北京大学量子材料科学中心

International Center for Quantum Materials, PKU

量子物质名家讲堂

Quantum Matter Distinguished Lecture Series

Precision Quantum Measurements on the Nanoscale

Jörg Wrachtrup

斯图加特大学

Time: 2:00 pm, July 27, 2026 (Monday)

时间：2026年7月27日（周一）下午2:00

Venue: Room W301, Physics building, Peking University

地点：北京大学物理楼，西301思源报告厅

Abstract

Precision measurements are a cornerstone of modern quantum technologies. Whereas high-precision measurements have traditionally been performed on macroscopic length scales, solid-state quantum sensors now enable precision measurements with nanometer spatial resolution. Using the electron spin of individual atomic defects, such as the nitrogen-vacancy (NV) center in diamond, local quantities including magnetic and electric fields, temperature, and strain can be measured with exceptional sensitivity on the nanoscale. These capabilities provide unprecedented insight into the microscopic properties of quantum materials. As an example, we have recently investigated magnetic order in twisted two-dimensional magnetic crystals [1] or the vortex formation in two-dimensional $NbSe_2$ superconductors. Nanoscale quantum sensors not only measure static but also dynamic processes. We have used this to e.g. measure molecular diffusion or charge carrier fluctuations as well as unconventional quasiparticle dynamics in superconductors. Most importantly, quantum sensing can be significantly enhanced by exploiting multiqubit sensors. This can be either multiple electron spins or nearby ancilla spins as local quantum processing qubits. This approach can be used to extend the accessible measurement bandwidth without sacrificing sensitivity and enables advanced sensing protocols. As a striking example, we demonstrate the realization of a quantum Fourier transform for the spectral analysis of oscillating magnetic fields [2]. We extended this approach to achieve a significant enhancement in sensitivity through using ancilla quantum bits as robust quantum memories [3,4].

References

[1] K. C. Wong *et al.*, *Nature Nanotechnology* **21**, 359–365 (2026).
[2] V. Vorobyov et al. *npj Quantum Information* 7, 124 (2021)
[3] R. Maier *et al.*, *Nature Communications* **17**, Article 4028 (2026).
[4] R. Maier *et al.*, *Physical Review Letters* **135**, 250802 (2025).

About the speaker

Jörg Wrachtrup教授是国际著名的量子物理专家。Jörg Wrachtrup教授自2000年起担任斯图加特大学第三物理研究所和应用量子技术中心的主任，同时也是斯图加特-马克斯·普朗克固态研究所的全职研究员和柏林-勃兰登堡科学院院士。Jörg Wrachtrup教授是固态量子物理学的先驱。他首次实现了单电子的电子自旋共振测量，研发了单分子级的光探测磁共振谱，并应用于固体材料中的单个掺杂原子-金刚石中的氮-空位中心（NV）。近年来，Wrachtrup团队利用NV量子探针演示了磁场、电场和温度的纳米级量子传感，揭示了二维磁性转角材料的摩尔结构，并以极高探测灵敏度和空间分辨实现了单个电子自旋，单个元电荷以及核磁共振测量。Wrachtrup教授迄今发表超过300余篇论文，曾获得过多项奖项，其中包括2020年欧洲物理学会欧洲物理奖（Europhysics Prize，凝聚态物理领域欧洲最著名的奖项之一）、2014年马克斯·普朗克奖（Max Planck Research Award）等著名奖项。

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