量子磁学

Quantum magnetism

Magnetism and magnetic effects are deeply rooted in quantum mechanics of the spin and angular momentum. This lecture focuses on the quantum-mechanical fundamentals of magnetism, its manifestation in the macroscopic behaviour and its application.

Starting with aspects of the Schrödinger equation of electrons in a Coulomb potential including relativistic corrections, i.e. the spin-orbit interaction, the rules that govern the occupation of single electron states in isolated atoms or ions will derived. The action of an external magnetic field on the atomic states will be discussed and its consequences for the occupation of the states in thermal equilibrium.

As the magnetic moment is a results of angular momenta, its dynamics is not trivial. We will deduce some of the basic equations of precession of the magnetic moment when exposed to a static magnetic field plus a radio frequency excitation, i.e. magnetic resonance.

When single magnetic atoms or ions are placed in a crystal lattice (or in an organic molecule), the electrons feel the electrostatic potential of the neighboring atoms or ions breaking rotation symmetry. We will briefly review the physics of the crystal or ligand field splitting the ground state multiplet even at zero magnetic field building the fundament of magnetic data storage as well as spin-quibits.

Finally, we will discuss magnetic interactions between individual moments, their role in forming either classical ground states or highly entangled many-particle states. We discuss magnetic phase transitions as function of temperature and external parameters for different dimensions as well as the quantized bosonic excitations from the ground state.

The theoretical concepts will be supported by experimental examples and their application in devices will be illustrated.

教师风采

Prof. Wulfhekel, received his PhD in 1997 from Universiteit Twente in Niederlande. From 1998-2006, he worked as a senior scientist in Max-Planck-Institut für Mikrostrukturphysik in Germany. Since 2006, he became full professor in Karlsruhe institute of technology (KIT). Currently, he is the dean of education in institute of physics at KIT. Prof. Wulfhekel is one of the leading expert in the field of magnetic nanostructures and layered systems, spin-polarized electron transport, magnetism and antiferromagnetism at the atomic scale.He has published 118 papers including 5 Nature Journal papers and 16 PRLs.

高春雷，教授，2000 年本科毕业于复旦大学物理系，2006 年于德国马普微结构物理研究所获得博士学位，2007-2009 年在德国马普微结构物理研究所从事博士后工作，2009-2015 年任上海交通大学物理与天文系特别研究员，2015 年 5 月至今任复旦大学物理系教授。高春雷教授主要从事低维表面物理的研究工作，研究体系包括磁性、超导、拓扑绝缘体等，共发表论文 50 余篇，引用 3000 余次。

杨方，微纳电子器件与量子计算机学院青年研究员，2015 年于上海交通大学物理系博士毕业，2016 年至 2019 年在德国卡尔斯鲁厄理工学院物理系开展博士后工作。研究方向为凝聚态物理，在拓扑绝缘体以及超导体领域获得了国际领先成果。

课程设置

学分: 1 学分　　学时：18 学时

基础知识要求：Quantum Mechanics, Solid State Physics, Statistical Mechanics/Thermodynamics

上课时间：2019 年 9 月 9 日 - 26 日

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选课网址：

http://register.fudan.edu.cn/p/publish/show.html?queryType=set&searchName=paidInfo.search&projectId=70538

课程进度安排：2019 年 9 月 9 日至 9 月 26 日				
日期	星期	节次	上课内容	授课教师
9 月 9 日	周一下午	5-7	Basic concepts of quantum magnetism	Wulfhekel 教授
9 月 12 日	周四下午	5-7	Magnetic resonance	Wulfhekel 教授/杨方青年研究员
9 月 16 日	周一下午	5-7	Broken symmetry and spin qubits	Wulfhekel 教授
9 月 19 日	周四下午	5-7	Magnetic phase transition	Wulfhekel 教授/杨方青年研究员
9 月 23 日	周一下午	5-7	Experimental methods of quantum magnetism	高春雷教授
9 月 26 日	周四下午	5-7	Exam	高春雷教授

参考教材：

- S. Blundell, Magnetism in Condensed Matter, Oxford University Press (2001).
- J. M. D. Coey, Magnetism and Magnetic Materials, Cambridge University Press