# 课程大纲
# COURSE SYLLABUS

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| **1.** | **课程代码/名称**<br>**Course Code/Title** | PHY5008/量子输运理论 Quantum Transport Theories |
| **2.** | **课程性质**<br>**Compulsory/Elective** | 专业选修课 Elective Course |
| **3.** | **课程学分/学时**<br>**Course Credit/Hours** | 3/48 |
| **4.** | **授课语言**<br>**Teaching Language** | 英文 English |
| **5.** | **授课教师**<br>**Instructor(s)** | 卢海舟 Haizhou Lu |
| **6.** | **是否面向本科生开放**<br>**Open to undergraduates or not** | 是 YES |
| **7.** | **先修要求**<br>**Pre-requisites** | （如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）<br>量子力学 II PHY305 和固体物理 PHY321-15<br>Quantum Mechanics II and Introduction to Solid State Physics |

**8.** **教学目标**
**Course Objectives**

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

修完本课程，需要掌握研究量子输运的基本概念和主要理论方法，包括久保公式，费曼图技术，Landauer-Buttiker 公式，传输矩阵及散射矩阵方法，非平衡格林函数等；并熟悉主要的量子输运现象，如量子霍尔效应，电子局域化效应，全局电导涨落，量子线性磁阻等。

After leaning this course, students will get acquired to the basic concepts and theoretical approaches in quantum transport, including Kubo formula, Feynman diagram techniques, Landauer-Buttiker formula, transfer matrix and scattering matrix methods, non-equilibrium Green's functions, etc; and major quantum transport phenomena, such as the quantum Hall effects, localization effects, universal conductance fluctuations, quantum linear magnetoresistance, etc.

**9.** **教学方法**
**Teaching Methods**

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

从个人研究经验出发，结合教材和领域最新研究热点，激发学生学习兴趣。幻灯片放映与黑板板书相结合。

Based on personal research experiences and latest progresses in quantum transport on state-of-art experiments and theories.

**10.** **教学内容**
**Course Contents**
（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

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| | **Section 1** | 基础概念 8 课时 |

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| | | 二维电子气，有效质量，态密度，特征长度，磁阻，横模<br>Preliminary concepts<br>Two-dimensional electron gas; Effective mass, Density of states; Characteristic lengths; Magnetoresistance; Transverse modes |
| | **Section 2** | 电导和投射系数 8 课时<br>Landauer 公式，非零温和偏压，不相容原理<br>Conductance from transmission<br>Landauer formula; Non-zero temperature and bias; Exclusion principle |
| | **Section 3** | 透射函数，散射矩阵和格林函数 16 课时<br>散射矩阵，格林函数，紧束缚模型<br>Transmission function, S-matrix and Green's functions<br>S-matrix; Green's function; Tight-binding model |
| | **Section 4** | 量子霍尔效应 4 课时<br>零电阻的来源，背散射效应<br>Quantum Hall effect<br>Origin of zero resistance; Effect of backscattering |
| | **Section 5** | 局域化与电导涨落 12 课时<br>局域化长度，弱局域化，电导涨落<br>Localization and fluctuations<br>Localization length; Weak localization; Conductance fluctuations |

**11. 课程考核**
**Course Assessment**

（①考核形式 Form of examination；②分数构成 grading policy；③如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

课堂小测验（60%）+口头报告（40%）

Quiz(60%)+Oral presentation(40%)

**12. 教材及其它参考资料**
**Textbook and Supplementary Readings**

Textbook
Supriyo Datta, Electronic transport in mesoscopic systems (Cambridge University Press)
References
[1] Gerald D. Mahan, Many-Particle Physics (Springer)
[2] Henrik Bruus and Karsten Flensberg, Many-Body Quantum Theory in Condensed Matter Physics: An Introduction (Oxford University Press)
[3] A. A. Abrikosov, L. P. Gorkov, and I. E. Dzyaloshinski, Methods of Quantum Field Theory in Statistical Physics (Dover Pulications)