Research Landscape of Mechanics in China Mainland

WEI YANG

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- Dynamics of Basic Research in China
- Three Driving Forces for Mechanics Researches
- Statistics of Mechanics Research in China
- China-Led Progresses in Mechanics

  Fluid Mechanics

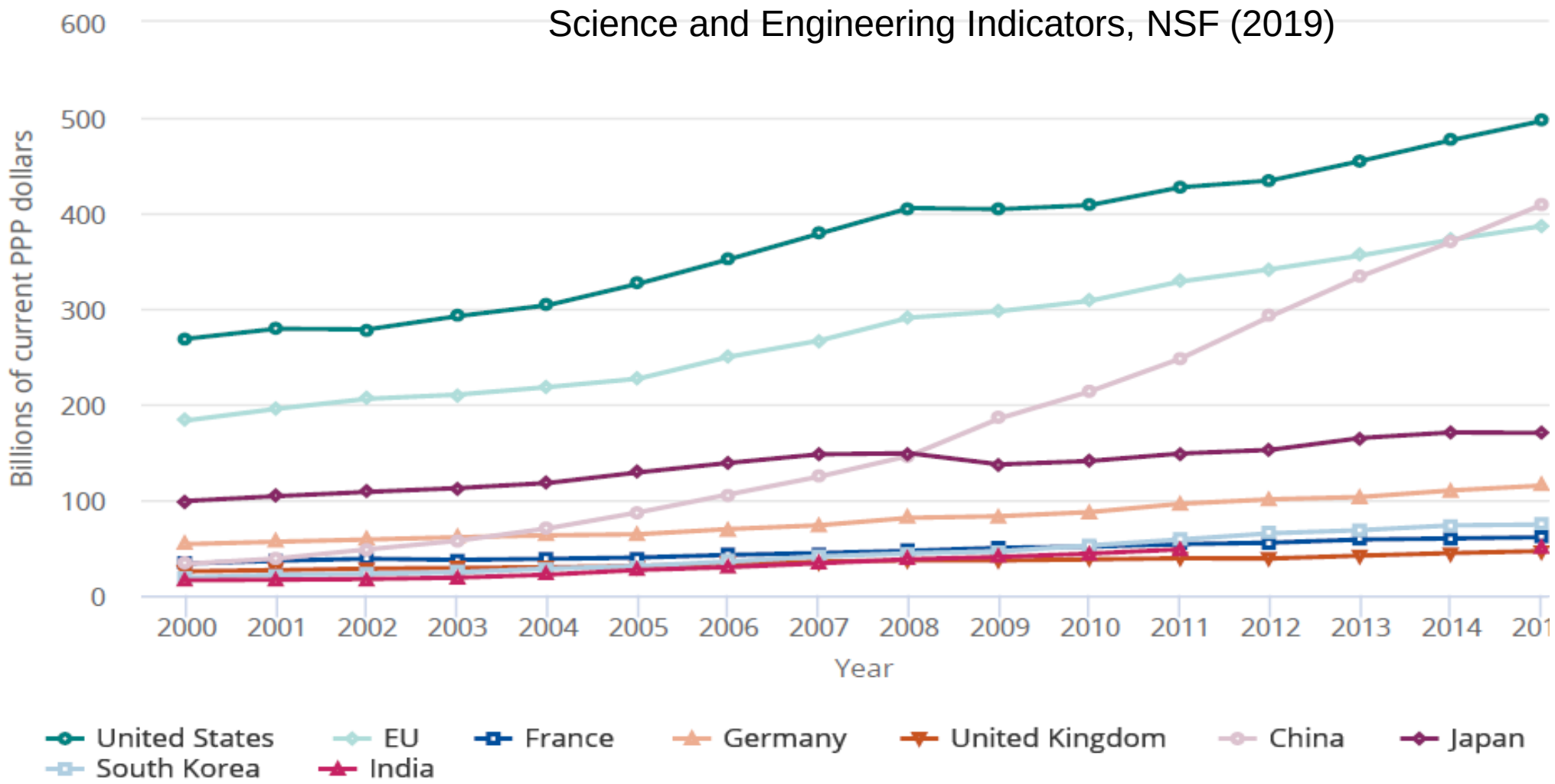
  Solid Mechanics

  Dynamics

Dynamics of Basic Research in China

Expenditures in R&D

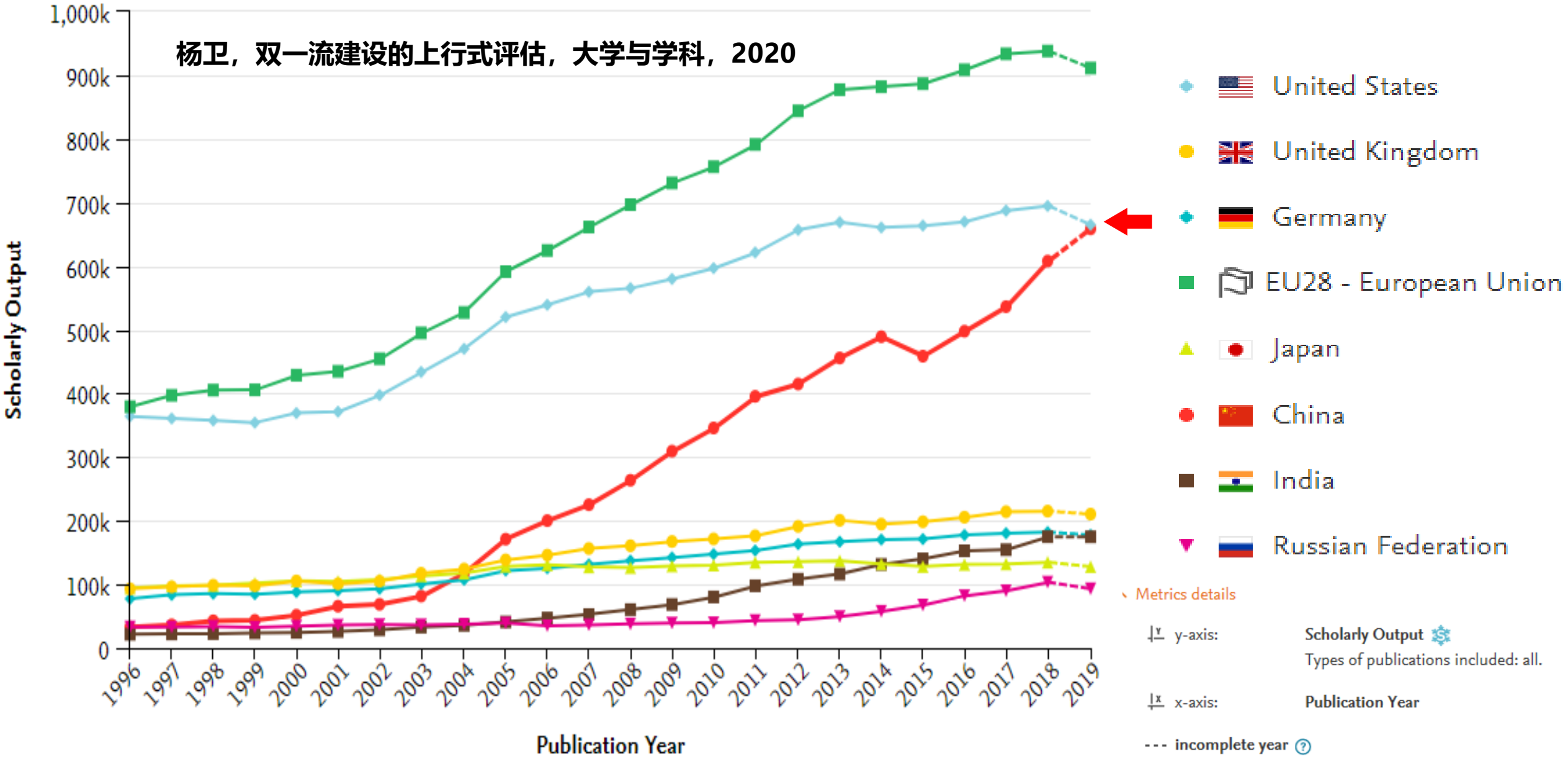
Gross domestic expenditures on R&D, by selected region, country, or economy: 2000–15



- BR/R&D : USA 17% , China 5%.
- China Investment to BF is about 1/4 of that of USA.

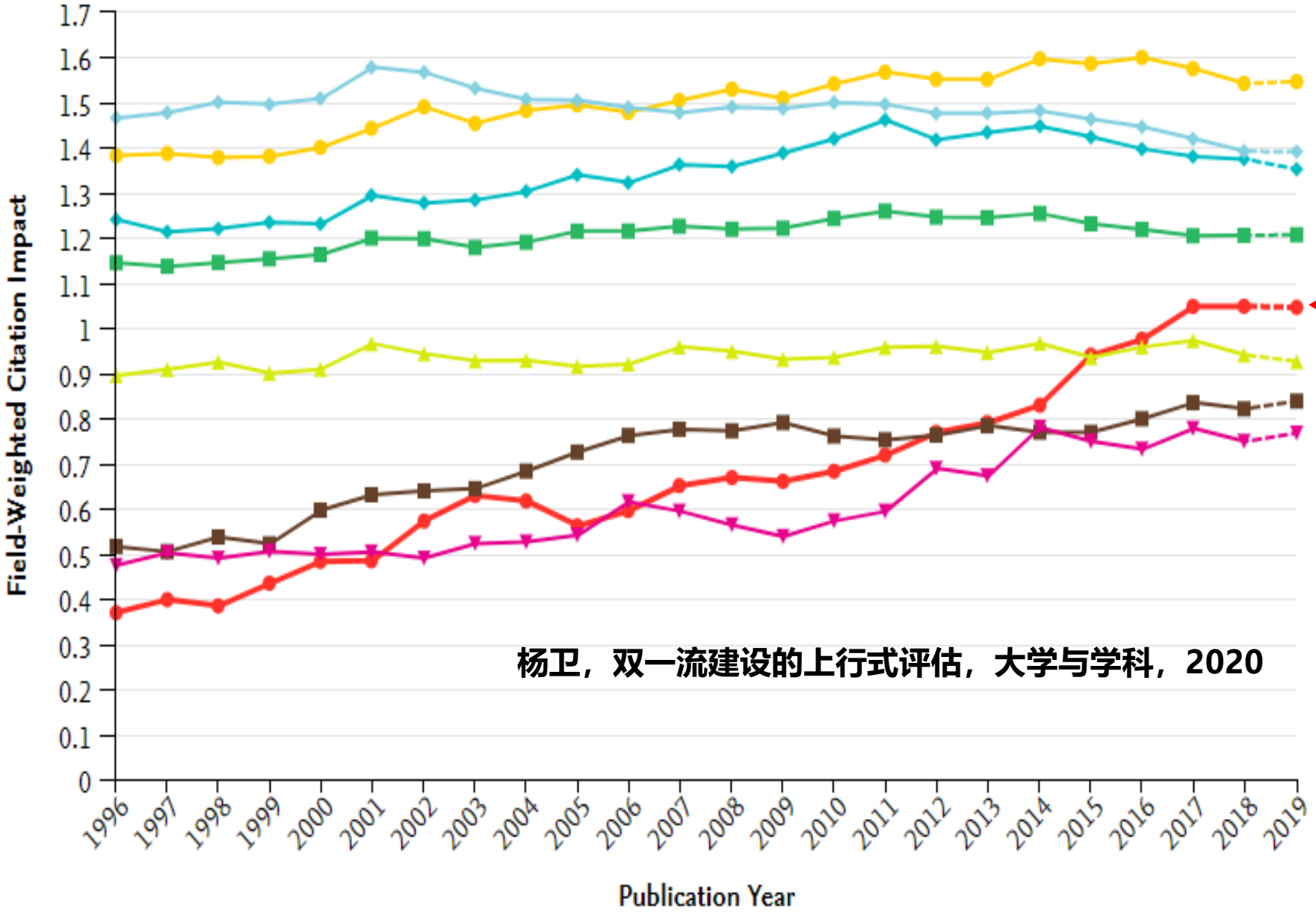
Quantity of Scholarly Output

Data Source: Scopus/SciVal
Date: 2020.01.20



Quality of Scholarly Output: FWCI

Data Source: Scopus/SciVal
Date：2020.01.20



- United States
- United Kingdom
- Germany
- EU28 - European Union
- Japan
- China
- India
- Russian Federation

Metrics details

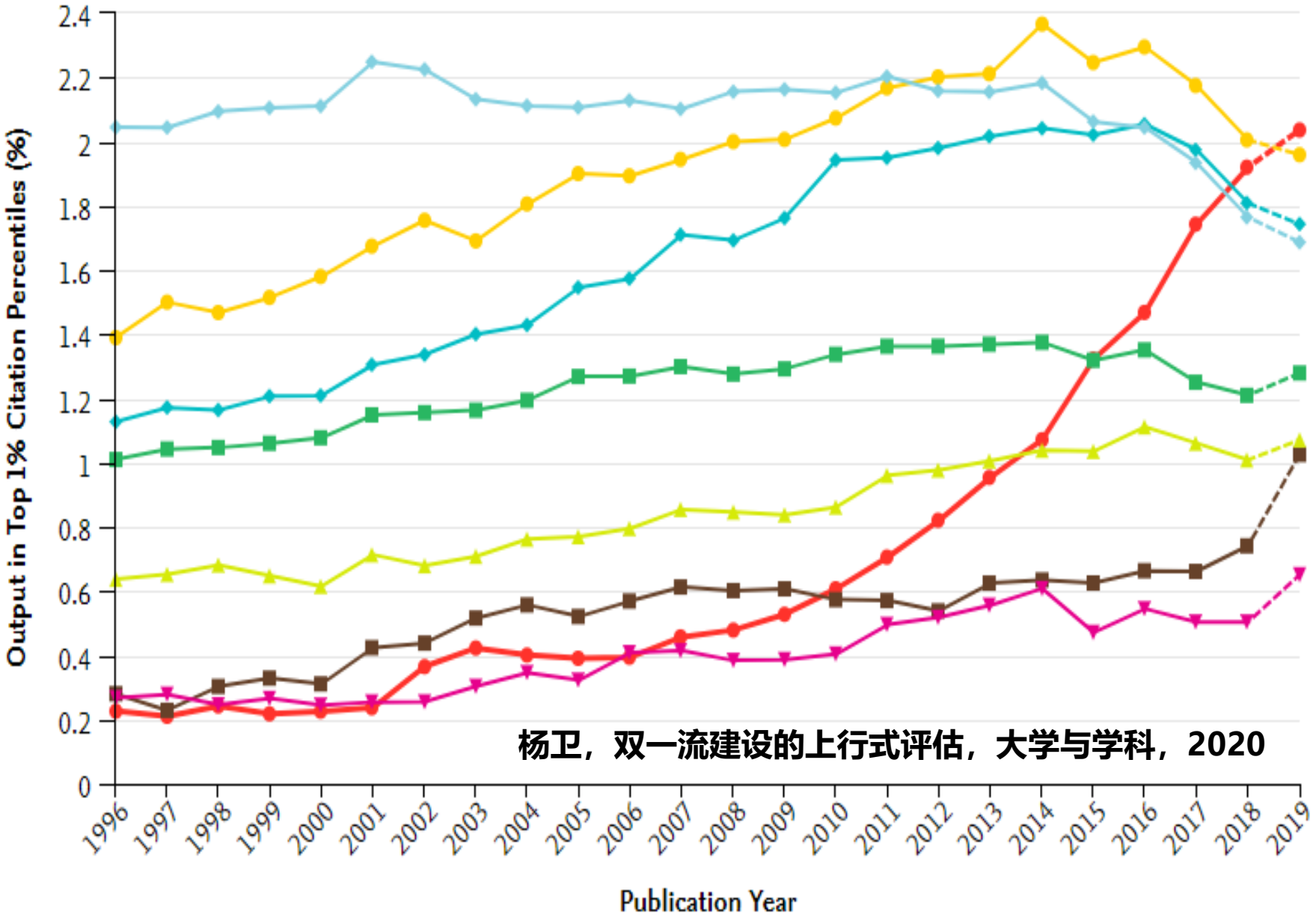
y-axis: Field-Weighted Citation Impact
Types of publications included: all. Self-citations included: yes.

x-axis: Publication Year

incomplete year

Quality of Scholarly Output: Top 1% Cited

Data Source: Scopus/SciVal
Date：2020.01.20



杨卫，双一流建设的上行式评估，大学与学科，2020

- United States
- United Kingdom
- Germany
- EU28 - European Union
- Japan
- China
- India
- Russian Federation

Metrics details

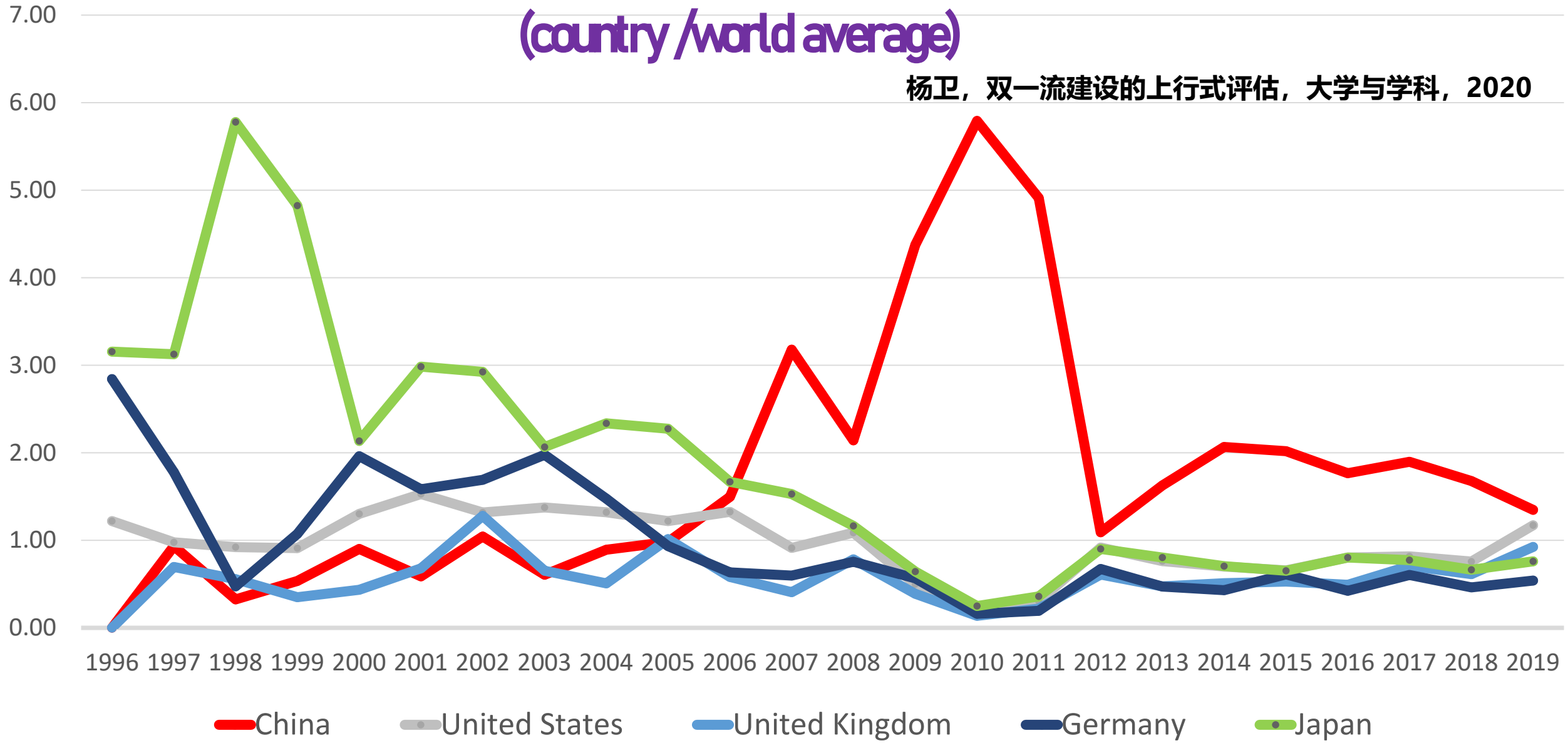
y-axis: Output in Top 1% Citation Percentiles (In top 1% of World)
Types of publications included: all. Self-citations included: yes. Field-weighted: no

x-axis: Publication Year

--- incomplete year

Data Source: Retraction Watch & Scopus/SciVal
Date：2020.01.20

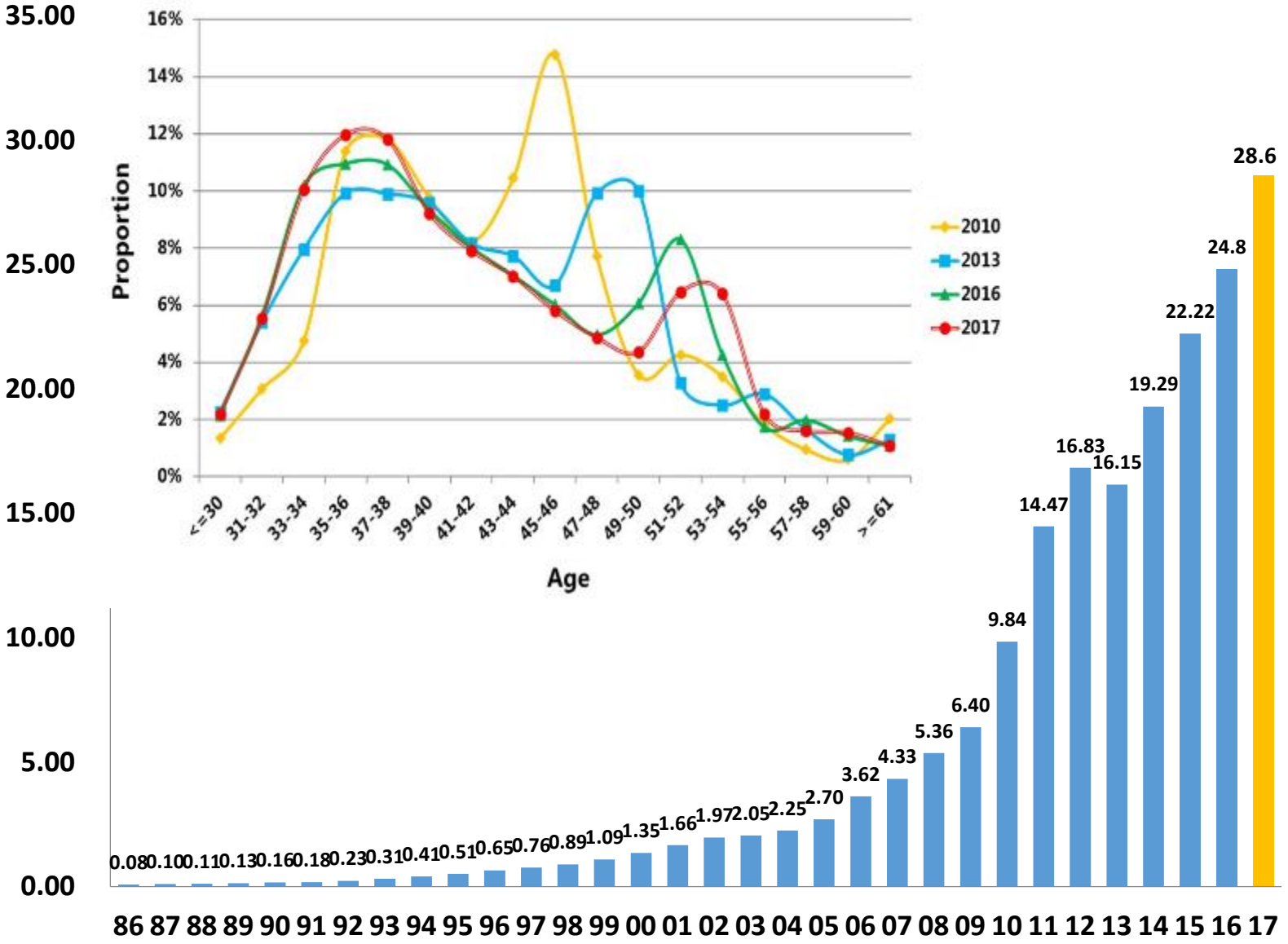
Retraction Rate Relative Comparison (country /world average)



Three Driving Forces

National Natural Science Foundation of China (NSFC)

- Budget escalates and reaches 35B CNY in 2020
- > 700 grants awarded annually for Mechanics.
- 7个一级代码：动力学与控制、固体力学、流体力学、生物力学、物理力学、爆炸与冲击动力学、环境力学
- Young investigators have the edge in competing NSFC grants.



Three Driving Forces

中华人民共和国教育部
Ministry of Education of the People's Republic of China

◆MoE: Nurturing World-class Universities and Programs

36+6 universities; 137 university programs

[by Disciplinary Evaluation (2012, 2017) + ESI, THE, QS, US News, Shanghai]

2020: Double the combined effort of 985 & 211;

2016-2020 RMB 110 Billions

2035: >10 in top 100

2050: Powerhouse of Higher Education

◆ **Excellency in Mechanics**
Mechanics Education (22)
Mechanics Programs (10)

Three Driving Forces

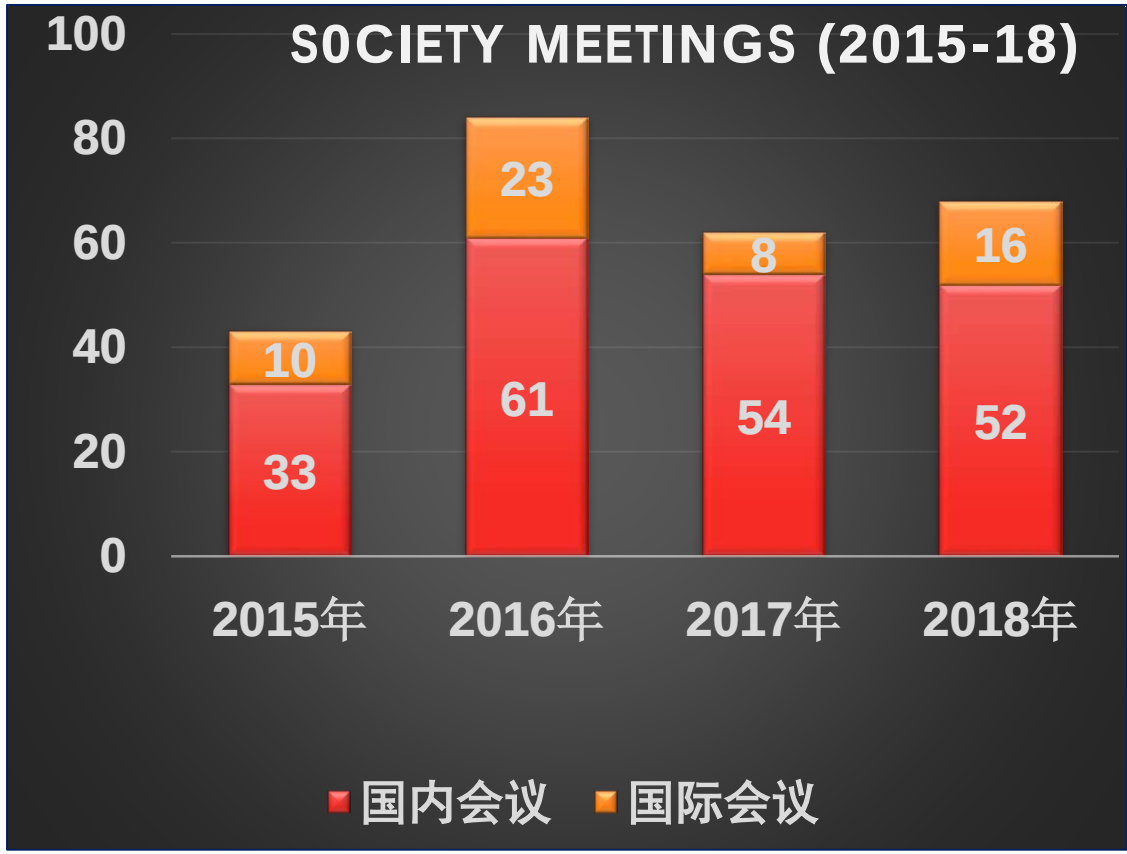
◆Chinese Society of Theoretical and Applied Mechanics (CSTAM)

35877 Members

335 Academic Meetings from 2015-2018

>13000 Participants Annually

6700 Presentations Annually



Congress of CSTAM - 2015， Aug. 15-18, 2015, Shanghai
Shanghai Jiao-Tong University, 3400 Participants

Congress of CSTAM - 2017 and 60 Anniversary of CSTAM, August 13-16, 2017. Beijing.
Beijing Institute of Technology, 3100 Participants.

Congress of CSTAM - 2019，August 25-28, 2019, Hangzhou
Zhejiang University, 4800 Participants

SUBCOMMITTEES ORGANIZED SYMPOSIA

- 全国固体力学大会 2000
- 全国流体力学学术会议 1000
- 全国非线性振动暨全国非线性动力学和运动稳定性学术会议 700
- 全国生物力学学术会议
- 全国爆炸力学学术会议 1300
- 全国实验力学大会 800
- 中国计算力学大会。。 1500

Solid Mechanics Meeting, 2018, > 2000 Participants.

Statistics of Mechanics Research in China

Solid Mechanics

国务院学位委员会力学评议组（2019）

Journal	JMPS Amount (percentage)		IJSS Amount (percentage)		CMAME Amount (percentage)		EM Amount (percentage)	
	2010~2012	2016~2018	2010~2012	2016~2018	2010~2012	2016~2018	2010~2012	2016~2018
China	38 9.9%	114 16.5%	142 14.9%	221 18.7%	66 8.6%	250 19.0%	21 5.3%	58 16.0%
USA	204 53.0%	359 52.0%	255 26.7%	315 26.6%	252 33.0%	433 32.9%	170 43.0%	135 37.3%
UK	24 6.2%	59 8.5%	62 6.5%	111 9.4%	34 4.45%	81 6.1%	33 8.4%	44 12.2%
France	60 15.6%	101 14.6%	139 14.6%	156 13.2%	113 14.8%	112 8.5%	43 10.9%	45 12.4%
Germany	41 10.6%	66 9.6%	53 5.6%	93 7.9%	113 14.8%	195 17.8%	20 5.1%	19 5.3%
Italy	27 7.0%	53 7.7%	67 7.0%	81 6.9%	55 7.2%	117 8.9%	20 5.1%	13 3.6%
Japan	4 1.0%	13 1.9%	29 3.0%	30 2.5%	11 1.4%	23 1.7%	19 4.8%	17 4.7%
Australia	5 1.3%	14 2.0%	38 4.0%	37 3.1%	13 1.7%	49 3.7%	3 0.8%	12 3.3%

Statistics of Mechanics Research in China

Fluid Mechanics

国务院学位委员会力学评议组（2019）

Journal	JFM Amount (percentage)		PoF Amount (percentage)		IJHMT Amount (percentage)		C&F Amount (percentage)	
	2010~2012	2016~2018	2010~2012	2016~2018	2010~2012	2016~2018	2010~2012	2016~2018
China	69 4.1%	237 9.3%	72 4.8%	359 19.2%	342 17.0%	1871 42.0%	62 8.0%	234 19.6%
USA	644 38.6%	924 36.1%	618 41.1%	407 21.7%	467 23.2%	808 18.1%	376 48.7%	523 43.9%
UK	326 19.5%	542 21.2%	144 9.6%	187 10.0%	69 3.4%	162 3.6%	68 8.8%	62 5.2%
France	265 15.9%	400 15.6%	243 16.2%	152 8.1%	112 5.6%	127 2.9%	83 10.7%	113 9.5%
Germany	97 5.8%	187 7.3%	91 6.1%	107 5.7%	76 3.8%	136 3.1%	72 9.3%	127 10.7%
Italy	95 5.7%	112 4.4%	78 5.2%	52 2.8%	56 2.8%	99 2.2%	30 3.9%	35 2.9%
Japan	58 3.5%	85 3.3%	63 4.2%	81 4.3%	82 4.1%	190 4.3%	33 4.3%	47 3.9%
Australia	84 5.0%	215 8.4%	61 4.1%	69 3.7%	37 1.8%	94 2.1%	28 3.6%	58 4.9%

Statistics of Mechanics Research in China

8 种顶尖力学期刊发表的全球学术机构排名（2016-2018）

Rank 全球排名	Institution 学术机构	Scholarly Output 收录	Citations 引用
1	Tsinghua University 清华大学	311	2356
2	Xi'an Jiaotong University 西安交大	287	2541
3	University of Cambridge 剑桥大学	238	1449
4	Imperial College London 帝国理工	237	2257
5	Universite Paris-Saclay	215	1570
6	Shanghai Jiaotong University 上海交大	209	1711
7	Chinese Academy of Sciences 中科院	170	1420
8	Purdue University 普度大学	170	1568
9	Harbin Institute of Technology 哈工大	168	1361
10	Dalian Institute of Technology 大连理工	167	1941
11	Stanford University 斯坦福	162	1602
12	MIT 麻省理工	157	1252
13	Princeton University 普林斯顿	136	1269
14	UIUC 伊利诺伊	136	1063
15	Sorbonne Universite	133	977
16	USTC 中科大	132	845

Progresses in Mechanics

Fluid

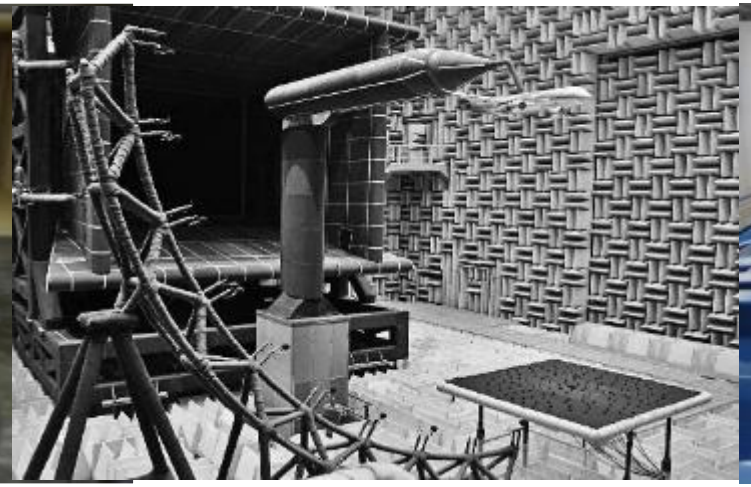
- Wind Tunnel Construction
- Hypersonic Flow
- Drag Reduction of C919 & CR929
- Turbulence Structures
- Dust Storm: Field Testing

Wind Tunnel Construction

- 在庄逢甘等制定的《2008-2020年国家大型空气动力试验设备设施平台建设规划》的指引下，一批具有世界先进水平的大型风洞在四川绵阳相继建成。
  - 具备了飞机结冰与防除冰、气动噪声控制等问题的研究和工程应用能力；新建的低速增压风洞使试验雷诺数提高到10^7量级。

庄逢甘

3米×2米结冰风洞

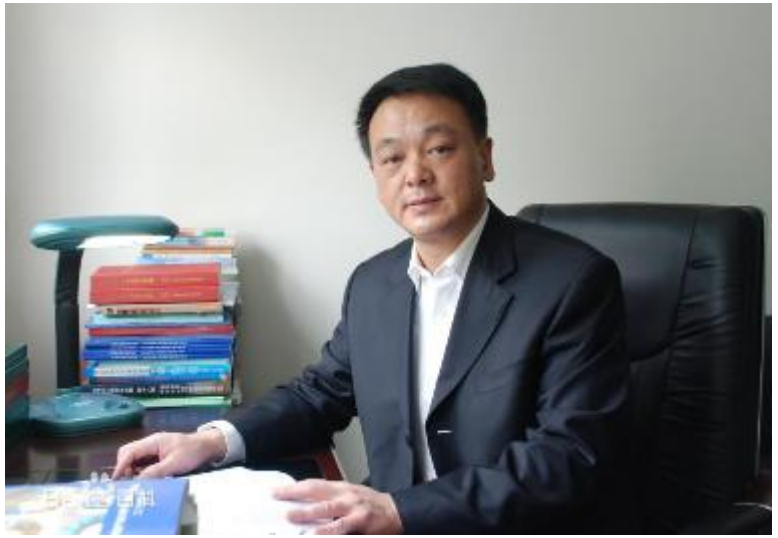


5.5米×4米声学风洞

低速增压风洞

Hypersonic Flow

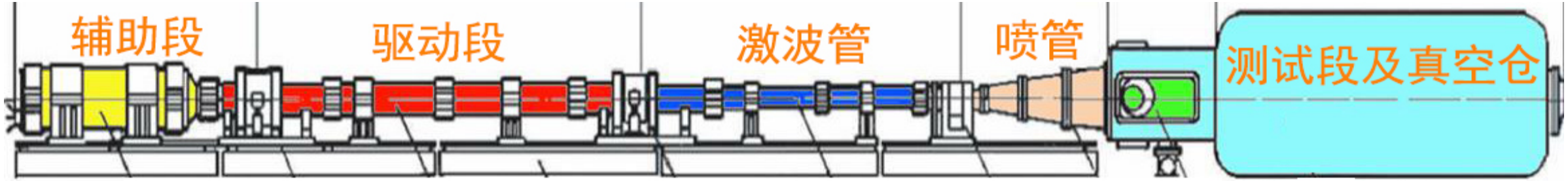
- **Φ2米高超声速风洞和Φ1米高超声速低密度风洞：**发展了诱导湍流增强换热、边界层增长抑制理论和方法，突破大流量加热器、低密度高马赫数喷管关键技术，使我国形成了近空间全空域宽速域高超声速空气动力试验研究能力。

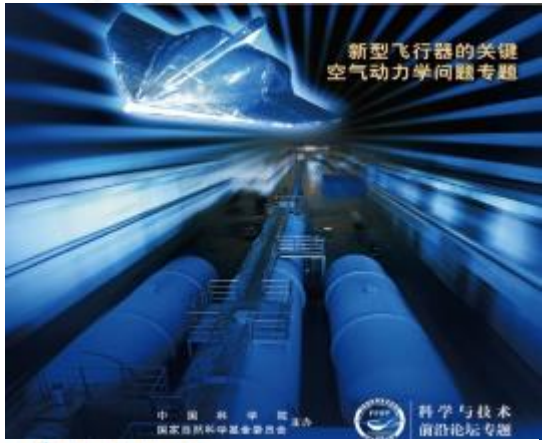


唐志共

Φ2米高超声速风洞

Φ1米高超声速低密度风洞





AIAA
Shaping the Future of Aerospace

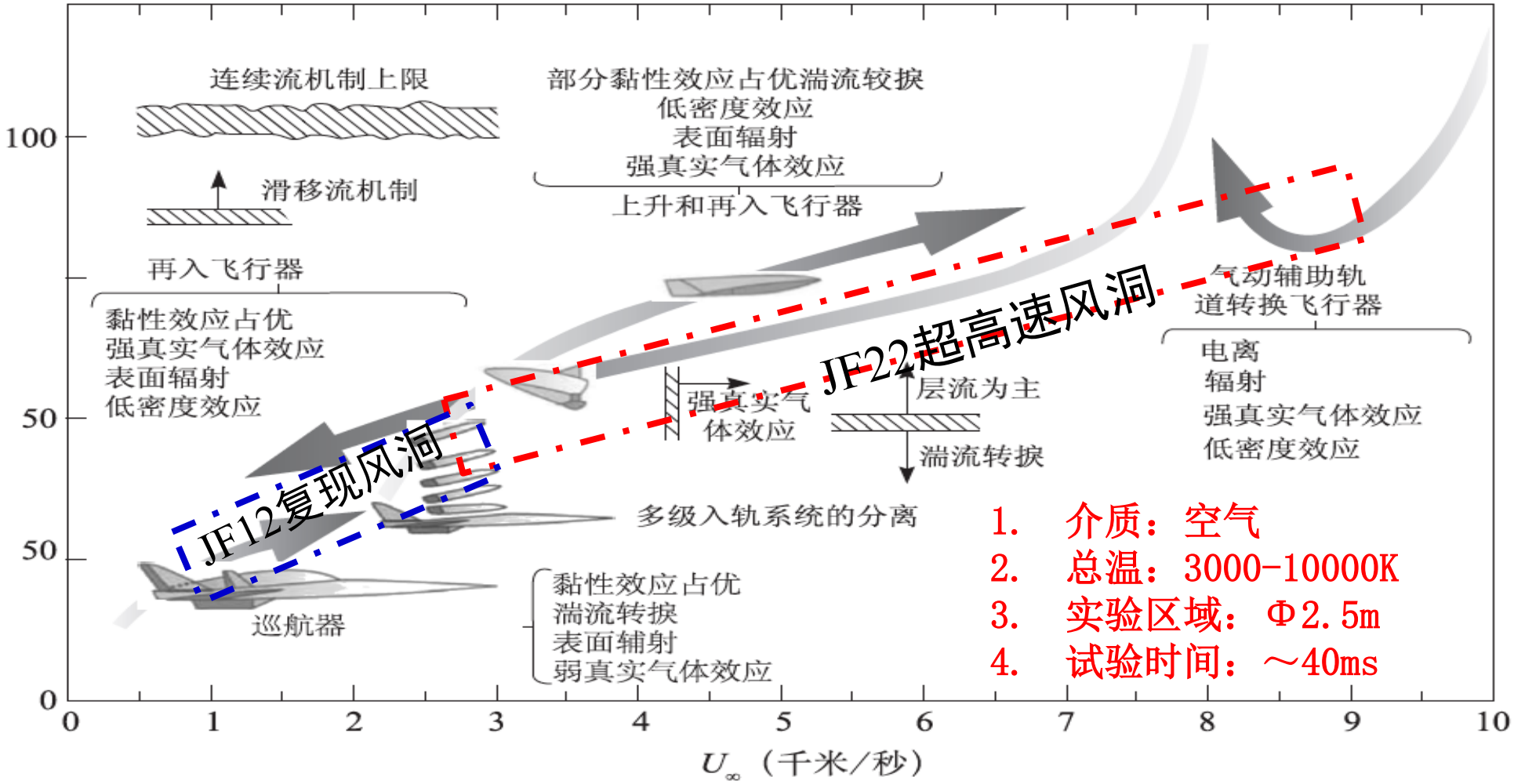
FOR IMMEDIATE RELEASE

CONTACT: DUANE HYLAND
703 264.7558

ZONGLIN JIANG WINS AIAA 2016 GROUND TESTING AWARD
Honored for Work on World's Largest Shock Tunnel

March 29, 2016 – Reston, Va. – Zonglin Jiang, an American Institute of Aeronautics and Astronautics (AIAA) Associate Fellow, and professor and director of the State Key Laboratory of High-Temperature Gas Dynamics at the Institute of Mechanics of the Chinese Academy of Sciences, Beijing, People's Republic of China, has won the AIAA 2016 Ground Testing Award. Jiang will receive the award at a room awards luncheon on June 14, as part of the AIAA Aviation and Aerospace Forum and Exposition 2016 (AIAA AVIATION 2016), June 13–17, at the Washington Hilton, Washington, D.C.

The award honors Jiang's "skillful leadership in conceiving, developing and successful commissioning of the



1. 介质：空气
2. 总温：3000-10000K
3. 实验区域：Φ2.5m
4. 试验时间：～40ms

姜宗林

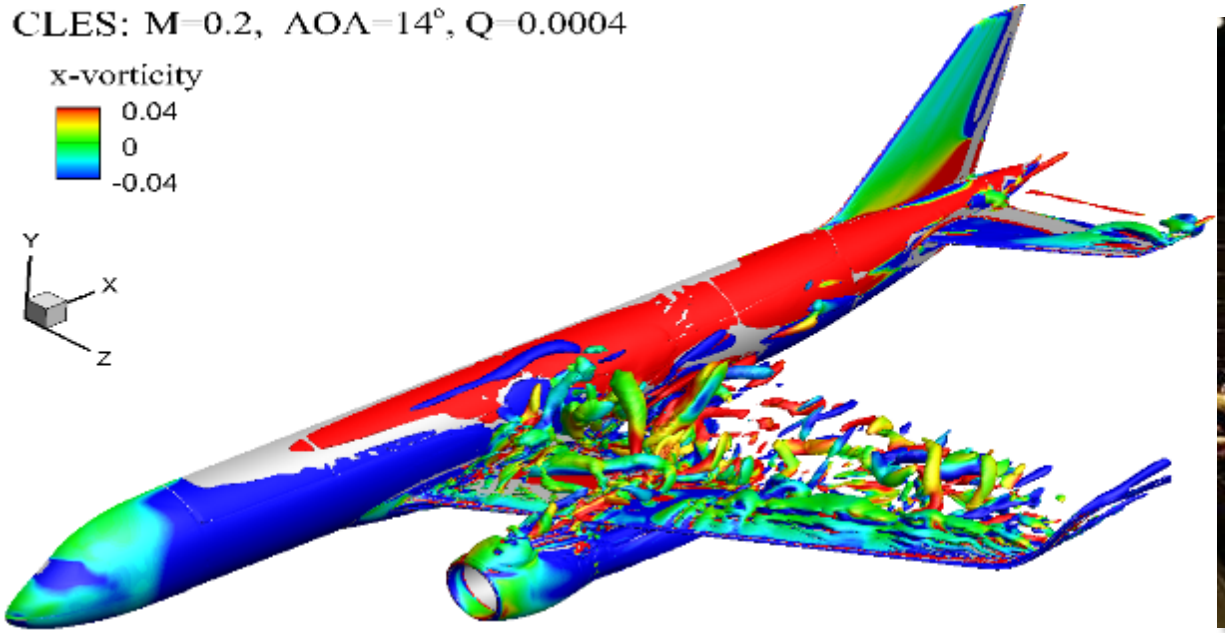
临界空间飞行器空天飞行的速度 - 高度图

Drag Reduction of C919 & CR929

陈迎春

- **在湍流多尺度结构方向开展了原创性工作**

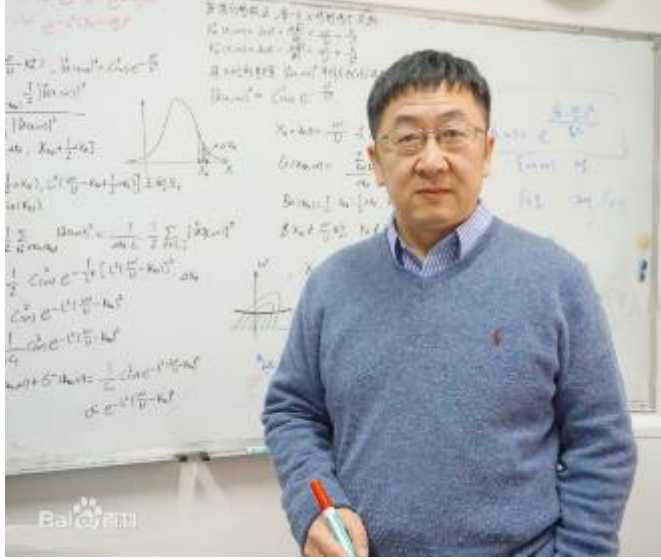
发展了基于物理约束的LES模型，并应用于大飞机气动设计。



C919大型客机巡航状态约束大涡模拟

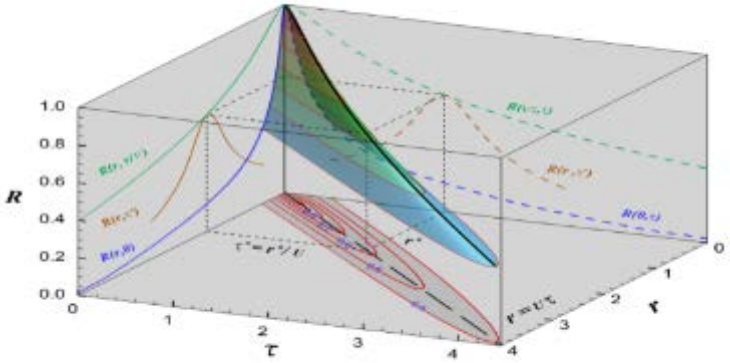
2012年世界力学家大会开幕式报告

Turbulence Structures

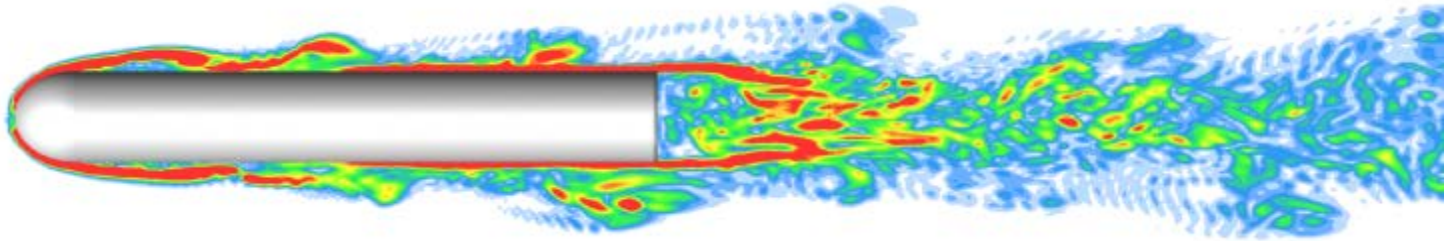


何国威

提出了**时空关联的统计（EA）模型**，发展了**时间精准的大涡模拟**方法，它们是大涡模拟研究的重要方法论。



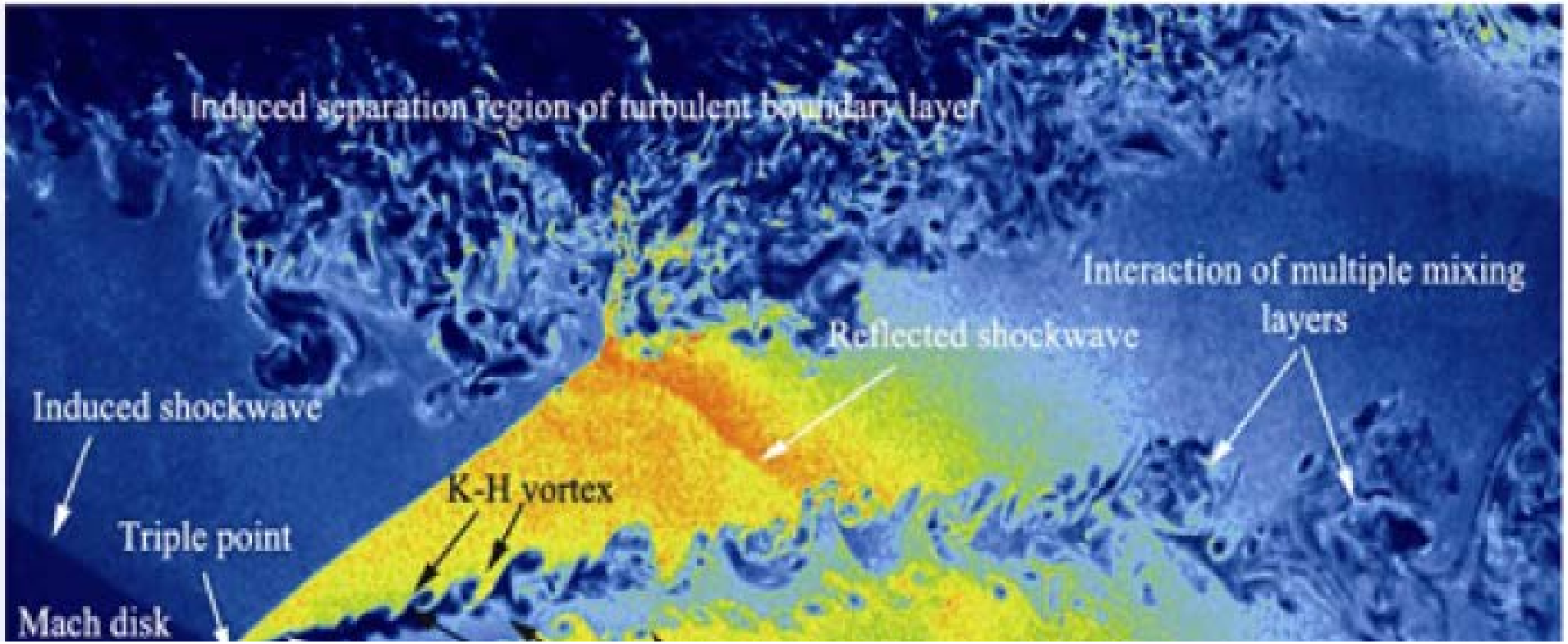
时空关联EA模型的图示



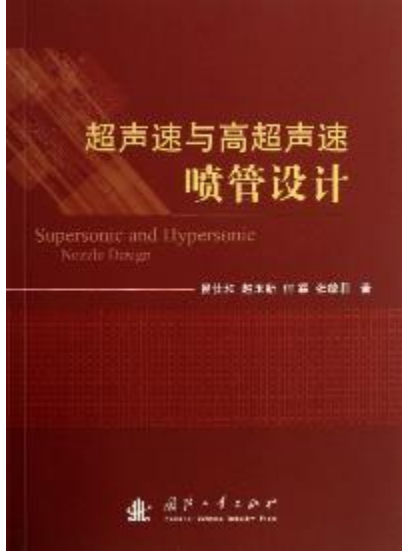
钝头柱体绕流的时间精准大涡模拟

该系列研究成果获邀在《流体力学年鉴》发表综述论文

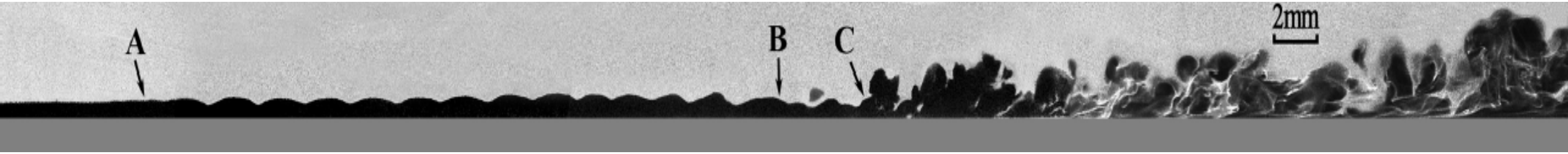
Turbulence Structures



纳米粒子激光散射技术识别超声速边界层中的湍流结构



易仕和



高超声速静风洞中边界层转捩完整过程的实验照片

李存标

Turbulence Structures

拉格朗日框架 涡面场 涡重联 虚拟速度 扭结 阻力

杨 越

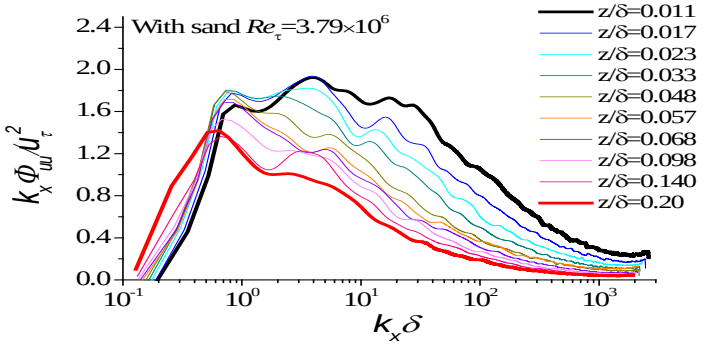
Dust Storm: Field Test

大气表面层高雷诺数(10^6)壁湍流的野外观测

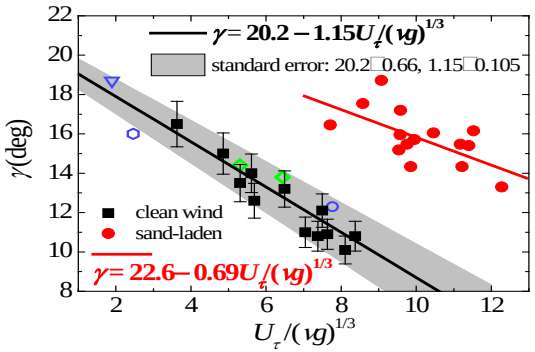
实验场地300km²平地，装置占地25亩

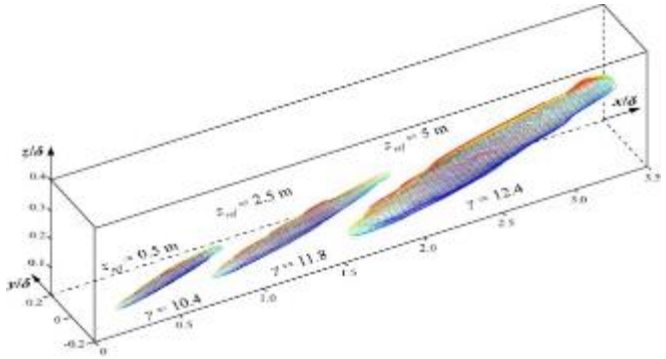
郑晓静、周又和

实现了对大气边界层风沙流以与沙尘暴的全方位（三维风速、粉尘浓度、温湿度、风沙电场）实时同步的全场观测，累积了长达5年的观测数据，为国际上野外壁湍流雷诺数最高。



揭示了大气表面层超大尺度结构起源的“自上而下”机制





揭示了净风和含沙超大尺度结构的尺度规律和倾角随摩阻风速降低的规律

Progresses in Mechanics

Solid

- Hardness & Strength of Diamond
- Heat Protecting Materials
- Structural Super-Lubricity
- Mechanics of Intelligent Media
- Flexible Electronics
- Mechanics of Soft Matters

Hardness & Strength of Diamond

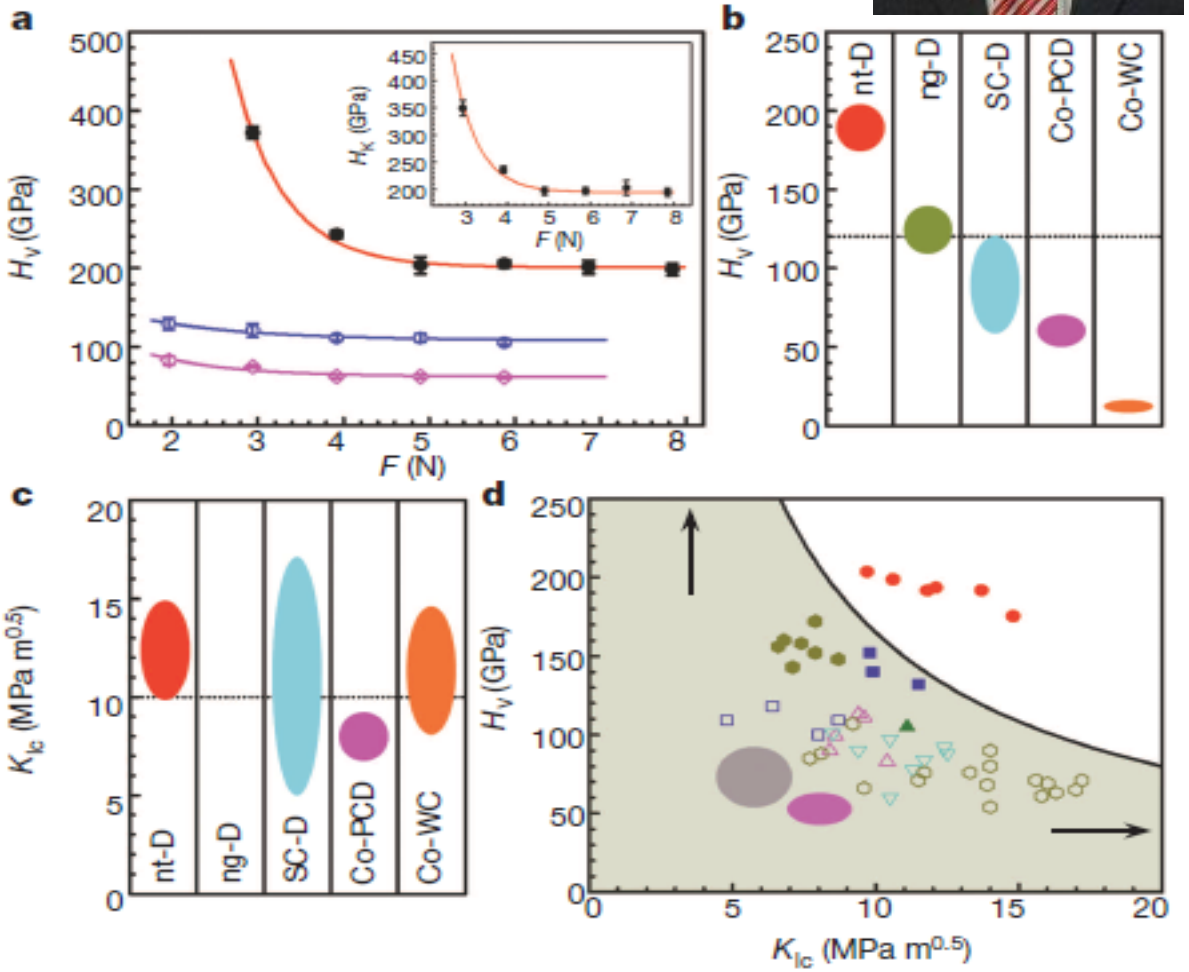
田永君

Diamond: SP3 bonding

BN: Russian Doll

260-450GPa: NT Diamond

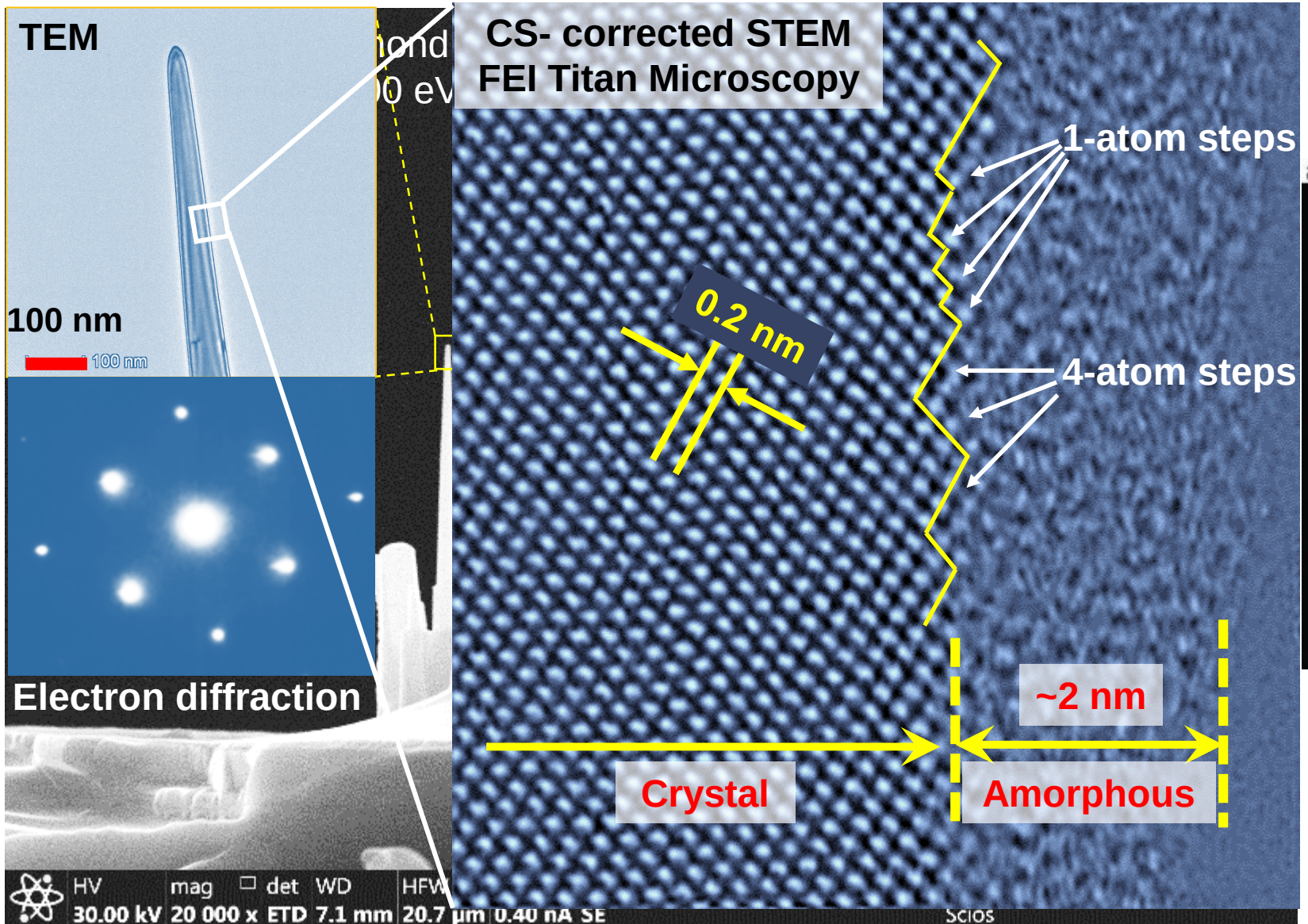
Quantum Confinement ?



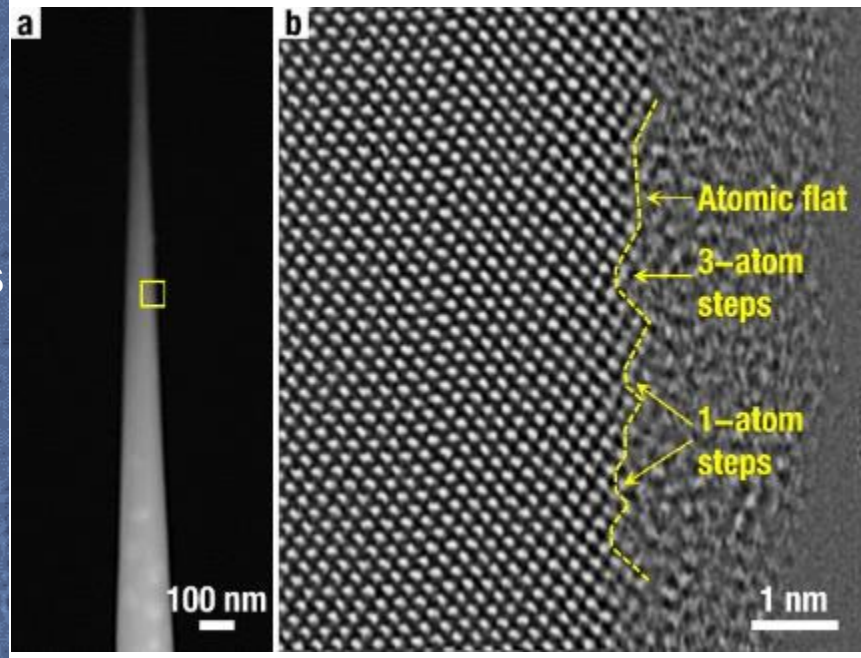
YJ Tian, Yanshan University

Approaching the Theoretical Strength

Dedicated sample preparation to minimize "flaws" on surface

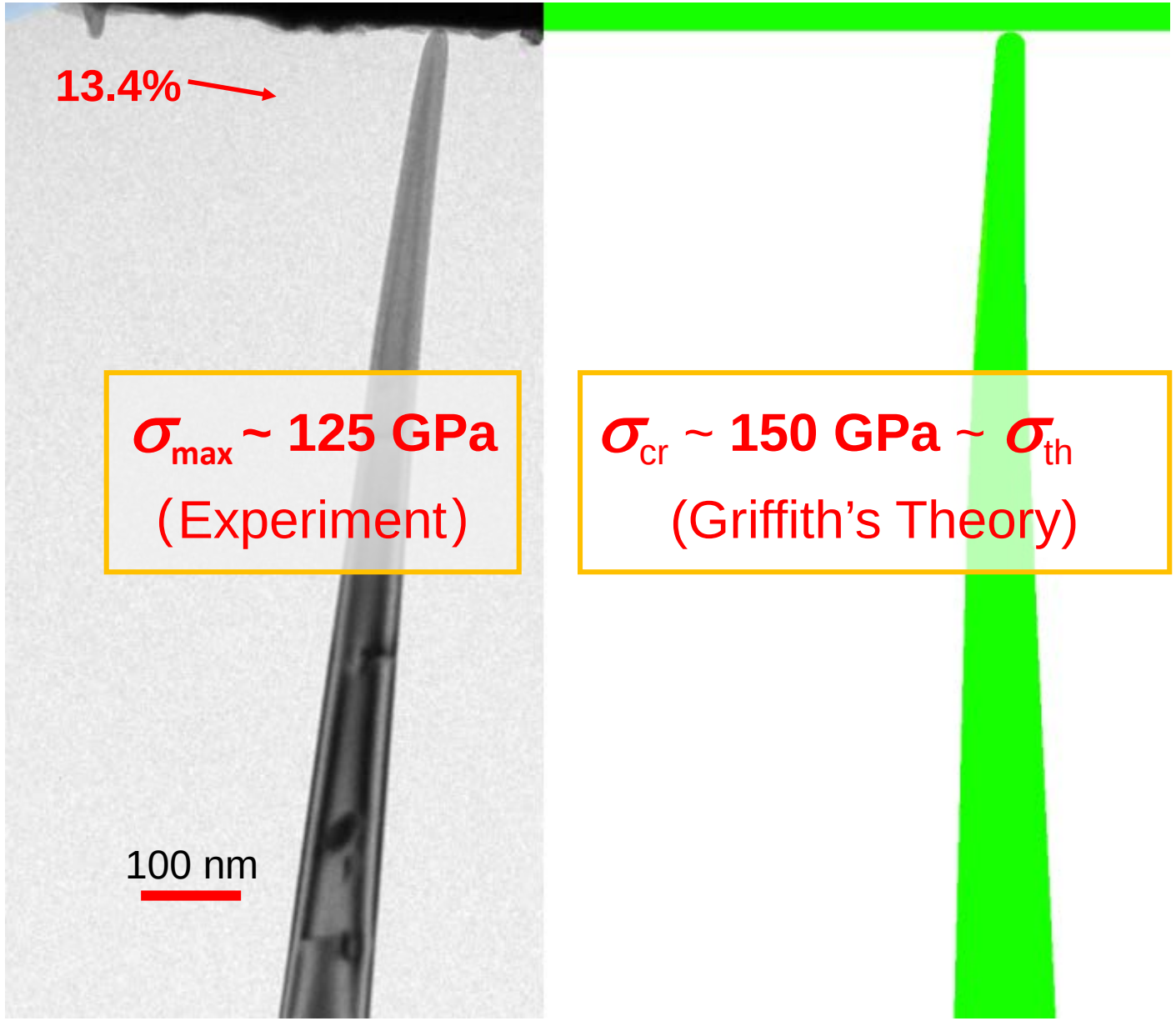


聂安民、卜叶强



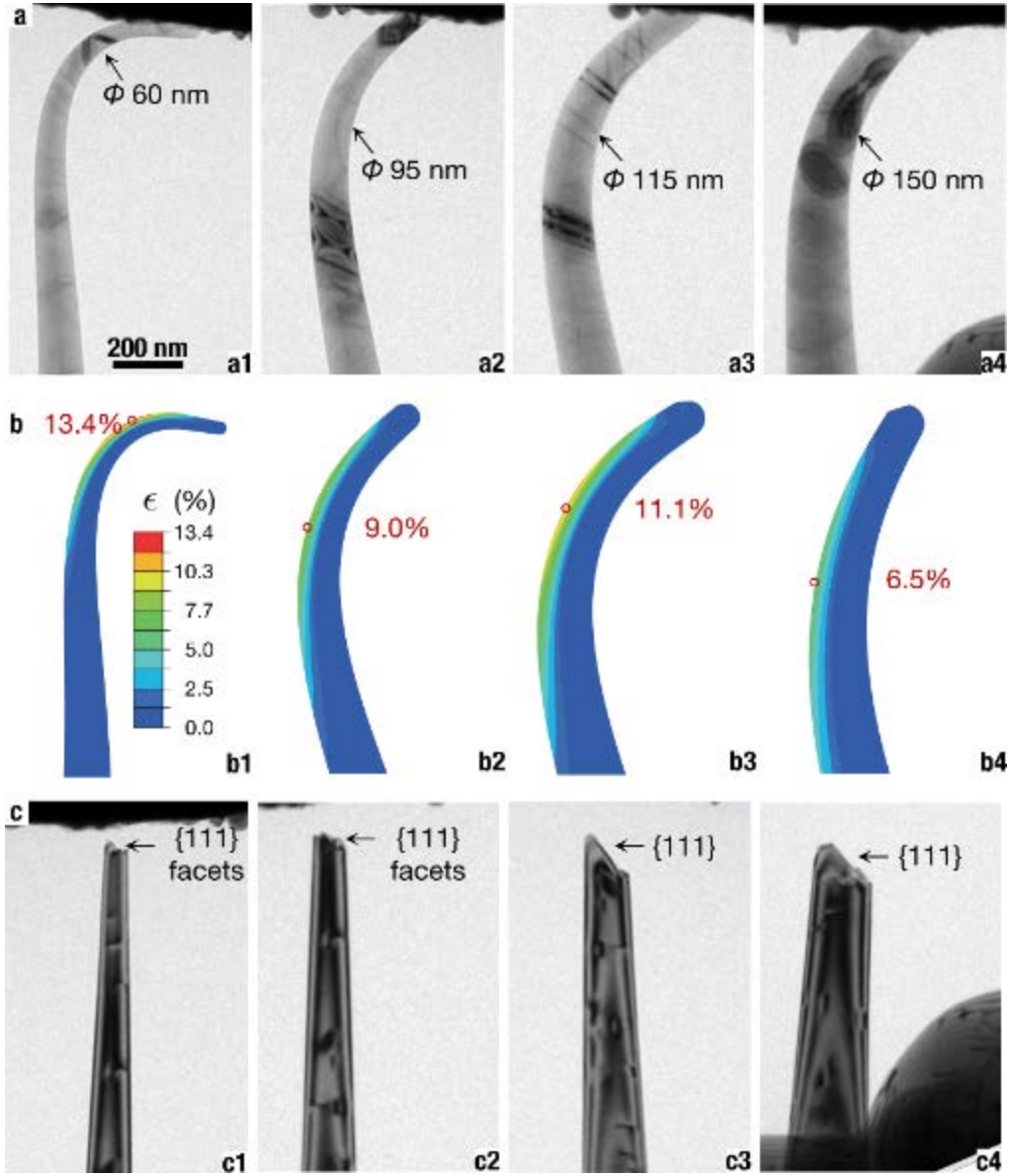
Nie, AM; Bu, YQ; Li, PH; Zhang, YZ; Jin, TY; Liu, JB; Su, Z; Wang, YB; He, JL; Liu, ZY; Wang, HT; Tian, YJ; Yang, W, Approaching diamond's theoretical elasticity and strength limits, *NATURE COMMUNICATIONS*, 10, 5533, 2019

<100> - Oriented Single Crystal Pillar



σ_{max} ~ 125 GPa
(Experiment)

σ_{cr} ~ 150 GPa ~ σ_{th}
(Griffith's Theory)



CFMS100

CENTURY FRACTURE MECHANICS SUMMIT
SINGAPORE 2019

第一排

杨卫
V Tvergaard
KH Lim
S Suresh
JR Rice
ZP Bazant
R Thampuran
JW Hutchinson
CF Shih
A Needleman
黄永刚
A Budiman
王自强
余寿文
张永伟

第二排

P Sharma
高华健
N Lapusta
夏焜
方岱宁
P Rosakis
M Ortiz
E Van der Giessen
CF Niordson
G Ravichandron
AJ Rosakis
O Hopperstad
U Ramamurty
RO Ritchie
RM McMeeking
张统一
锁志刚

第三排

N Fleck
李晓雁
魏宇杰
黄瑞
郭田福
刘彬
D Srolovitz
毛星原
吕坚
王彪
魏悦广
J Lou
季葆华

道明
郭万林

第四排

HB Chew
AE. Giannako-p
R Narasimhan
P Woelke
KL Nielsen

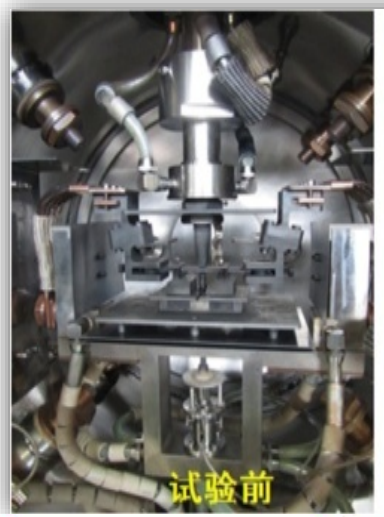
CB He
V Tan
P Branicio
王宏涛

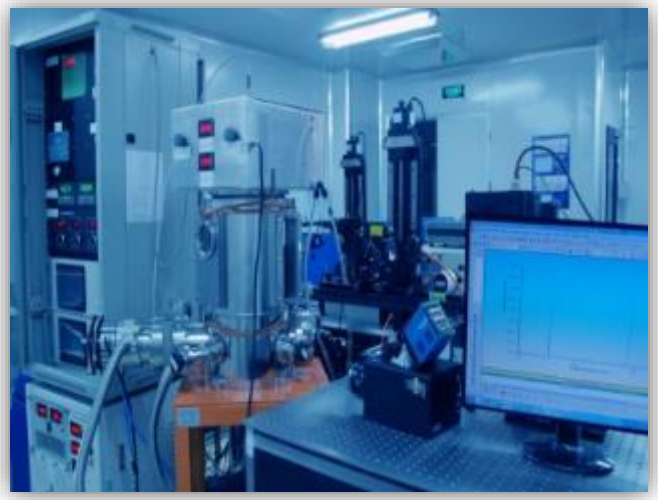
朱合彬

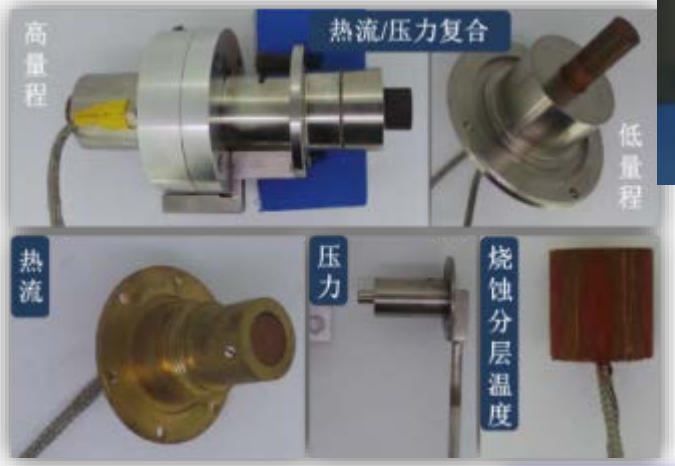
JR Greer
陈曦

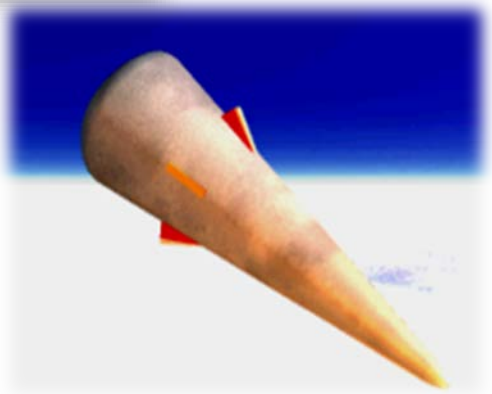
Heat Protecting Materials

韩杰才



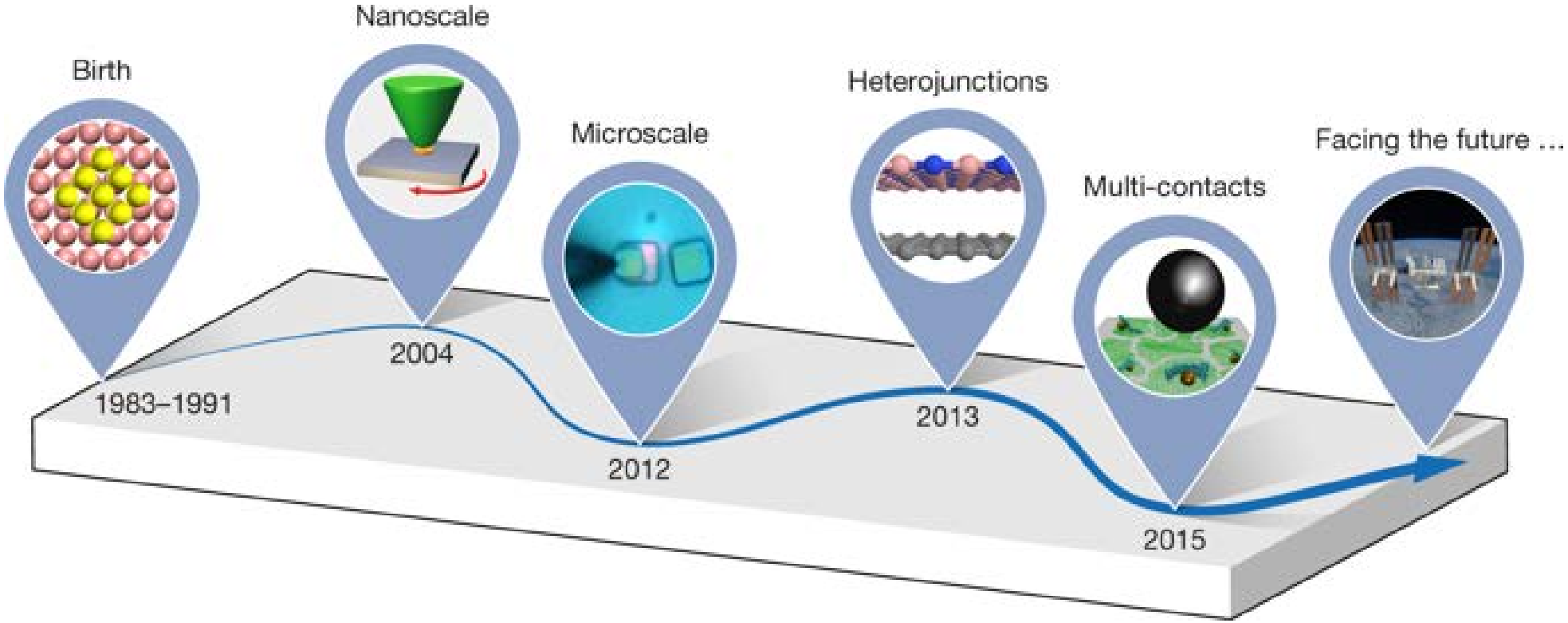






发展了多场耦合高温实验方法与在线信息获取技术，研发了快速升温1800℃有氧/2600 ℃惰性超高温力学试验机、1600℃有氧高温压痕仪等仪器。圆满完成多个近空间高超声速飞行器的飞行测试任务。

Structural Super-Lubricity

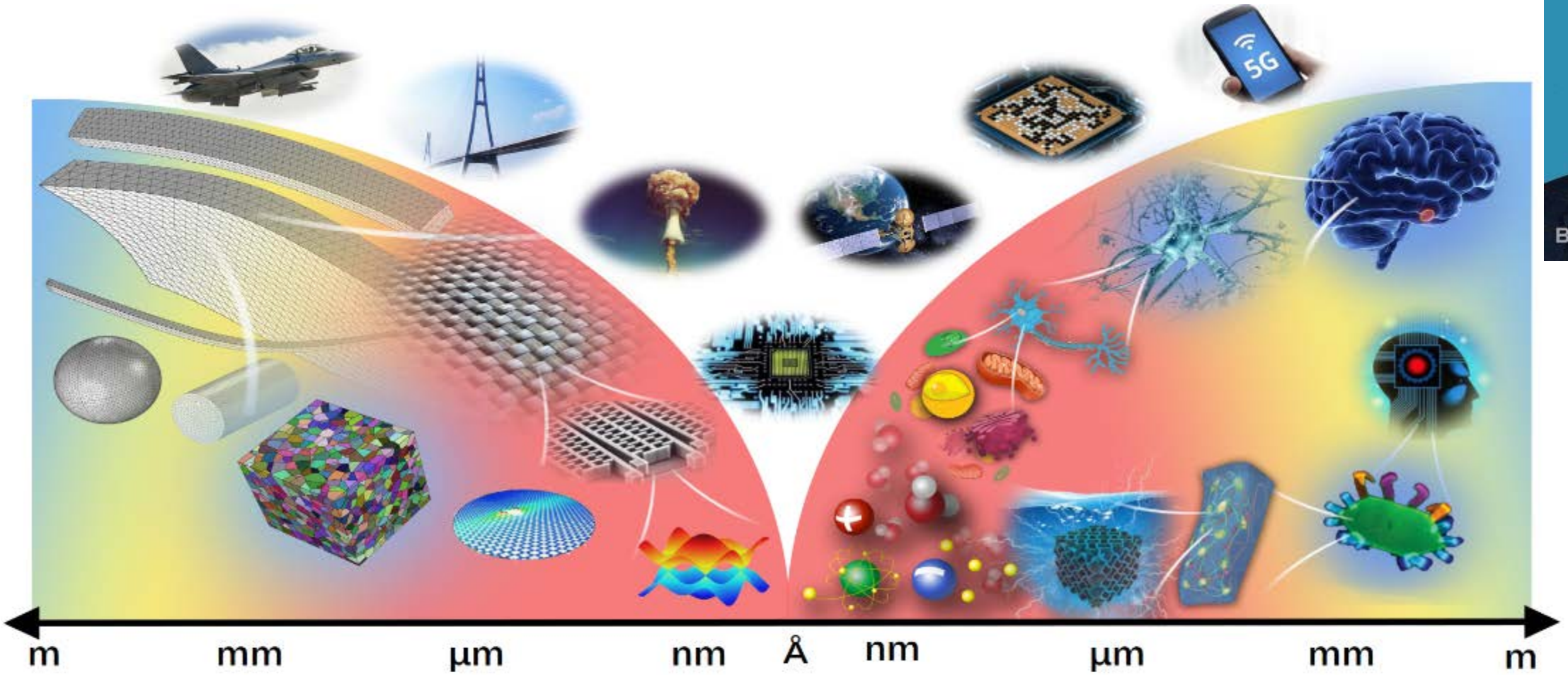


郑泉水

Oded Hod*, Ernst Meyer, Quanshui Zheng*, Michael Urbakh: Structural superlubricity and ultralow friction across the lengthscales. *Nature*, 563 (2018),485–492

Mechanics of Intelligent Media

郭万林



力与变形-运动 | 多场耦合-信息功能性 | 物质-信息-能量-智能融合

牛顿力学 | 物理力学 | 智能介质力学

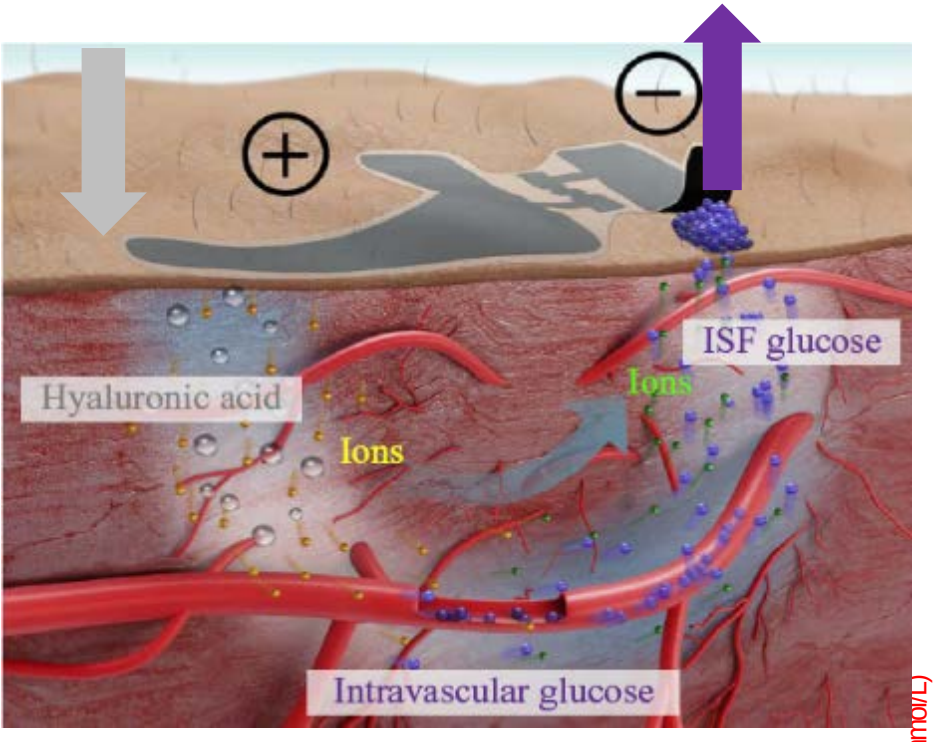
连续介质力学 | 热力学与统计物理 电动力学 | 新的力学理论与方法?

分析力学 有限元 微分 变分 | 分子动力学 量子力学 积分 | 超越微积分的新数学方法?

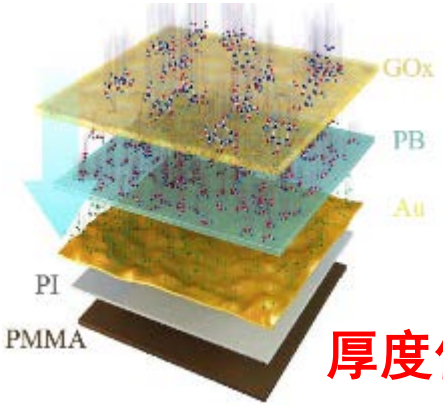
Flexible Electronics — 双通道

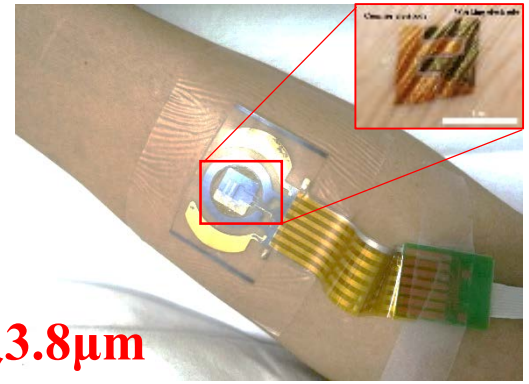
利用力化学耦合的电化学双通道原理 + 类皮肤柔性传感器，实现血糖无创连续监测

Y. Chen,…, X. Feng, **Science Advances**, 2017；* ***IEDM**, 2017*

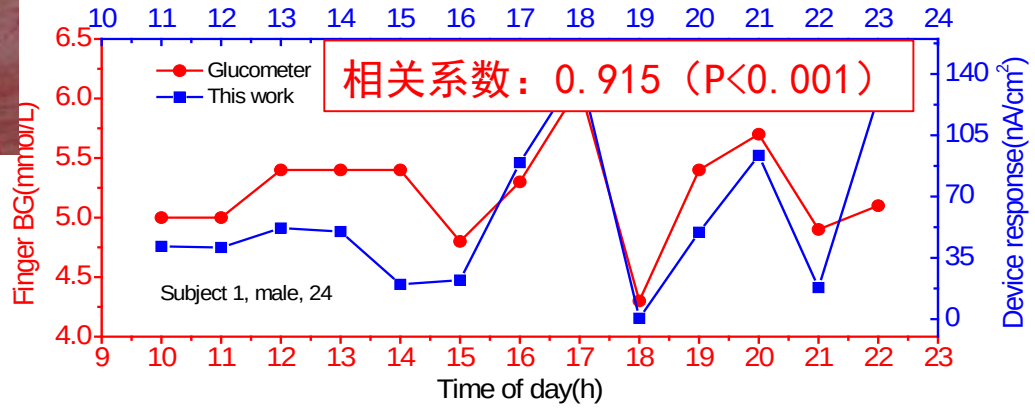


组织液渗透压调控

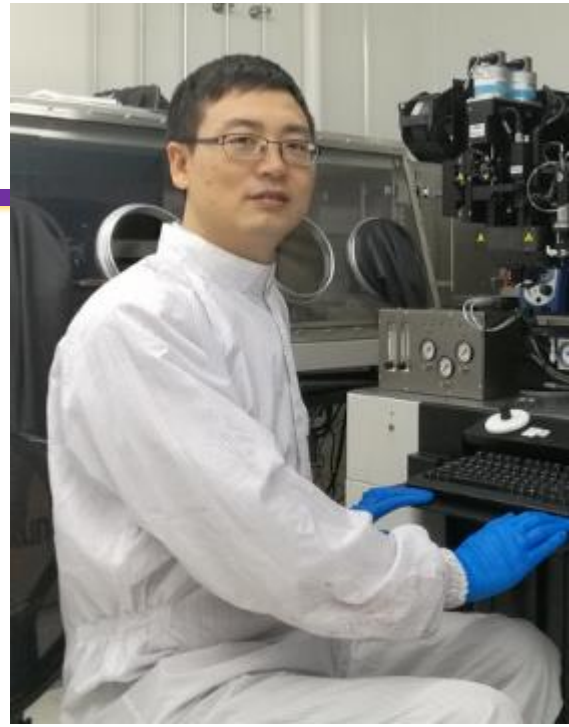




厚度仅3.8μm



一天之内连续测量



冯 雪

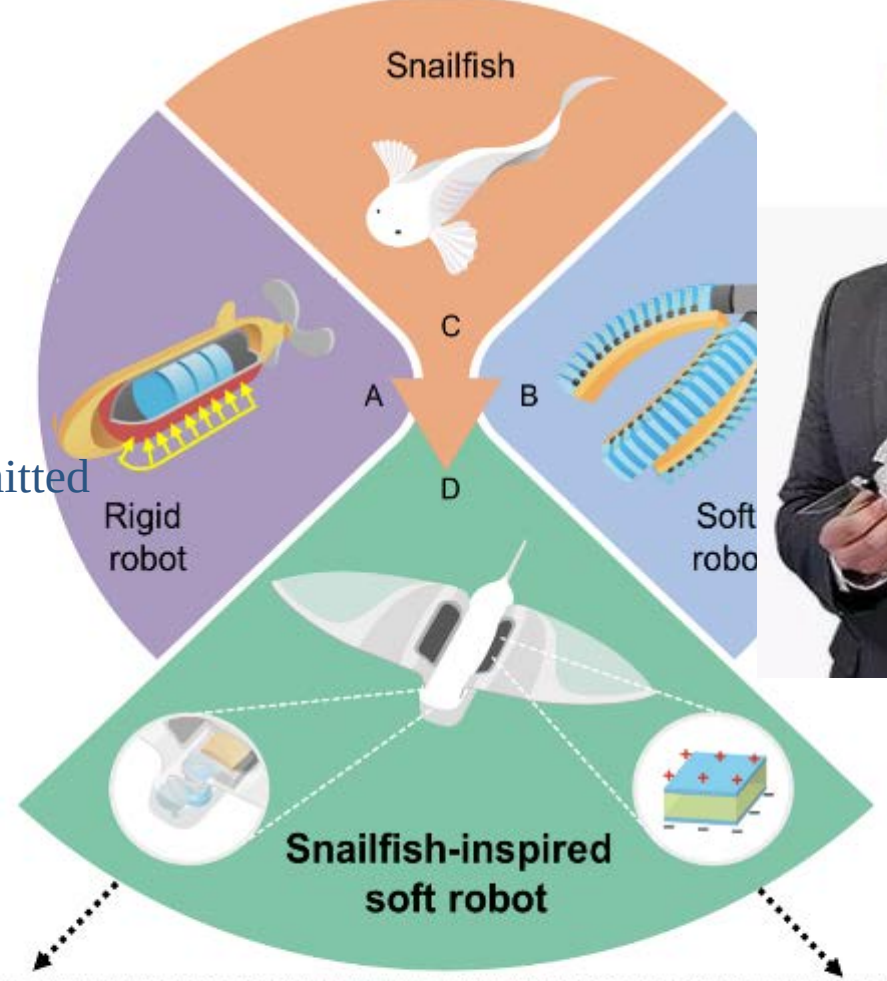
国际影响： 被IEEE旗舰杂志Spectrum率先报道，后被来自美、英、西、意、俄等50余家世界媒体报道

Mechanics of Soft Matters

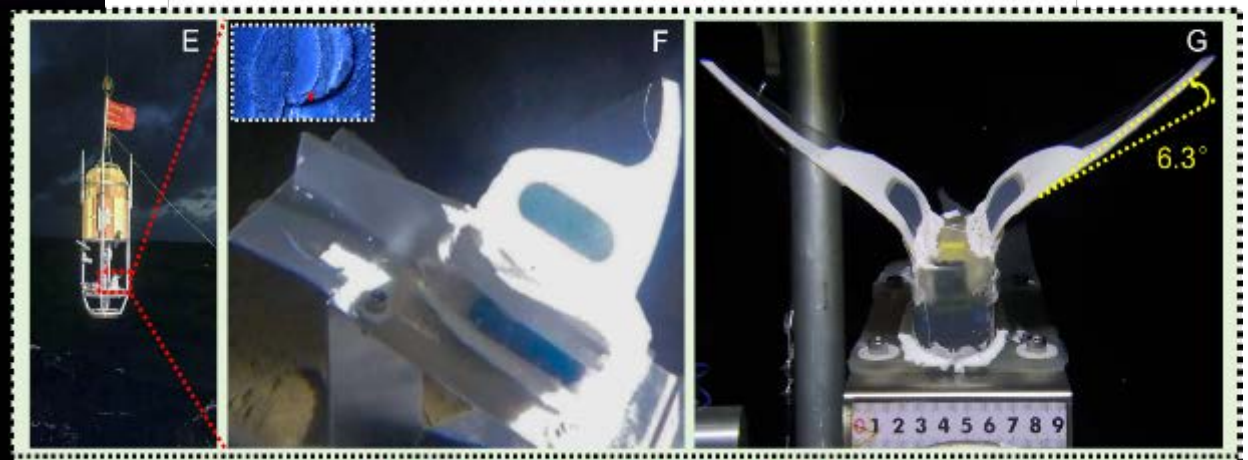
— Robotic Fish

马里亚纳海沟，2019.12.03

G. Li et al., Snailfish-Inspired Soft Robot in the Mariana Trench, submitted



李铁风



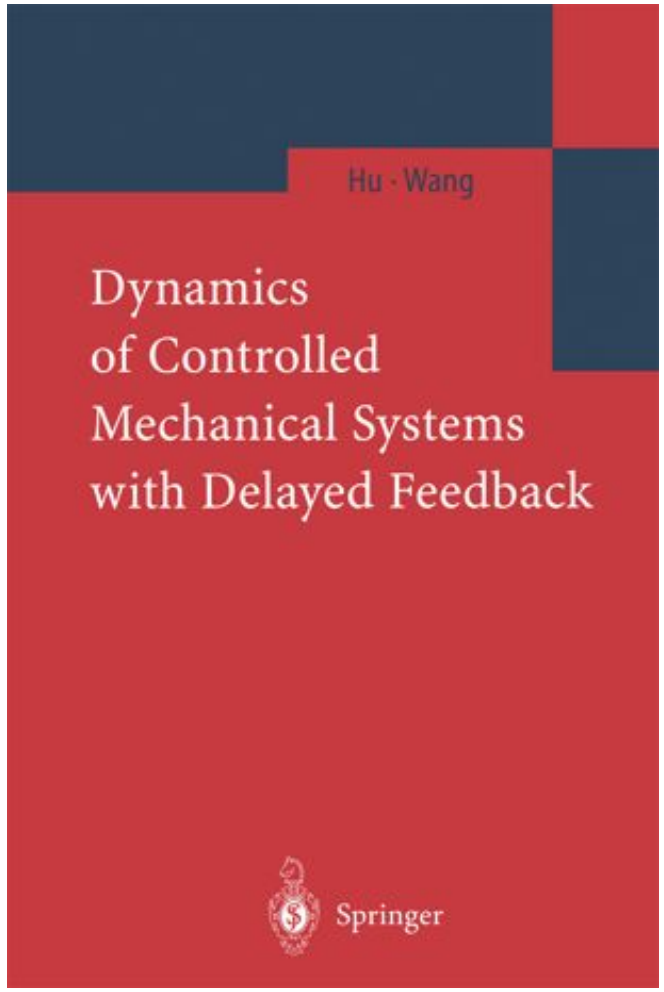
Progresses in Mechanics

Dynamics

- Nonlinear Dynamics of Controlled Systems
- Dynamics of High Speed Trains
- Noise Reduction of Submarines
- Vibration Suppression of Long March 5 Rockets
- Super-Gravity Platform
- BCI and Robots

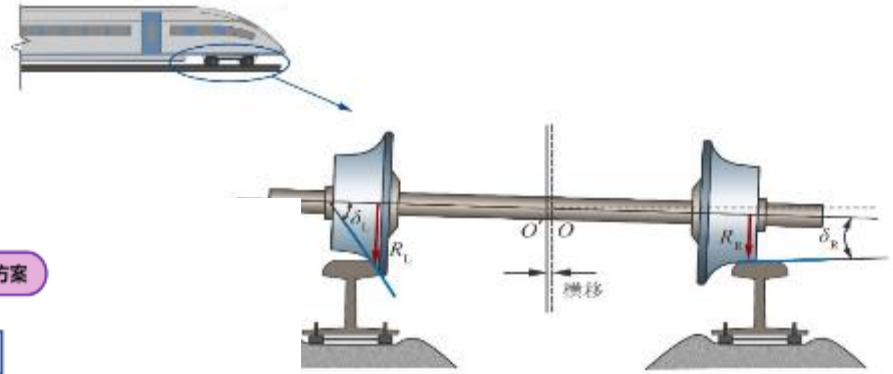
Nonlinear Dynamics of Controlled Systems

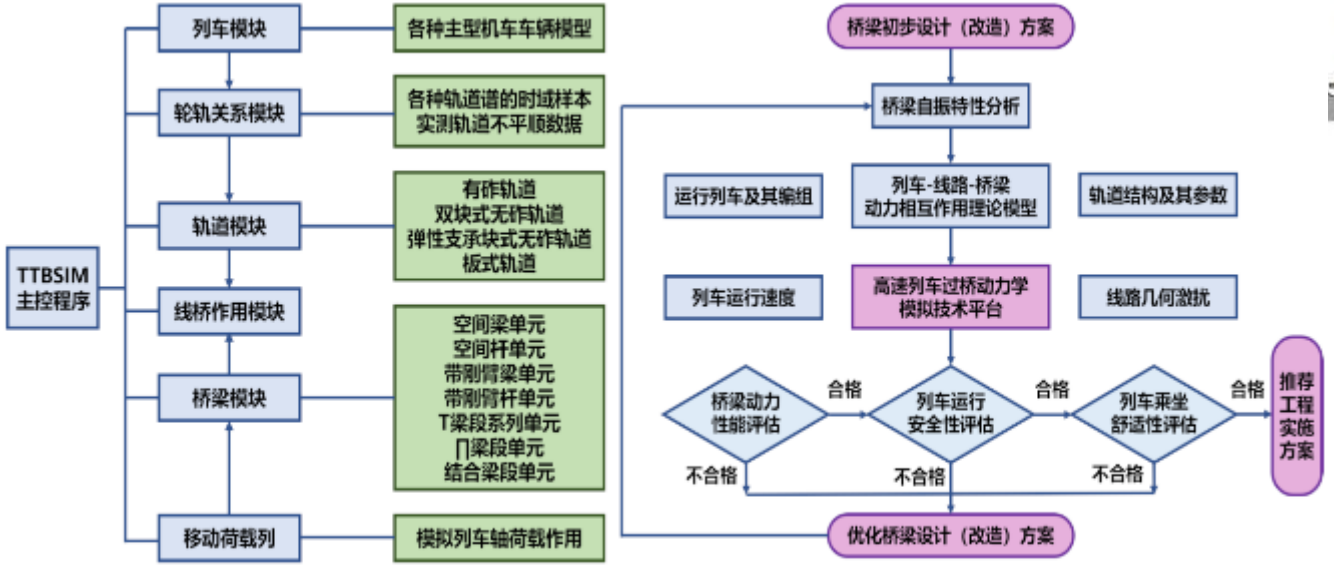
- *Dynamics of Controlled Mechanical Systems with Delayed Feedback, Springer-Verlag*
- 在主动控制下，由反馈时滞、弹性约束、迟滞阻尼等因素引起的非线性动力学规律。



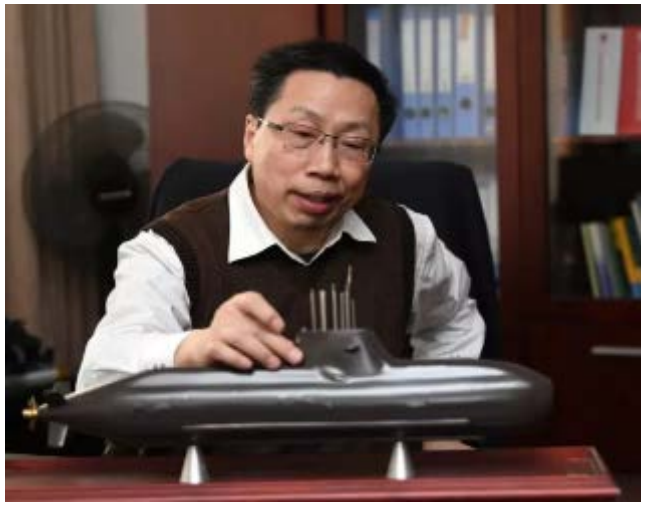
Dynamics of High Speed Trains

- **车辆 - 轨道耦合动力学，**率先创建了车辆 - 轨道耦合动力学理论体系；建立了完整的机车车辆 - 轨道统一模型，提出了机车车辆与线路动力性能最佳匹配设计原理及方法。





Noise Reduction of Submarines



何琳

- 主被动混合减振
- 智能气囊

吴崇建

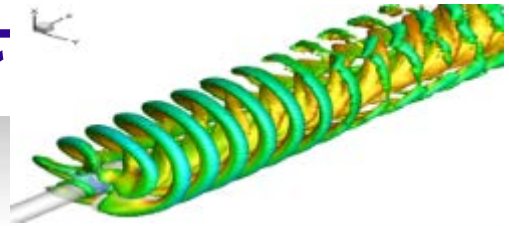
- 0XXB, 0XXC总师
- 水母模态

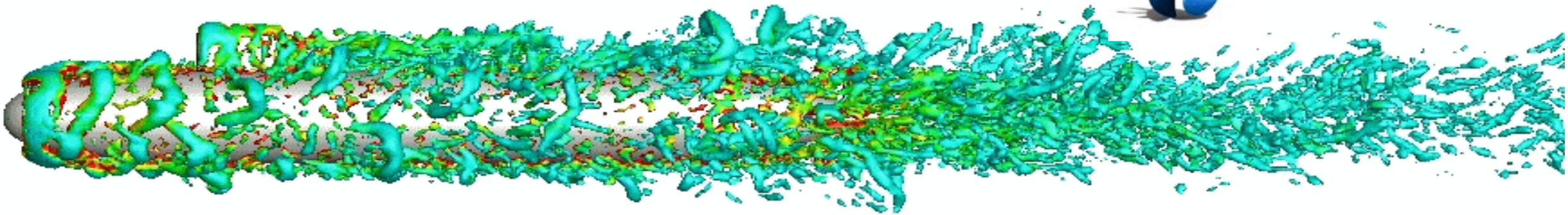
马骋

- 桨-鳍-舵一体化设计

何国威

- SUBOFF LES





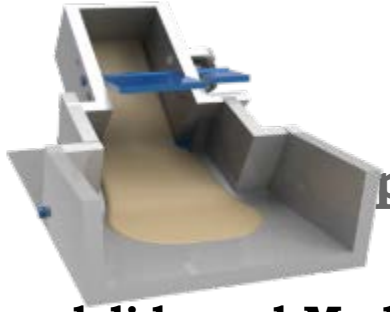
Vibration Suppression of Long March 5 Rockets

赵治华

Super-Gravity Platform

Mega Centrifuge and Inflight Apparatus

perposition of High Gravity Field and Extreme Environment)

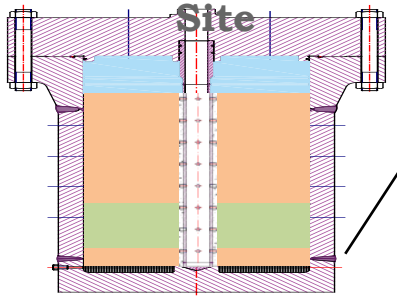


Landslide and Mudslide Trigger (300g)

3.5m in Length→Modelling Fail-Slide-Flow Process in Kilometer Scale

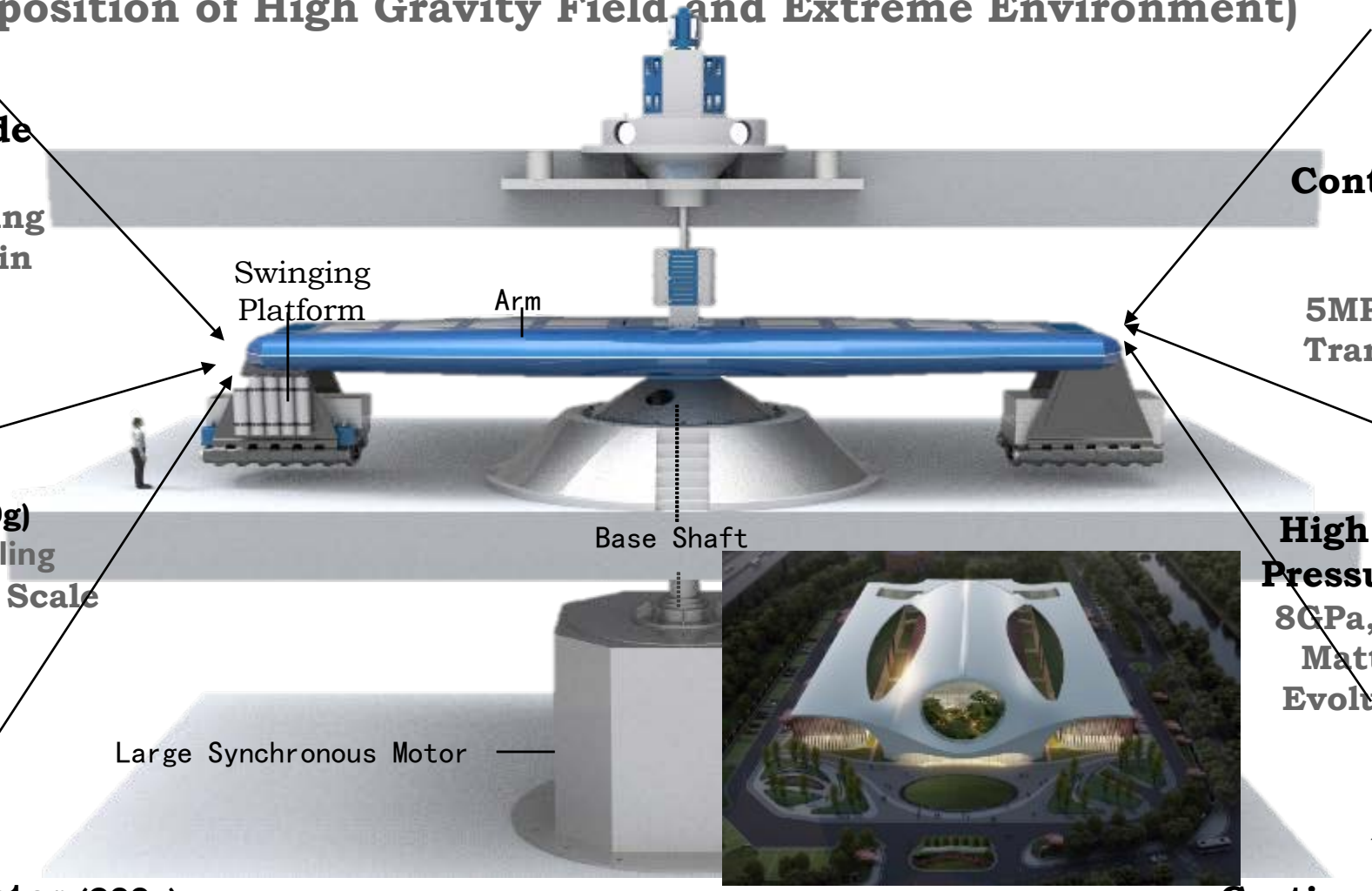
3D Shaking Table (50g)

ϕ0.75m×0.6m → Modelling 3D Ground Motion of 30m Scale Site



High Pressure Reactor (200g)

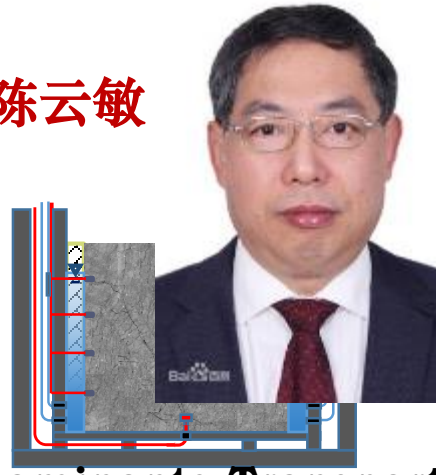
φ0.6m×1.0m, 20MPa → Modelling Exploitation of Methane Hydrate in 2000m Deep Sea



Maximum Capacity 2200g·ton

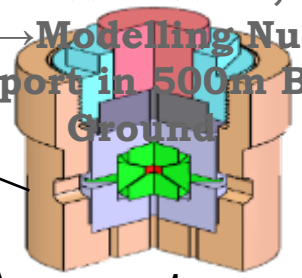
Maximum Acceleration 1500g

陈云敏



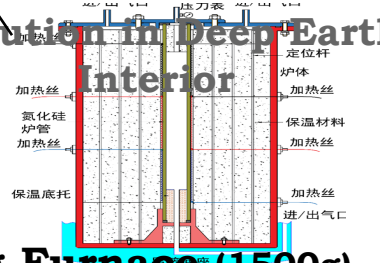
Contaminants Transport Apparatus (500g)

1m×1m×1m, 5MPa→Modelling Nuclide Transport in 500m Below Ground



High Temperature and Pressure Reactor(1000g)

8GPa, 1500℃→Modelling Matter Movement and Evolution in Deep Earth Interior



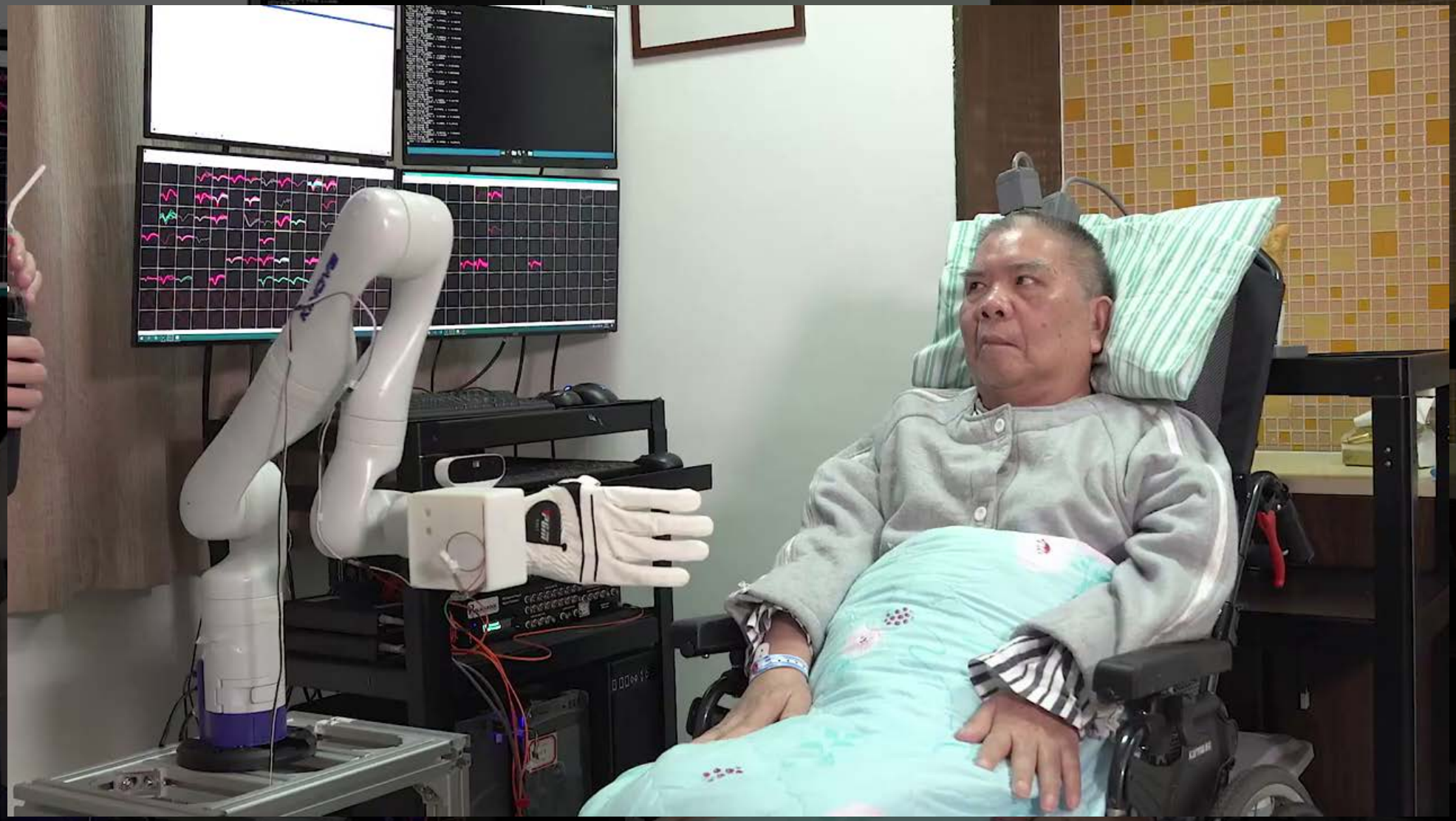
Casting Furnace (1500g)

1500g, 1200℃→Preparation of High-Throughput Materials

BCI and Robots

浙二 + 浙大 求高 + 交叉力学

金永斌



China's first clinical translational study of implantable BCI

Thank You!

West Campus of Purple-Gold Harbor, ZJU

2006 ESI 695

2019/20 NI 29(8), QS 54(14), THE 107(12), ESI 65(5), ARWU 70(6), US News 157(13)