课程大纲
COURSE SYLLABUS

1.	**课程代码/名称** **Course Code/Title**	PHY5004/高等固体物理 Advanced Solid State Physics
2.	**课程性质** **Compulsory/Elective**	专业必修课 Degree Required Course
3.	**课程学分/学时** **Course Credit/Hours**	4/64
4.	**授课语言** **Teaching Language**	英文 English
5.	**授课教师** **Instructor(s)**	李军学 Junxue Li
6.	**是否面向本科生开放** **Open to undergraduates or not**	是 YES
7.	**先修要求** **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.） 固体物理 PHY321-15 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.）

使学生掌握扎实的固体物理知识和具备清晰的物理图像。

The goal of this course is to let our graduate students master fundamental concepts of solid state physics and have a clear physical picture about the physical process in solid state physics.

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.）

课堂授课以 PPT 为主，板书为辅，授课内容偏实验方向，侧重物理图像的建立。鼓励学生多做项目和报告。

I will use the PowerPoint and blackboard to teach. The contents will be focused on the experimental surveys and physical pictures. I will encourage students to teach themselves by doing projects and presentation.

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.）

Section 1	**简介**：什么是固体物理和为什么它很重要； **Introduction**（2 学时）： What is solid state physics and why it is important;
Section 2	**声子**： 光学支和声学支声子，色散关系，测量声子的实验手段，热容； **Phonon**（4 学时）：

	Acoustic phonon and optic phonon; Dispersion; Experimental methods to measure phonon; Heat capacity due to phonon;
Section 3	**自由电子模型**：费米面，电子对热容的贡献；电导； **Free electron gas model**（4 学时）： Fermi surface; Heat capacity from free electrons; electric conductivity;
Section 4	**能带**：布洛赫函数，近自由电子模型；中心方程；能隙； **Energy band**（2 学时）： Bloch function; Nearly free electron model; central equation; Energy gap;
Section 5	**半导体**：能隙，运动方程；有效质量；本征迁移率；热电效应； **Semiconductor crystals**（8 学时）： Band gap; equation of motion; effective mass; intrinsic mobility; thermoelectric effects;
Section 6	**费米面和金属**：如何构建费米面和布里渊区；能带计算；量子振荡； **Fermi surface and metals**（6 学时）： How to construct a Fermi surface; the relation between Brillouin zone and Fermi surface; band calculation; quantum oscillations;
Section 7	**超导电性**：超导历史；Meissner 效应；热容；能隙；同位素效应；London 方程；Ginzburg-Landau 理论；BCS 理论；Josephson 结； **Superconductivity**（8 学时）： History; Meissner effect; heat capacity; energy gap; isotope effect; London equation; Ginzburg-Landau theory; BCS theory; Josephson effect;
Section 8	**抗磁性与顺磁性**：朗之万抗磁性，顺磁性的量子理论；洪特定则；晶体场劈裂；轨道角动量的淬灭； **Diamagnetism and paramagnetism**（4 学时）： Langevin diamagnetism; Quantum theory of paramagnetism; Hund rules; Crystal field splitting; Quenching of the orbital angular momentum;
Section 9	**铁磁性和反铁磁性**：铁磁序；磁振子；亚铁磁序；反铁磁序；铁磁磁畴； **Ferromagnetism and anti-ferromagnetism**（6 学时）： Ferromagnetic order; magnons; Ferrimagnetic order; Antiferromagnetic order; Ferromagnetic domains;
Section 10	**磁共振**：核磁共振；铁磁共振；反铁磁共振；电子顺磁共振； **Magnetic resonance**（6 学时）： Nuclear magnetic resonance; Ferromagnetic resonance; Antiferromagnetic resonance; Electron paramagnetic resonance;
Section 11	**等离激元，极化声子，极化子**：电子气的介电函数；等离激元；极化声子；电子-电子相互作用；电子-声子相互作用；线性金属的皮尔斯不稳定性； **Plasmons, polaritons and polarons**（6 学时）： Dielectric function of the electron gas; Plasmons; Polaritons; Electron-electron interaction; Electron-phonon interaction; Peierls instability of the linear metals;
Section 12	**光学过程与激子**：反射率；Kramers-Kronig 关系；激子；拉曼效应； **Optical processes and excitons**（2 学时）：

		Optical reflectance; Kramers-Kronig relations; Excitons; Raman effect in Crystals;
	Section 13	**电介质与铁电性**：介电常数与极化性；结构相变；铁电晶体；位移相变；压电性； **Dielectrics and ferroelectrics**（2 学时）： Dielectric constant and polarizability; Structural phase transitions; Ferroelectric Crystals; Displacive transitions; Piezoelectricity;
	Section 14	**表面与界面物理**：表面电子结构；二维通道的磁电阻；p-n 结；异质结；发光二极管； **Surface and interface physics**（2 学时）： Surface electronic structure; magnetoresistance in a 2D channels; p-n junctions; Heterostructures; Light-emitting diodes;
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.） 平时成绩（60％）：包括平时作业; 期末考试成绩（40％）：项目和报告（基于阅读多篇文献后的报告，必须附文献） Regular performance (60%): including homework; Final exam (40%): project and presentation.	
12.	**教材及其它参考资料** **Textbook and Supplementary Readings**	
	(1) Charles Kittel: Introduction to solid state physics, eighth edition. (2) Neil W. Ashcroft, N. David Mermin, Solid state physics. (3) Steven. H. Simon, The oxford solid state basics. (4) P. W. Anderson, Basic notions of condensed matter physics, Benjamin/Cummings, Menlo Park (1984). (5) 冯端、金国钧，凝聚态物理学，高等教育出版社(2013); Duan Feng, Guojun Jin, Condensed Matter Physics, Higher Education Press (2013). (6) Gerald D.Mahan, Condensed Matter in a Nutshell, Princeton (2011). (7) 阎守胜，固体物理基础，北京大学出版社(2011); Shousheng Yan, Foundation of Solid State Physics, Peking University Press (2011). (8) 90 年代物理学---凝聚态物理学，科学出版社(1992); Physics in the 1990s---Condensed Matter Physics, Science Press (1992). (9) 张礼，近代物理学进展，清华大学出版社(2009); Li Zhang, Progress in Modern Physics, Tsinghua University Press (2009). (10) P.M.Chaikin & T.C. Lubensky, Principles of condensed matter physics, Cambridge (1995).	