



非平衡量子多体系统专题编者按

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在传统固体电子材料中, 量子多体物理的研究对象多为处于热力学平衡态 (热力学性质) 或近平衡态 (输运性质) 的系统, 而对远离热力学平衡态的性质较少涉及. 近十年来, 由于量子调控技术和测量手段的飞速发展, 在凝聚态物理、超冷原子、固态量子信息等领域中涌现出大量新型的人造量子多体系统. 通过动态调控物理参数, 或者将系统耦合上非平衡的环境, 人们可以将这类量子多体系统驱动到远离平衡态的状态. 由于其独特的性质, 这类新型量子关联体系会演化出一些与传统平衡态多体系统完全不同的新现象与新物理, 很多重要的物理概念 (如拓扑序、自发对称破缺、普适类) 在非平衡物理的框架下可能被赋予新的内涵. 同时, 由于量子技术的飞速发展, 理解这类复杂系统对于以量子计算和量子调控为代表的新一代量子科学技术的发展具有重要的现实意义.

非平衡量子多体系统是一个崭新的研究领域, 其中有大量的未解之谜. 由于其具有强关联和非平衡的双重困难, 人们对这一系统的认知极其有限. 同时, 非平衡量子关联体系的研究范围不局限于某一特定的物理分支, 而是涉及凝聚态物理、原子分子物理和量子光学、量子信息与量子计算、非平衡统计物理等诸多现代物理学的前沿领域. 这些不同体系中涌现出来的非平衡量子关联现象, 既融合了各自体系的不同特征, 又展现出普适的一般规律. 我们期待未来不同学科的物理思想和研究方法在这一领域交叉融合, 碰撞出更为绚丽的火花. 本专题邀请了若干活跃在这一新兴领域的专家撰稿, 重点介绍非平衡和开放量子多体系统相关的最新研究进展. 内容涵盖了非平衡量子磁性与超导、周期驱动的量子动力学、耗散与非厄密系统、可积系统、时间晶体等方向. 我们期待专题中介绍的成果能够加强国内学者在这一领域的交流, 激发读者的兴趣, 吸引更多青年学者和学生加入到这一新兴领域的研究中.

(客座编辑: 蔡子 上海交通大学)

SPECIAL TOPIC—Non-equilibrium quantum many-body systems

Preface to the special topic: Non-equilibrium quantum many-body systems

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In the context of traditional solid physics, the majority of studies in quantum many-body physics focus on the systems in or close to the thermodynamic equilibrium state, while the far-from-equilibrium system is less known in general. In the past decades, due to the rapid development of quantum manipulation and measurement, enormous novel synthetic quantum materials have emerged in condensed matter, ultracold atomic, and solid state quantum information systems, where the systems can be driven out of equilibrium by dynamically tuning the Hamiltonian parameters, or coupling the system to a non-equilibrium bath. Due to its unique feature, such non-equilibrium quantum many-body systems exhibit novel properties that

are completely different from the traditional equilibrium quantum many-body systems. Lots of fundamental concepts (for instance, the topological order, spontaneous symmetry breaking and universality class) have to be reexamined in the framework of non-equilibrium physics. Furthermore, understanding such complex quantum systems is also of important practical significance for the development of the new generation of quantum technologies.

As a new branch of physics, non-equilibrium quantum many-body systems are far from being understood due to the intrinsic difficulties of it strongly correlated and non-equilibrium features. At the same time, instead of focusing on a specific branch of physics, the researches in this field involve interdisciplinary theories and methods in condensed matter physics, atomic and molecular physics and quantum optics, quantum information and quantum computation, non-equilibrium statistic physics. The emergent non-equilibrium quantum many-body phenomena in above systems do not only possess the interest of its own, but also exhibit universal behavior that is independent of the details of these systems. It is expected that the interplay between the ideas and methods in various branches of modern physics can trigger exciting physics in this new field. This special topic contains several review papers written by experts working actively in this emergent field. These papers review latest progresses in several important directions in this field, including the non-equilibrium quantum magnetism and superconductivity, periodically driven quantum systems, dissipative and non-Hermitian systems, integrable systems and time crystals. We hope this special topic can inspire the interest of the readers, and attract more young scholars and students to join this exciting field.

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