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English translation

NTU jointly publishes in "Nature", congratulations to Professor Shen Yijie's team

On February 6, 2025, Henan University Researcher Wang Bo, Fudan University Professor Zi Jian, Professor Shi Lei, NTU Assistant Professor Shen Yijie and Professor Konstantin Bliokh of the Donostia International Physics Center in Spain and other scientists jointly published a paper entitled "Topological water-wave structures manipulating particles".

The paper studied the intersection of topological physics and fluid mechanics and was published in the international academic journal "Nature". It used topological water waves to design particles and provide new directions for particle technology. The final results were reported by top international academic media such as Phys.org and AZoQuantum, and were evaluated as "paradigm breakthroughs in the field of fluid mechanics".

Research team and results publication

The research team used quantum computing to optimize wave field parameters, dynamically adjust control accuracy in real time, and achieved submillimeter floating object positioning for the first time with an error of less than 0.1 mm.

The research results were published in "Nature" on February 6, 2025, providing new solutions for future marine engineering and environmental protection fields.


nature › articles › article

Article | Published: 05 February 2025

Topological water-wave structures manipulating particles

Bo Wang, Zhiyuan Che, Cheng Cheng, Caili Tong, Lei Shi, Yijie Shen, Konstantin Y. Bliokh & Jian Zi

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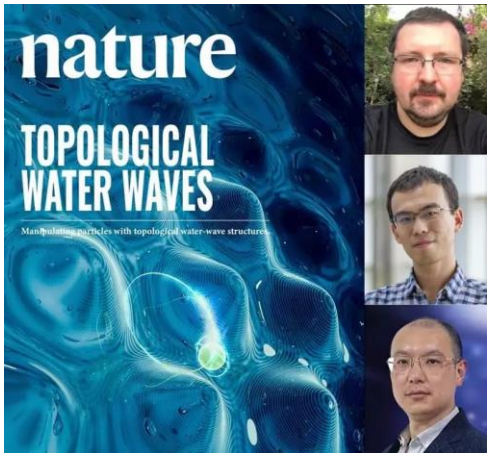
Results publication page. Source: Nature



Researcher Wang Bo from the School of Future Technology of Henan University is the first author of the paper,
Postdoctoral fellow Che Zhiyuan from the Department of Physics of Fudan University is the co-first author of the paper,
Professor Zi Jian and Professor Shi Lei from the Department of Physics of Fudan University, Professor Konstantin Bliokh from the International Center of Physics in Donostia, Spain, and Assistant Professor Shen Yijie from Nanyang Technological University are the co-corresponding authors of the paper
Source: AAAS

The power of water waves

I. Research background

Water waves are one of the most common phenomena in nature.

From the surging waves to the rippling waves on the lake, they contain huge energy.

However, for a long time, human use of water waves has mostly remained in the passive stage, such as using waves to generate electricity or sailing with the help of ocean currents.

This study by Nanyang Technological University has taken our interaction with water waves to a whole new level - actively manipulating water waves to achieve precise control of floating objects.

Water waves float. Source: NTU

II. Technical core

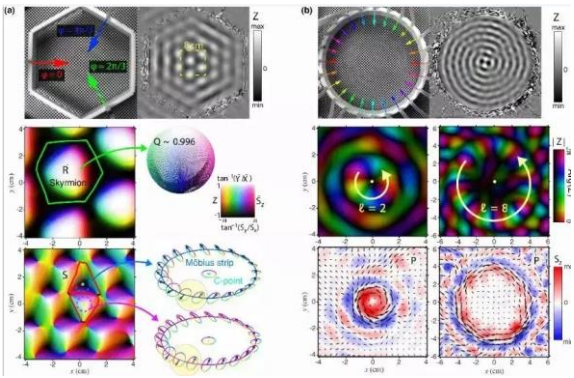
Fusion of wave programming and quantum algorithms

The research team proposed the theory of "structured water wave field", and designed the frequency, amplitude and interference pattern of water waves through precise algorithms, transforming disordered waves into programmable "hydraulic grippers".

The research team first successfully generated a variety of topological water wave structures in the three-wave interference field.

Including phase vortices in the displacement field, Skyrmion lattices, Meron lattices in the spin density field, circular polarization singularities of local water surface particles, and polarized Möbius strips.

Subsequently, Bessel-type water wave vortex fields of different orders were constructed through multi-wave (24 beam) interference technology, and high-order phase vortices in the displacement field and the generation of Skyrmionium were successfully observed.



Experimentally generated and observed topological water wave structures:
a. Water wave displacement field Skyrmions, spin density field Merons and polarization singularities and Möbius strips
b. Bessel-type water wave vortex with different topological charges, spin and orbital angular momentum vertical components have a locked relationship.
Source: Henan University official website

Key breakthroughs:

1. Using quantum computing to optimize wave field parameters and dynamically adjust control accuracy in real time

2. For the first time, submillimeter-level floating object positioning was achieved with an error of less than 0.1 mm

This study systematically reveals the rich manifestations of topology in water wave systems, and provides important theoretical and experimental basis for in-depth exploration of topological effects in classical wave systems.

Assistant Professor Shen Yijie of Nanyang Technological University, Singapore, took a photo with the water wave experimental device.
Source: NTU

III. Scientific principles

Wave field control from chaos to order

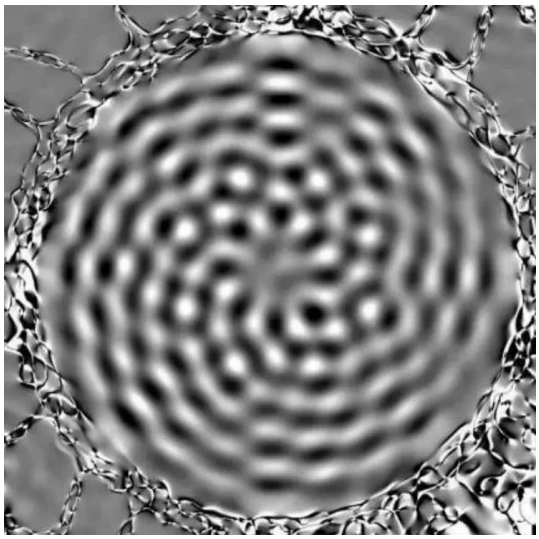
Traditional water waves are limited by turbulence and energy dissipation, making it difficult to accurately control objects. NTU technology solves the problem through three major innovations:

1. Waveguide structure design: Arrange a micro-oscillator array on the water surface to generate interference fringes to guide the movement of floating objects

The structure used to generate waves in the experiment
Source: Henan University

2. Adaptive feedback system: AI analyzes the position of floating objects in real time and dynamically corrects wave field parameters

3. Energy localization: Focusing energy on the target area through wave frequency resonance to reduce environmental interference



The way water rotates in the complex pattern generated by the waves generated by the *ring-shaped plastic structure in the water tank. Source: Henan University*

International evaluation and application prospects

I. International academic evaluation

Phys.org (UK, March 11)

"This technology transforms water waves from a 'natural disturbance source' into a 'controllable energy tool' for the first time, opening up a new dimension for fluid manipulation."

This research result opens up new possibilities for the application of water waves.

This technology has not only been successful in the laboratory, but may also be widely used in the marine environment in the future, bringing new hope to the fields of marine engineering and environmental protection.

AZoQuantum (UK, March 11)

"The cross-application of quantum algorithms and fluid mechanics heralds the birth of the next generation of intelligent marine equipment."

The breakthrough of this research lies in its ability to accurately control water waves.

By generating complex wave patterns, researchers were able to achieve precise movement and fixation of floating objects, which is of great significance in the future development of marine resources and environmental protection.

Tech360TV (Singapore, March 11)

"The potential for commercial transformation is huge, and it may give rise to a trillion-level underwater robot market."

This study not only demonstrates the ability to manipulate water waves, but also provides new solutions for future marine engineering and environmental protection.

This technology can be used to clean chemical pollutants on the water surface, and even to manipulate the movement direction of large ships, providing new ideas for the sustainable development of the marine economy.

2. Application prospects

From marine engineering to medical targeting

1. Marine environmental protection: Precisely guide offshore oil spill collection devices, increase efficiency by 50%, control floating sensor networks to monitor red tides, and expand coverage by 3 times.

2. Medical technology: Non-invasive manipulation of drug-loaded microcapsules to target tumor areas, reduce damage to healthy tissues, and assist minimally invasive surgical instruments in directional movement within blood vessels.

3. Industrial manufacturing: Non-contact underwater assembly of micron-level chips to avoid mechanical damage.

3. Research Significance

This joint research once again proves that the power of science and technology can transform the rules of nature into human tools.

From manipulating water waves to precisely controlling floating objects, we see the perfect combination of human wisdom and natural forces.

In the future, with the continuous improvement and promotion of this technology, we have reason to believe that the ocean will no longer be a difficult field to control, but a new stage for sustainable development of mankind.

Let us look forward to how this innovative technology will shine on the future ocean stage and open a new chapter of harmonious coexistence between humans and the ocean!

https://www.sgnews.co/143610.html

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NTU 联合发表《Nature》，祝贺申艺杰教授团队

2025 年 2 月 6 日，河南大学王博研究员与复旦大学资剑教授、石磊教授，以及 NTU 申艺杰助理教授和西班牙 Donostia 国际物理中心 Konstantin Bliokh 教授等科学家联合发表了题为“拓扑水波结构操纵粒子”的论文。

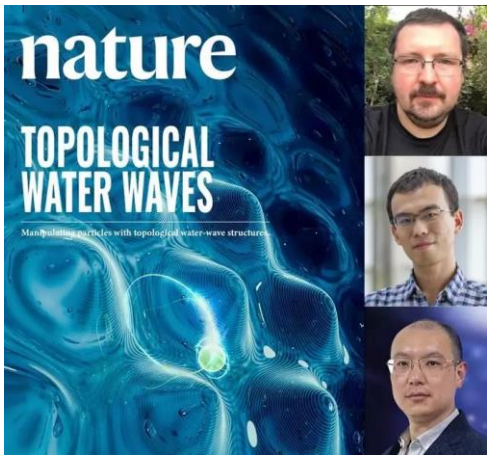
该论文研究了拓扑物理与流体力学的交叉研究，在国际学术《自然》上发行，利用拓扑水波对粒子进行了设计，为粒子技术提供新方向。 最终成果获国际顶级学术媒体 Phys.org、AZoQuantum 等争相报道，被评价为“流体力学领域的范式突破”。

研究团队与成果发表

研究团队利用量子计算优化波场参数，实时动态调整控制精度，首次实现亚毫米级浮物定位，误差小于 0.1 毫米。

该研究成果于 2025 年 2 月 6 日发表在《Nature》上，为未来的海洋工程和环保领域提供了新的解决方案。

成果发表页面。来源：Nature



河南大学未来技术学院王博研究员为论文第一作者，
复旦大学物理学系博士后车治辕为论文共同第一作者，
复旦大学物理学系资剑教授与石磊教授、西班牙 Donostia 国际物理中心 Konstantin Bliokh 教授、南洋理工大学申艺杰助理教授为论文共同通讯作者
来源：AAAS

水波的力量

一、研究背景

水波，是自然界中最常见的现象之一。

从海浪的汹涌澎湃到湖面的微波荡漾，它们蕴含着巨大的能量。

然而，长期以来，人类对水波的利用大多停留在被动阶段，比如利用波浪发电或借助海流航行。

南洋理工大学的这项研究，将我们与水波的互动提升到了一个全新的高度——主动操纵水波，实现对漂浮物体的精准控制。

水波浮动。图片来源：NTU

二、技术核心

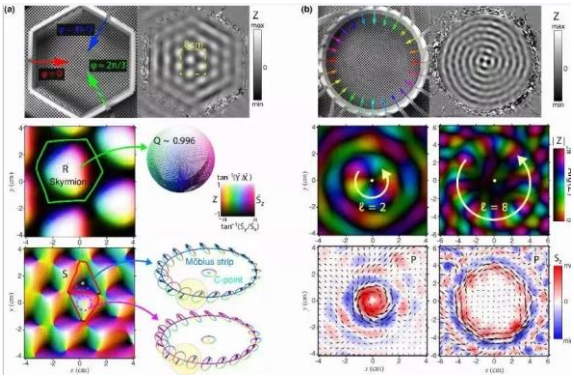
波编程与量子算法融合

研究团队提出“结构化水波场”理论，通过精密算法设计水波频率、振幅与干涉模式，将无序波动转化为可编程的“水力抓手”。

研究团队首先在三波干涉场中成功生成了多种拓扑水波结构。

包括位移场中的相位涡旋、Skyrmion 晶格、自旋密度场中的 Meron 晶格、局部水面粒子的圆偏振奇点以及偏振莫比乌斯带等。

随后，通过多波（24 束）干涉技术，构造了不同阶数的贝塞尔型水波涡旋场，成功观测到了位移场中的高阶相位涡旋以及 Skyrmionium 的生成。



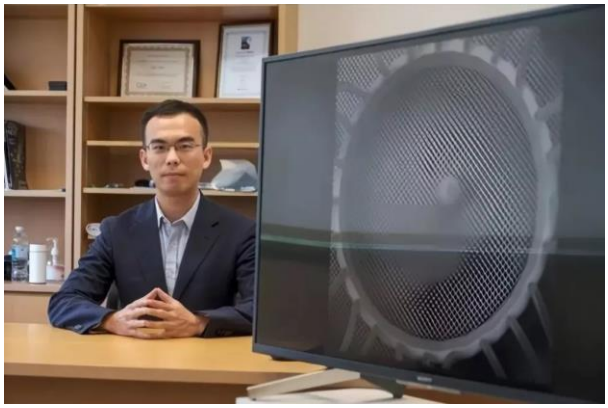
实验上生成和观测到的拓扑水波结构：
a.水波位移场 Skyrmions，自旋密度场 Merons 和偏振奇点与莫比乌斯环。
b.具有不同拓扑荷的贝塞尔型水波涡旋，自旋和轨道角动量垂直分量具有锁定关系。
来源：河南大学官网

关键突破：

1. 利用量子计算优化波场参数，实时动态调整控制精度

2. 首次实现亚毫米级浮物定位，误差小于 0.1 毫米

这一研究系统性地揭示了拓扑学在水波体系中的丰富表现形式，为深入探讨经典波动体系中的拓扑效应提供了重要的理论与实验依据。



新加坡南洋理工大学申艺杰助理教授与水波实验装置合影。
来源:NTU

三、科学原理

从混沌到有序的波场控制

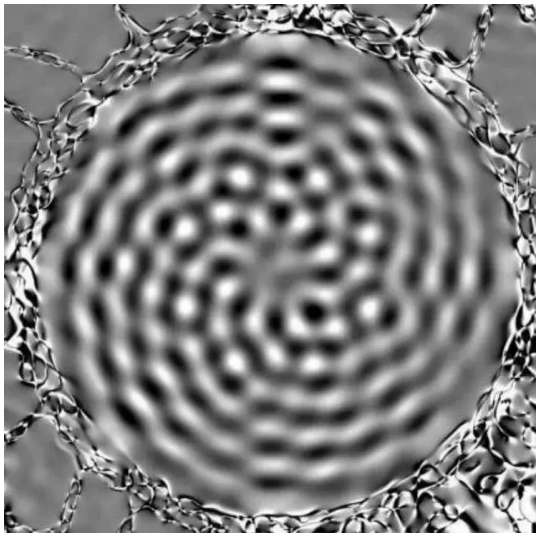
传统水波受湍流与能量耗散限制，难以精准操控物体。NTU 技术通过三大创新破解难题：

1. 波导结构设计：在水面布置微型振子阵列，生成干涉条纹引导浮物运动

实验中用于产生波的结构。
来源：河南大学

2. 自适应反馈系统：AI 实时分析浮物位置，动态修正波场参数

3. 能量局域化：通过波频共振将能量聚焦于目标区域，减少环境干扰



水在水箱中由环形塑料结构产生的波浪产生的复杂图案中旋转的方式。来源：河南大学

国际评价与应用前景

一、国际学术评价

Phys.org（UK，3 月 11 日）

“该技术首次将水波从‘自然扰动源’转化为‘可控能量工具’，为流体操控开辟全新维度。”

这项研究成果为水波的应用开辟了新的可能性。

该技术不仅在实验室中取得了成功，未来还可能在海洋环境中实现大规模应用，为海洋工程和环保领域带来新的希望。

AZoQuantum（UK，3 月 11 日）

“量子算法与流体力学的交叉应用，预示下一代智能海洋设备的诞生。”

这项研究的突破性在于其对水波的精准操控能力。

通过生成复杂的波浪模式，研究人员能够实现对漂浮物体的精确移动和固定，这一成果在未来的海洋资源开发和环境保护中具有重要意义。

Tech360TV（新加坡，3 月 11 日）

“商业转化潜力巨大，或催生万亿级水下机器人市场。”

这项研究不仅展示了水波的操控能力，还为未来的海洋工程和环保领域提供了新的解决方案。

该技术可以用于清理水面上的化学污染物，甚至可以操控大型船只的移动方向，为海洋经济的可持续发展提供了新的思路。

二、应用前景

从海洋工程到医药靶向

1. 海洋环保：精准引导海上溢油收集装置，效率提升 50%，控制漂浮传感器网络监测赤潮，覆盖范围扩大 3 倍。

2. 医疗科技：无创操控载药微囊靶向肿瘤区域，减少健康组织损伤，辅助微创手术器械在血管内的定向运动。

3. 工业制造：微米级芯片的无接触水下组装，避免机械损伤。

三、研究意义

这项共同进行的研究再次证明，科技的力量可以将自然界的规则转化为人类的工具。

从操纵水波到精准控制漂浮物，我们看到了人类智慧与自然力量的完美结合。

未来，随着这项技术的不断完善和推广，我们有理由相信，海洋将不再是一个难以驾驭的领域，而是人类可持续发展的新舞台。

让我们一起期待，这项创新技术如何在未来的海洋舞台上大放异彩，开启人类与海洋和谐共生的新篇章!

https://www.sgnews.co/143610.html