北京大学力学与工程科学学院
School of Mechanics and Engineering Science

湍流与复杂系统国家重点实验室
State Key Laboratory for Turbulence & Complex Systems

Pushing computational limits: From geophysical turbulence to AI assisted turbulence control

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Max Planck Institute

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地　点：新奥工学大楼 3F - 3048 会议室

主持人：谢金翰

摘要： Turbulence is a ubiquitous mechanism for transporting heat and momentum, shaping phenomena from laboratory convection to the swirling, rapidly rotating flows found in planetary atmospheres and interiors. Yet the very regimes that matter most for geophysics and astrophysics are notoriously hard to study: rotation reorganizes the flow into slender, anisotropic structures, boundary layers become dynamically active, and the relevant scale separations demand simulations that push modern high-performance computing to its limits. In this talk, I will first discuss how large-scale DNS enables a regime map of rotating convection, revealing how flow organization and boundary-layer dynamics change across rotation-dominated and buoyancy-dominated states. Building on this, I will highlight the emergence of geostrophic turbulence at extreme forcing, where transport obeys “diffusion-free” behavior. Finally, I will turn from understanding to control. By leveraging deep reinforcement learning, we can discover adaptive actuation strategies that exploit the instantaneous flow state to enhance turbulent transport beyond what traditional, hand-designed controls typically achieve. Importantly, the policies learned by the AI need not remain black boxes: their essential logic can be distilled into compact, interpretable rules that transfer to new flow conditions. Together, these developments illustrate a coherent trajectory—from pushing computational limits to resolve geophysical turbulence, to using AI to actively shape turbulence in ways that are both effective and physically explainable

报告人简介：朱晓珏博士现为德国哥廷根的马克斯·普朗克独立研究组组长（Independent Max Planck Research Group Leader）。他于 2018 年在荷兰特文特大学流体物理研究组获得博士学位，随后于 2019 年至 2021 年在哈佛大学应用数学系担任博士后研究员。朱博士曾获得多项荣誉与奖励，包括戴姆勒和奔驰基金会 Fellowship of the Daimler and Benz Foundation for Junior Professors、剑桥大学 David Crighton Fellowship 以及荷兰 NWO 物理学博士论文奖（NWO Physics Thesis Award，荷兰最佳物理学博士论文）。迄今为止，他的研究组已接待五位洪堡学者。朱博士的研究方向聚焦于计算流体力学，重点关注湍流与多相流。他已发表近 70 篇学术论文，其中包括 35 篇发表在 JFM，以及 10 余篇发表在 PRL、PNAS、Nature Communications、Science Advances 等期刊上的研究成果。

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