



# 量子磁性与自旋物理课题组

课题组负责人：于涛

2024年7月1日

# 一、课题组人员组成情况 <http://www.yutaolab.com/>

课题组成立第三年。

目前有教授1名，博士研究生4名，硕士研究生3名，本科生1名。



于涛 教授

课题组负责人

国家海外高层次人才项目 / 湖北省百人计划

服务器计算平台 · 磁性与超导异质结构实验室

2018年获中国科技大学博士学位。

在荷兰代尔夫特理工大学、日本东北大学和德国马普所（物质结构和动力学研究所）进行博士后研究工作。

2021年加入华中科技大学。

在Physics Reports(第一及通讯作者2篇)、Physical Review Letters(第一及/或通讯作者8篇)、Nature Physics、Science Advances、Physical Review B等期刊发表论文60余篇。

## PhD Students



Wenxin Wu (吴文欣)

PhD Students (2024.6-now)



Chengyuan Cai (蔡成渊)

PhD Students (2021.9-now)



Xiyin Ye (叶茜茵)

PhD Students (2023.6-now)



Zhiping Xue (薛治平)

PhD Students (2024.6-now)

## Master Students



Ping Li (李萍)

Master Students (2024.6-now)



Xi-Han Zhou (周熙涵)

Master Students (2022.4-now)

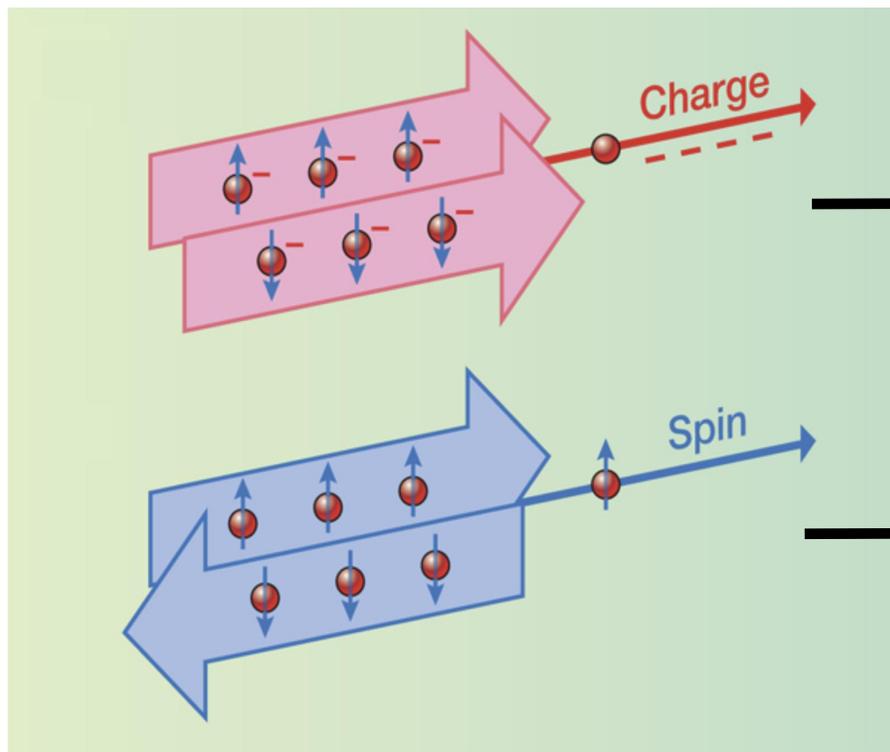


Qian-Nan Huang (黄倩南)

Master Students (2024.8-now)

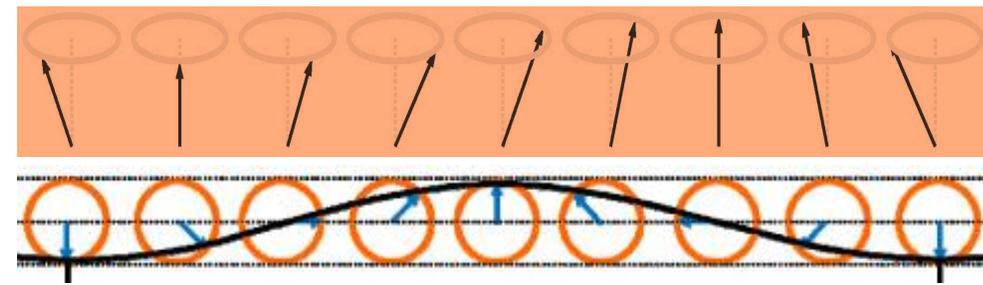
## 二、课题组研究方向及代表性成果

自旋电子学/磁子学：用电子或磁子自旋自由度传输信息

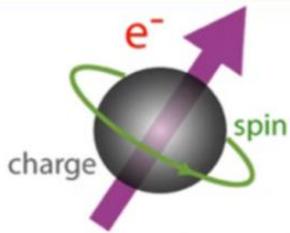


半导体  
工业

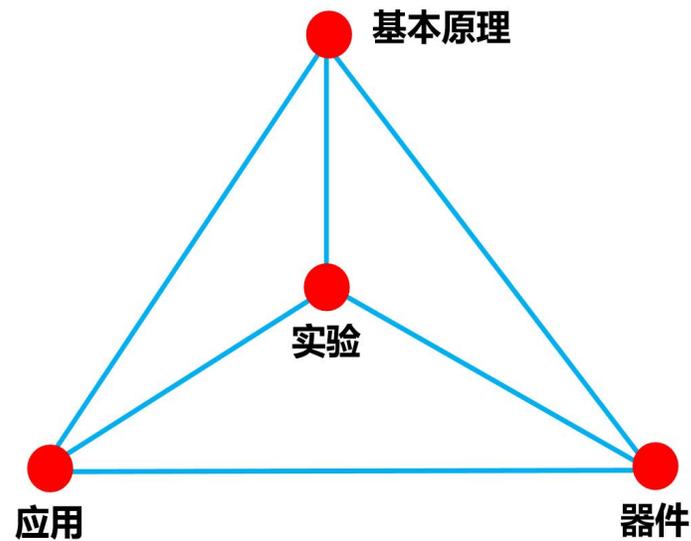
自旋电子  
学/磁子学



# 二、课题组研究方向及代表性成果



自旋电子学研究有望  
解决器件功耗问题



2021年度磁硬盘市场  
~300亿美元

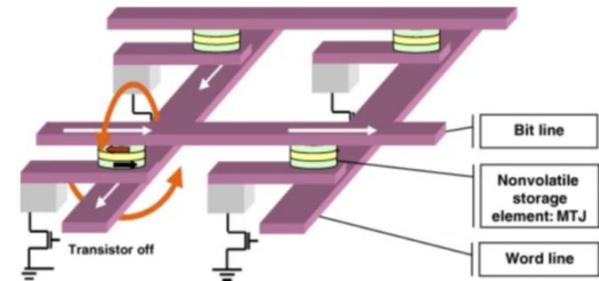


介质: **CoPtCr**等

2021年度磁传感器  
~52亿美元



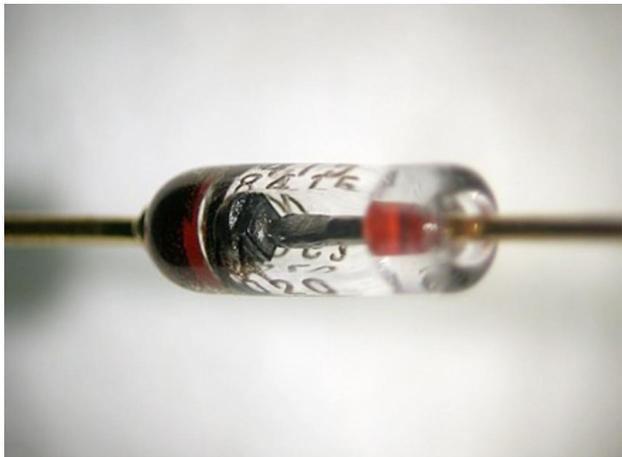
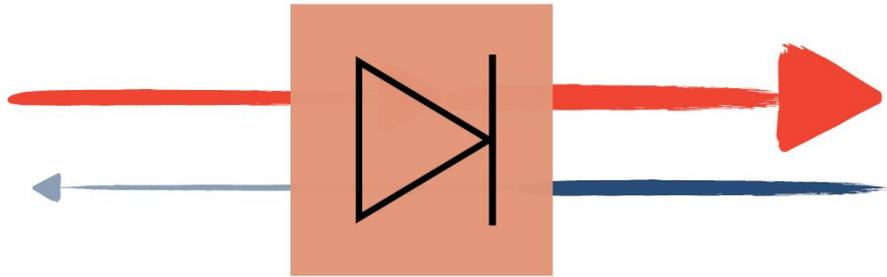
2021年度磁随机存储器  
~4亿美元



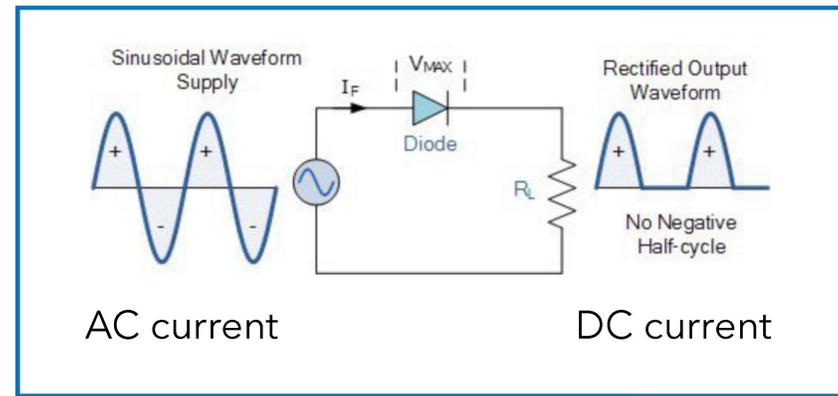
介质: **CoFeB/MgO**等

# 二、课题组研究方向及代表性成果

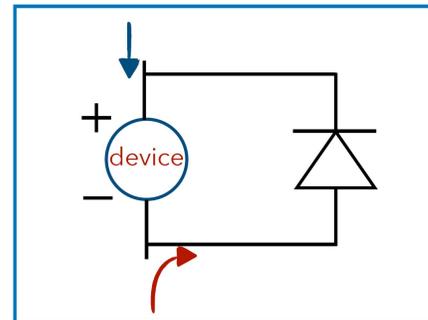
## 自旋输运的理论研究



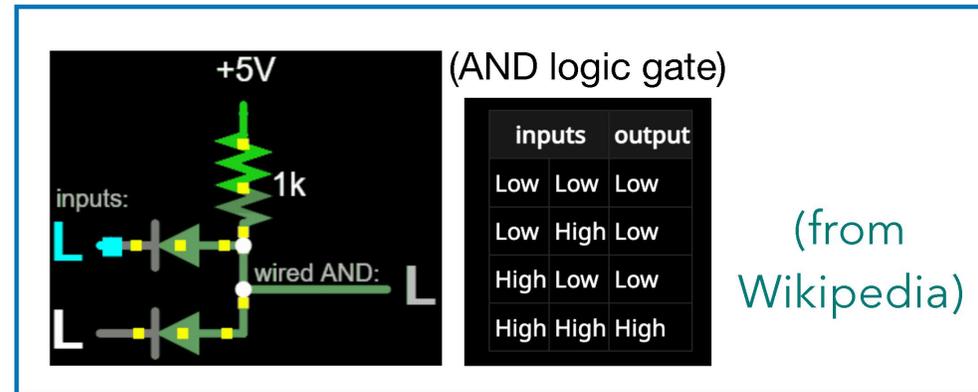
整流



电路保护



逻辑运算



(a) 手性磁子学

(b) 非厄米拓扑磁子学

(c) 超导磁子学

既有理论研究，  
也有实验研究

与准粒子耦合  
(光子、声子、  
电子、磁子等)

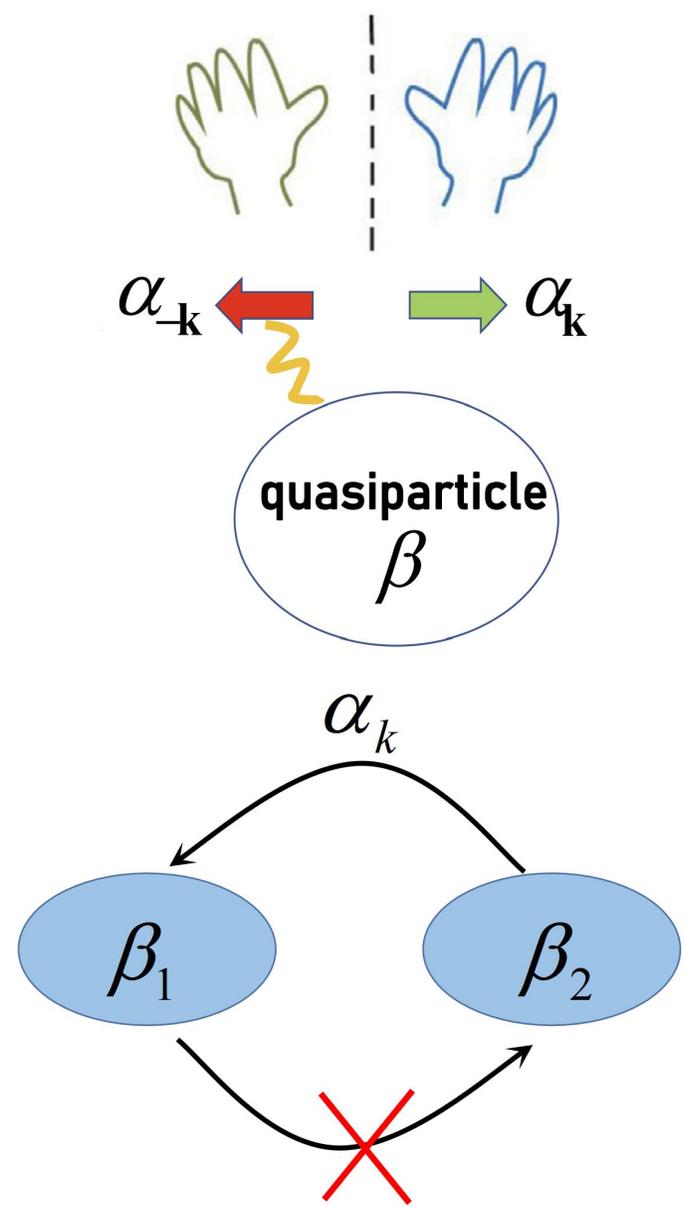
磁子或电子  
(自旋、轨  
道)

与超导耦合

与环境耦合

多数理论预言获实验验证。

# (a) 手性磁子学：手性相互作用 [Yu, Luo, and Bauer, Phys. Rep. 1009, 1-115 (2023)]



Physics Reports 1009 (2023) 1–115



Contents lists available at ScienceDirect

Physics Reports

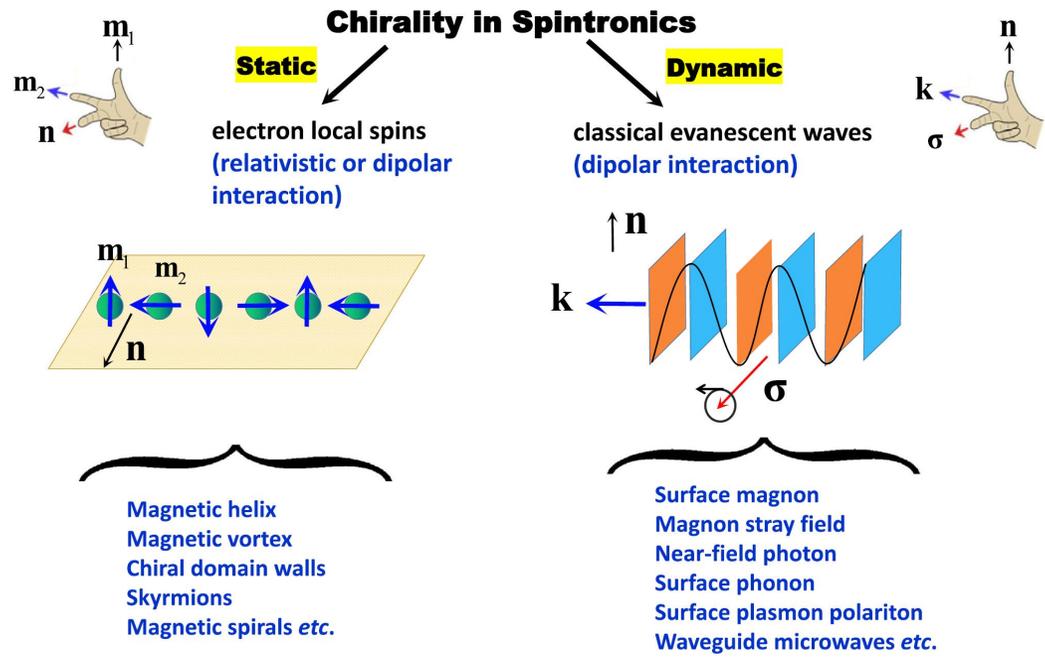
journal homepage: [www.elsevier.com/locate/physrep](http://www.elsevier.com/locate/physrep)



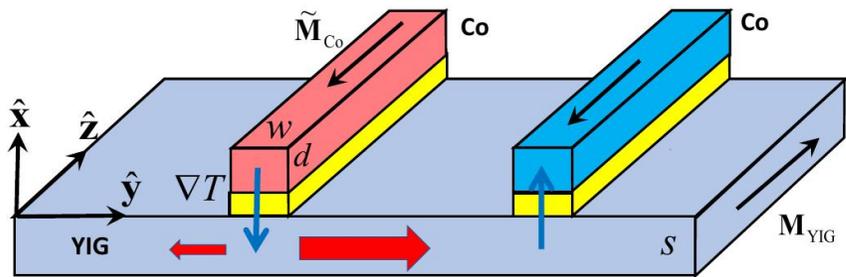
## Chirality as generalized spin-orbit interaction in spintronics

Tao Yu <sup>a,\*</sup>, Zhaochu Luo <sup>b,c</sup>, Gerrit E.W. Bauer <sup>d,e</sup>

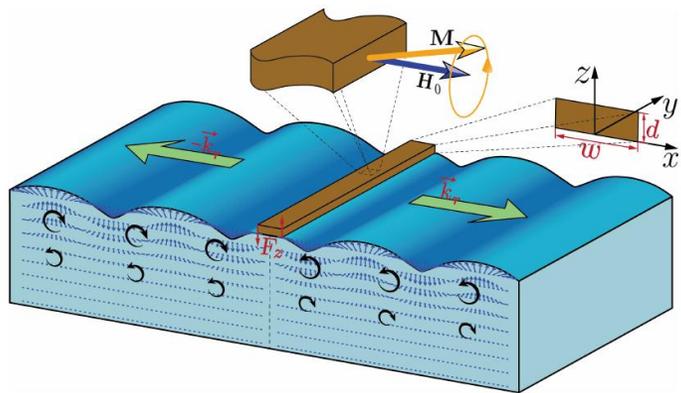
<sup>a</sup> School of Physics, Huazhong University of Science and Technology, Wuhan 430074, China  
<sup>b</sup> State Key Laboratory of Artificial Microstructure and Mesoscopic Physics, School of Physics, Peking University, 100871 Beijing, China  
<sup>c</sup> Beijing Key Laboratory for Magnetoelectric Materials and Devices, Beijing, 100871, China  
<sup>d</sup> WPI-AMR and Institute for Materials Research and CSRN, Tohoku University, Sendai 980-8577, Japan  
<sup>e</sup> Kavli Institute for Theoretical Sciences, University of the Chinese Academy of Sciences, Beijing 100190, China



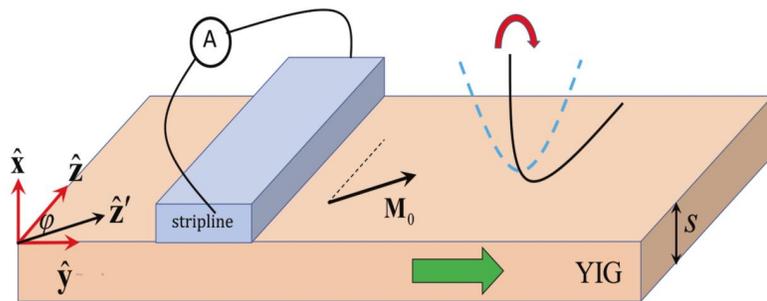
# 课题组贡献的主要物理效应



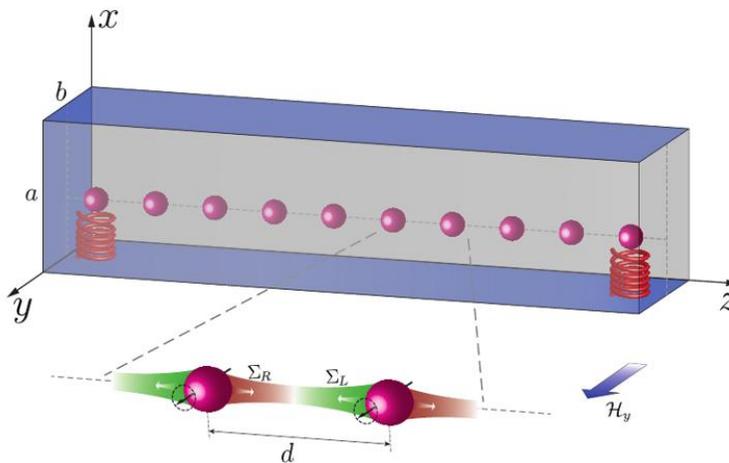
手性磁子泵浦、手性磁子塞贝克效应  
 [Au *et al.*, APL **100**, 182404 (2012)  
 Yu, Blanter, and Bauer, PRL **123**, 247202 (2019)]



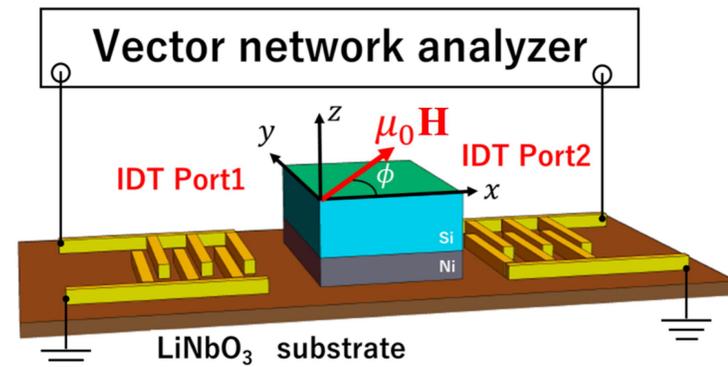
单方向声子泵浦  
 [Zhang, Bauer, and Yu, PRL **125**, 077203 (2020)]



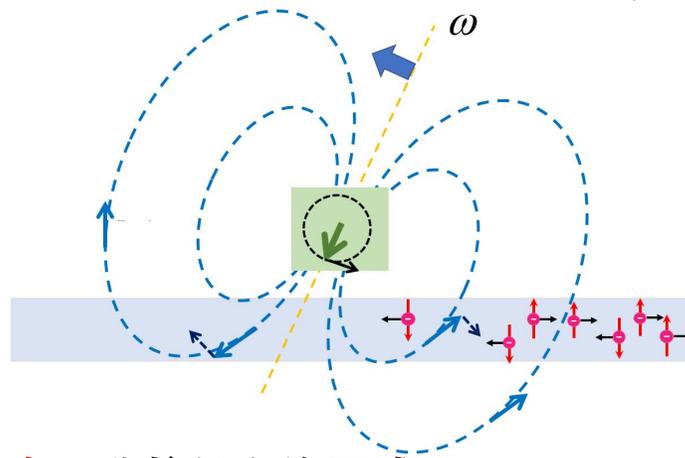
非线性磁子多普勒效应  
 [Yu and Bauer, PRL **126**, 137202 (2021)  
 Bertelli *et al.*, Sci. Adv. **6**, eabd3556 (2020)]



微波二极管  
 [Yu *et al.*, PRL **124**, 107202 (2020)  
 Hu, Fu, and Liu, PRL **128**, 217201 (2022)]



声子二极管  
 [Sasaki *et al.*, PRB **95**, 020407(R) (2017)  
 Xu *et al.*, Sci. Adv. **6**, eabb1724 (2020)  
 Küb *et al.*, PRL **125**, 217203 (2020)  
 Shah *et al.*, Sci. Adv. **6**, eabc5648 (2020)]



电子非接触自旋泵浦  
 [Yu and Bauer, PRL **124**, 236801 (2020)]

# (b) 非厄米拓扑磁子学及课题组主要贡献

[Yu, Zou, Zeng, Rao, and Xia, Phys. Rep. 1062, 1 (2024)]

Physics Reports 1062 (2024) 1–86



## Non-Hermitian topological magnonics

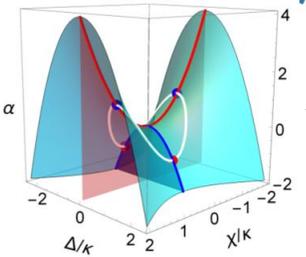
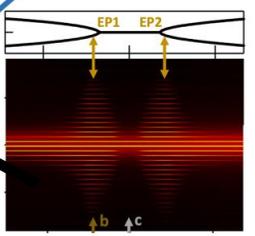
Tao Yu <sup>a,\*</sup>, Ji Zou <sup>b</sup>, Bowen Zeng <sup>a,c</sup>, J.W. Rao <sup>d</sup>, Ke Xia <sup>e</sup>

- <sup>a</sup> School of Physics, Huazhong University of Science and Technology, Wuhan 430074, China
- <sup>b</sup> Department of Physics, University of Basel, Klingelbergstrasse 82, 4056 Basel, Switzerland
- <sup>c</sup> School of Physics and Electronic Science, Changsha University of Science and Technology, Changsha 410114, China
- <sup>d</sup> School of Physical Science and Technology, ShanghaiTech University, Shanghai 201210, China
- <sup>e</sup> School of Physics, Southeast University, Jiangsu 211189, China

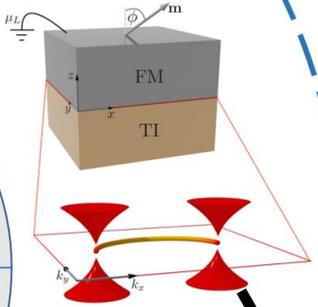


奇异点增强的磁子频率梳

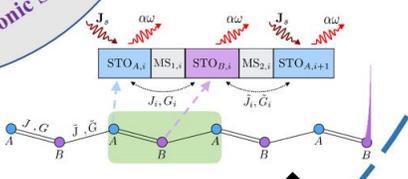
[Rao, TY\* *et al.*, PRL 130, 046705 (2023); Nat. Phys. (published online)]



磁子奇异面

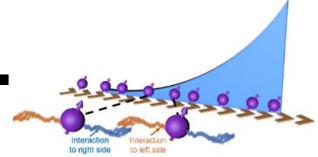


磁子节点线

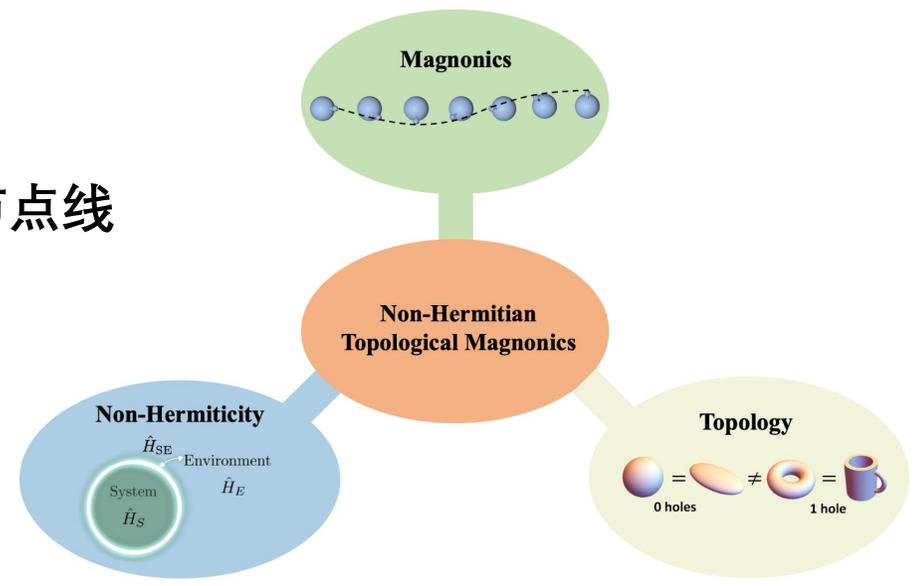


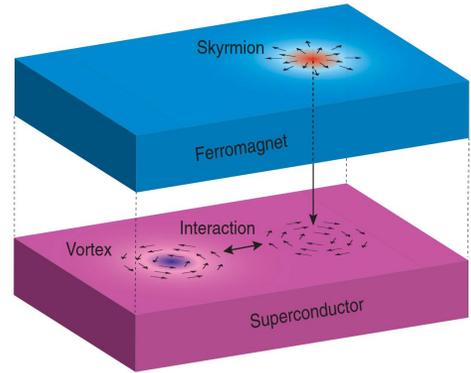
磁子非厄米趋肤效应

[TY\* and Zeng, PRB 105, L180401 (2022); Zeng and TY\*, PRR 5, 013003 (2023) Cai, Kennes, Sentef, and TY\*, PRB 108, 174421 (2023)]



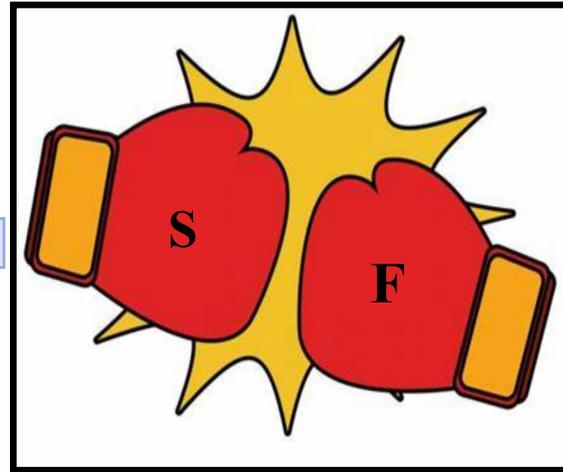
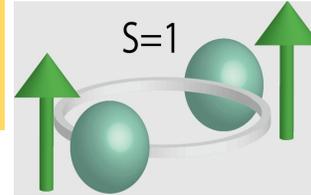
非厄米驱动磁子边界态



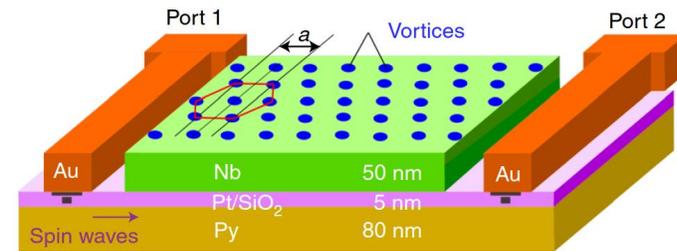


unconventional superconductivity

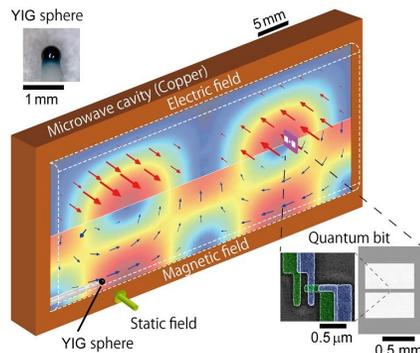
superconducting spintronics



superconducting magnonics



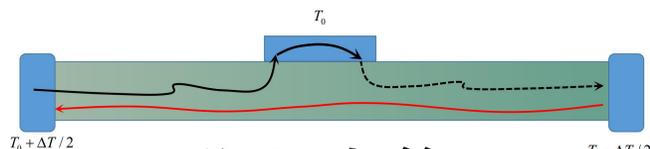
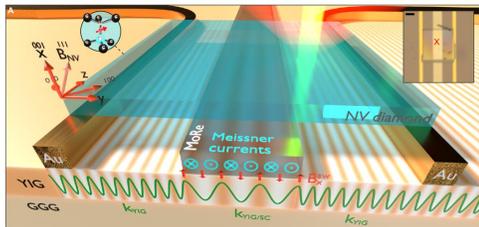
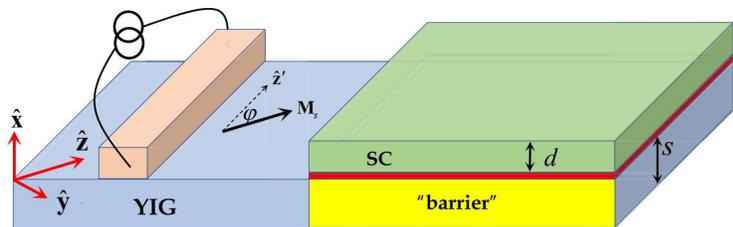
quantum magnonics



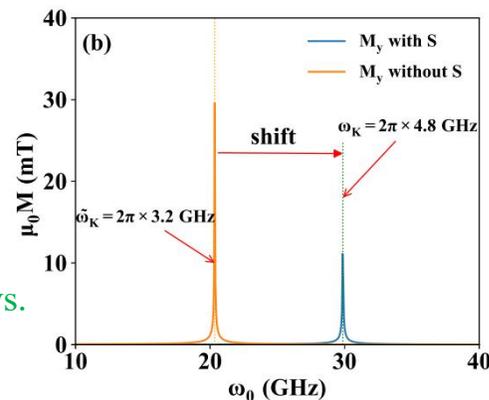
# 课题组贡献的主要物理效应

## 超导抗磁性“电控”磁子输运

## 片上量子磁子学（超强耦合）

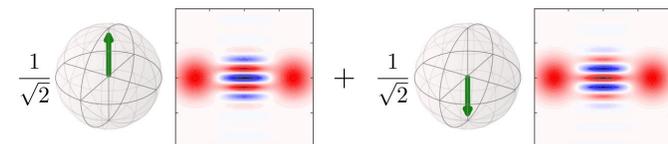


磁子二极管



片上磁子-光子超强耦合

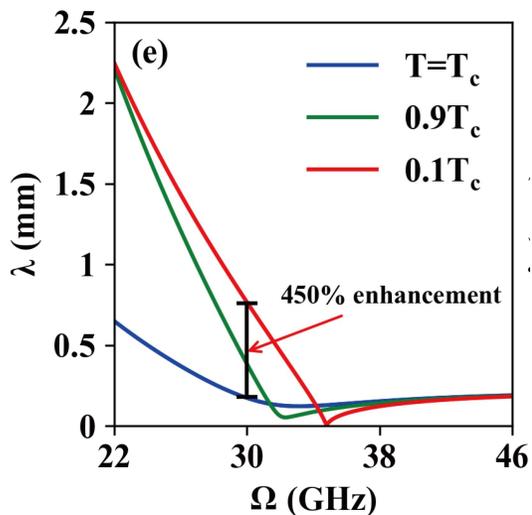
[Zhou and TY\*, PRB 108, 144405 (2023)]



磁子-光子真空压缩态

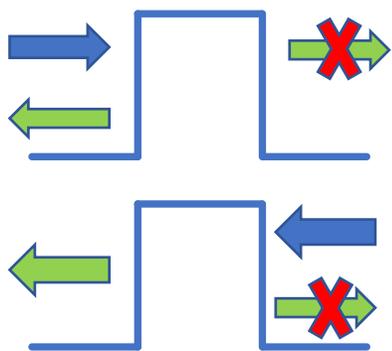
## 超导“电控”磁子频率

[TY\* and Bauer\*, PRL 129, 117201 (2022);  
van der Sar c.s., Science 382, 430 (2023)]



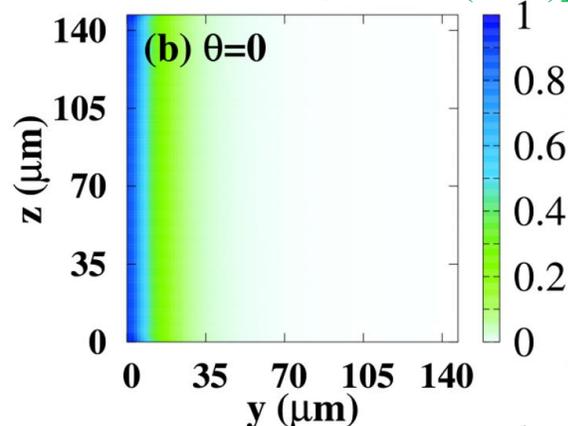
超导增强磁子输运

[Zhou, Ye, Bai, and TY\*, arXiv:2404.02598]



“电控”增强磁子单向透射

[Ye, Xia, Bauer, and TY\*, arXiv:2401.12022]



磁子非厄米趋肤效应

# 三、课题组人才培养特色及培养情况

- 1) 强化基础；
- 2) 上课和科研结合；
- 3) 与北大、科大、山大、东南、武大等进行联合组会；
- 4) 理论学生参与实验解释；实验学生参与理论学习；
- 5) 学生和国外学者频繁交流合作

经费充足

独立服务器计算平台

磁性动力学实验测试

薪水优厚

日常讨论充分，  
手把手传授



**每个学生每年都有重要科研成果发表。**

# 四、课题组2024年研究生招生情况及联系方式



博士研究生  
名额1-2名

硕士研究生  
名额1-2名

邮箱: [taoyuphy@hust.edu.cn](mailto:taoyuphy@hust.edu.cn)

微信: 18062429682

## 欢迎互动提问

课题组负责人：于涛

2024年7月1日