中心网址　　招生视频

地址：中国武汉珞喻路1037号华中科技大学
创新研究院(恩明楼)8楼
邮编：430074
电邮：mathcenter@hust.edu.cn
网页：mathcenter.hust.edu.cn

8th Floor of Enming Building
1037 Luoyu Road, Wuhan, China
Postal Code: 430074
E-mail: mathcenter@hust. edu.cn