南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

# 课程详述

## COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

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| 1. | **课程名称 Course Title** | 低温物理学 Low Temperature Physics |
| 2. | **授课院系 Originating Department** | 物理系 Physics Department |
| 3. | **课程编号 Course Code** | PHY328 |
| 4. | **课程学分 Credit Value** | 3 |
| 5. | **课程类别 Course Type** | 专业选修 Subject Elective |
| 6. | **授课学期 Semester** | 春季 Spring |
| 7. | **授课语言 Teaching Language** | 双语 English & Chinese |
| 8. | **授课教师、所属学系、联系方式（如属团队授课，请列明其他授课教师） Instructor(s), Affiliation& Contact （For team teaching, please list all instructors）** | 戴俊峰，助理教授，物理系<br>第二科研楼 225 室<br>Jun-Feng DAI, Assistant Professor, Physics Department<br>Rm. 225, Research Building II.<br>dai.jf@sustc.edu.cn<br>0755-8801-8223 |
| 9. | **实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact** | 待公布 To be announced |
| 10. | **选课人数限额(可不填) Maximum Enrolment （Optional）** | |

| 11. 授课方式 Delivery Method | 讲授 Lectures | 习题/辅导/讨论 Tutorials | 实验/实习 Lab/Practical | 其它(请具体注明) Other（Please specify） | 总学时 Total |
|---|---|---|---|---|---|
| 学时数 Credit Hours | 32 | | 32 | | 64 |

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|---|---|
| 12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements | 热力学与统计物理 I （PHY204）<br>Thermodynamics and Statistical Physics I （PHY204） |
| 13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite | 无 None |
| 14. 其它要求修读本课程的学系 Cross-listing Dept. | 无 None |

## 教学大纲及教学日历 SYLLABUS

15. **教学目标 Course Objectives**

《低温物理学》是由物理系开设，面向物理专业的选修课程。低温物理学是研究物质在低温下的物理现象的学科，同时包括低温的获得和测量技术知识。修完本课程，要求学生了解低温的获得、保持以及测量的方法；理解部分低温下的物理现象及其应用。

"Low Temperature Physics" is an elective course offered by the physics department for physics. It focuses on the physical phenomena at low temperatures, including both acquisition of low temperature and measurement techniques. Through this course, students are required to grasp the methods of obtaining, maintaining and measuring low temperatures, and understand the physical phenomena at low temperatures and their applications.

16. **预达学习成果 Learning Outcomes**

掌握： 低温的获得与保持方法，低温的测量手段。

理解： 超流现象；玻色-爱因斯坦凝聚理论；超导电性及 BCS 理论；

How to obtain and maintain low temperature, and grasp the measurement methods of low temperature.

Understand the phenonema of superfluid, Bose-Einstein Condensation, superconductivity and BCS theory.

17. **课程内容及教学日历 （如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）**
**Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)**

**Theory （理论部分）**

**1.Cooling Techniques （制冷技术）**

The first, second and third weeks: 1. Liquefaction of Gases and Bath Cryostats: Expansion Engines, Joule–Thomson Expansion, Separation of N2 and O2, Storage of LT liquids and Bath Cryostats; 2. Evaporation Cryostats; 3 Closed-Cycle Refrigerators; * 4 Dilution Refrigerators; 5 Pomeranchuk Cooling; * 6 Adiabatic Demagnetization; 7 Nuclear Spin Demagnetization; （第一-三周：1 气体液化和低温恒温器：绝热膨胀发动机、焦耳汤姆森膨胀过程、分离 N2 和 O2、低温液体储存和低温恒温器 2 蒸发制冷机 3 闭循环制冷机* 4 稀释制冷机 5 Pomeranchuk 制冷* 6 绝热消磁制冷 7 核自旋退磁制冷）

**2.Thermometry （测温）**

The fourth and fifth weeks: A. Primary Thermometers 1 Gas Thermometers 2 Vapor-Pressure Thermometers 3 3He Melting-Curve Thermometer 4 Noise Thermometers 5 Superconducting Fixed-Point Thermometers 6 Nuclear-Orientation Thermometers * （第四、五周：第一类温度计：1、气体温度计 2 、蒸汽压温度计 3、氦 3 熔融曲线温度计 4、噪音温度计 5、超导体固定温度点温度计 6、原子核取向温度计）

The sixth and seventh weeks: B. Secondary Thermometers 1 Resistance Thermometers 2 Thermoelectric Elements 3 Capacitive Thermometers * 4 Magnetic Thermometers * 5 Nuclear Spin Resonance Thermometers （第六、七周：第二类温度计 1、电阻温度计 2、热电温度计 3、电容温度计 4、磁温度计 5、核自旋共振温度计）

**3.Superconductivity （超导）**

The eighth and ninth weeks: A. Phenomenological observations 1. Zero resistance 2. Superconducting transition temperature 3. Meissner–Ochsenfeld Effect 4. Critical field and types I & II 5. London Equations and penetration depth （第八、九周：A 现象学 1、零电阻 2、超导转变温度 3、Meissner-Ochsenfeld 效应 4.关键场和第 I 和 II 类超导体 5.伦敦方程和渗透深度）

The tenth and eleventh weeks: B. BCS Theory 1. Cooper Pairs 2. BCS Ground State 3. Excitation of the BCS Ground State 4. BCS State at Finite Temperatures 5. Measurement of the Energy Gap 6. Tunneling Experiments 7. Critical Current and Energy Gap （第十、十一周：B. BCS 理论 1.库珀对 2. BCS 基态 3. BCS 基态的激励 4.有限温

度下的 BCS 状态 5.能隙的测量 6.隧道实验 7.临界电流和能隙）

The twelfth, thirteen and fourteenth week: C. Flux Quantization – Josephson Effect 1. Flux Quantization 2. Pair Tunneling – Josephson Effect 3. Quantum Interference 4. SQUID. （第十二到十四周：C.量子化通量 - 约瑟夫逊效应 1.磁通量化 2.隧道库伯对 - 约瑟夫逊效应 3.量子干涉 4. SQUID）

**4. Bose–Einstein Condensation （波色爱因斯坦凝聚）**

The fifteenth and sixteenth: Theory of Bose-Einstein Condensation, The Bose-Einstein Condensate experiments （第十五和十六周：波色爱因斯坦凝聚理论及实验）

Experiment （实验部分）

Title: The resistance of semiconductors and metals at different temperatures （题目：半导体和金属材料在不同温度下的电阻特性）

Experimental requirement: sample preparation, fabrication of devices, sample installation, programming, measurement, data analysis, report.

实验要求：完成样品制备，器件制造，样品安装，程序撰写，测量，数据分析以及撰写报告。



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

(1) Low-Temperature Physics, By Christian Enss and Siegfried Hunklinger, Springer Berlin Heidelberg New York, 2005

(2) 低温物理学（第二版）曹烈兆、阎守胜、陈兆甲 著，中国科学技术大学出版社，2009

## 课程评估 ASSESSMENT

19.

| 评估形式 Type of Assessment | 评估时间 Time | 占考试总成绩百分比 % of final score | 违纪处罚 Penalty | 备注 Notes |
|---|---|---|---|---|
| 出勤 Attendance | | | | |
| 课堂表现 Class Performance | | 10% | | |
| 报告 Presentation | | 20% | | |
| 课程项目 Projects | | 30% | | |
| 平时作业 Assignments | | | | |
| 期中考试 Mid-Term Test | | | | |
| 期末考试 Final Exam | | 40% | | |
| 期末报告 Final Presentation | | | | |
| 其它（可根据需要改写以上评估方式） Others (The above may be modified as necessary) | | | | |

20. 记分方式 GRADING SYSTEM

☑ A. 十三级等级制 Letter Grading
☐ B. 二级记分制（通过/不通过） Pass/Fail Grading

## 课程审批 REVIEW AND APPROVAL

21. 本课程设置已经过以下责任人/委员会审议通过
This Course has been approved by the following person or committee of authority

物理系教学指导委员会
Education Instruction Committee of Physics department