Academic Year 2018

International Physics Course

Syllabus (Classes)

April 1st, 2018

Osaka University, Graduate School of Science

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1 Master Course

(IPC)High Energy Physics

Course Code	24P039
Course Number	24PHYS5F307
Credits	2
Instructor	AOKI Masaharu Office:
Office Hours	
Eligibility	IPC course 1, 2 Optional
Schedule	Spring and Summer Term Period: Mon2
Room	理/E201 講義室
Type of Class	Lecture Subject
Course Objective	Understand the basics of High Energy Physics (experimental studies of elementary particle physics).
Learning Goals	Students can - draw Feynman diagrams of various interactions, - do calculations using relativistic kinematics, - describe the basic physics behind the interaction of particles with materials, - understand how the standard model was established.
Requirements, Prerequisites	Quantum Mechanics and Special Relativity
Special Note	

Class Plan	High Energy Physics is a research field based on a quantum mechanics and a special relativity. In this lecture, we will overview this field so that the students can have images what will they do. The lecture will be given from the experimentalist's point of view, and thus the mathematical strictness will be sometimes ignored. The lecture will try to cover whole contents of the textbook only in 15 weeks and that is very tough. The students are very encouraged to read the textbook in home to catch-up the speed of this lecture. 1. Particles and Interactions 2. Decay Rates and Cross Sections 3. Relativistic KInematics 4. Dirac Equation 5. Interaction by Particle Exchange 6. Electromagnetic Interaction 7. Symmetries 8. Quark Model 9. QCD 10. Weak Interaction (1) 11. Weak Interaction (2) 12. Neutrino Oscillations 13. CP Violation 14. Electroweak Unification 15. Tests of the Standard Model
Independent Study Outside of Class	Students are required to do homework, and study some topics introduced in the class.
Textbooks	Mark Thomson Modern Particle Physic, Cambridge University Press
References	D.Griffths Introduction to Elementary Particles, John Wiley&Sons Inc. D.H.Perkins Introduction to High Energy Physics, Addison Wesley
Grading Policy	Final exam: 60% Home work, mini midterm exam, mini quiz: 40%
Other Remarks	

(IPC)Nuclear Physics in the Universe

Course Code	24P031
Course Number	24PHYS5F307
Credits	2
Instructor	SHIMA Tatsushi Office:
Office Hours	
Eligibility	Master course and Doctor course students
Schedule	Spring and Summer Term Period: Fri4
Room	理/B307 講義室
Type of Class	Lecture Subject
Course Objective	Atomic nuclei can be specified as the Quantum Finite Many-Body System with two Fermions. We seek to reorganize the basic understanding of Sub-Atomic Physics, especially the Nuclear Physics, from a rather broad view point on the basis of Quantum Mechanics. Nucleosynthesis in Nuclear Astrophysics is also discussed. There, we will see the connection between the Micro World and the Macro World.
Learning Goals	We try to understand the very basic properties of nuclei in which four fundamental forces play roles. We will see how those forces induce various phenomena on nuclei, such as nuclear reactions and nuclear decays. We will learn how those nuclear processes are related to the evolutions of the stars, the universe and matters.
Requirements, Prerequisites	Since nuclei are Quantum Finite Many-body System with two Fermions
Special Note	
Class Plan	basic understandings of Quantum Mechanics and also Electromagnetism are strongly requested.
Independent Study Outside of Class	Starting from the basic properties of sub-atomic particles, we seek to get an overview of the world of nuclei. [Class Plan] 1) Overview of subatomic physics and nuclear astrophysics 2) Basic features of particle physics 3) Properties of nuclear interactions and nuclear mass 4) Fundamental interactions in nuclei and in the universe 5) Strong interaction and nuclear structure 6) Decay widths and uncertainty principle 7) Nuclear decays by means of weak and electromagnetic interactions 8) Gravity in micro world 9) Overview of nuclear excitations 10) Nuclear excitations and deexcitations 11) Commutation relationship, operator and sum rule 12) Big-bang nucleosynthesis 13) Stellar evolution and nuclear reactions 14) Stellar nucleosynthesis and nuclear reactions 15) Recent topics in astrophysical nucleosynthesis

Textbooks	Students will write a summary report on how they understood the subject of each lecture. They have to submit the report in the following week.
References	Important subjects will be summarized in slides, which will be uploaded on the web site.
Grading Policy	Cauldrons in the Cosmos, Claus E. Rolfs and W.S. Rodney, University Of Chicago Press
Other Remarks	Obligatory attendance at lectures and reports.

(IPC)Introduction to Theoretical Nuclear Physics

Course Code	24P032
Course Number	24PHYS5F308
Credits	2
Instructor	HOSAKA Atsushi Office:
Office Hours	Anytime by e-mail
Eligibility	Master course M1 and M2 Optional
Schedule	Spring and Summer Term Period: Tue3
Room	理/E304 講義室
Type of Class	
Course Objective	This is an introductory course for the description of atomic nuclei as many-body systems of nucleons. Emphasis is put on the dynamics based on the special theory of relativity which gives us a systematic view on the understanding of nuclear binding energy, the size of nuclei and the magic numbers. As a simple application, we discuss the equation of state for the nuclear matter. We further discuss chiral symmetry for the basis of the strong interaction physisc, where we also introduce the concept of spontaneous symmetry breaking.
Learning Goals	Students can lean how much of nuclear physics is based on a rather simple physics laws. Among them is the SSB of chiral symmetry and the presence of the pion.
Requirements, Prerequisites	Students are encouraged to be familiar with some elementary issues of analytical mechanics and quantum mechanic.
Special Note	
Class Plan	【Class plan】 1. Introduction – basic issues of atomic nuclei 2. Magic numbers and spin-orbit force 3. Dirac equation 1 – Derivations 4. Dirac equation 2 – Applications 5. Field theory for nuclei 1 – Scalar field and quantization 6. Field theory for nuclei 2 – Fermion field 7. Lagrangians for various fields 8. Nuclear matter 1 – Introduction to sigma-omega model 9. Nuclear matter 2 – Mean field method and binding energy 10. Nuclear properties 11. Chiral symmetry – Pions and currents 12. Linear sigma model 13. Nambu-Goldstone theorem 14. Nambu-Jona-Lasinio model 15. Examination
Independent Study Outside of Class	Students should spend home works which are given every class.
Textbooks	

References	Hiroshi Toki and Atsushi Hosaka, Atomic nuclei as relativistic many-body systems Osaka University Press, 2011 (in Japanese) Atsushi Hosaka and Hiroshi Toki, Quarks, Baryonsand chiral symmetry, World Scientific, 2001
Grading Policy	Reports and examination
Other Remarks	This is a joint course with a Japanese class of the same subject

(IPC)Synchrotron Radiation Spectroscopy

Course Code	24P035
Course Number	24PHYS5F305
Credits	2
Instructor	KIMURA Shin-ichi Office:
Office Hours	To be announced.
Eligibility	International Physics Cource Mater cource Optional
Schedule	Spring and Summer Term Period: Fri2
Room	理/E203 講義室
Type of Class	Lecture Subject
Course Objective	Synchrotron radiation (SR) is a powerful light source in the energy/wavelength region from infrared to X-ray. Nowadays, SR is widely used to obtain the microscopic information of electronic and crystal structures of not only condensed-matters but also biological materials. The technologies of SR beamlines and analysis methods is ever-progressing. The goal of this course is to understand the method of SR spectroscopy and recent topics using SR.
Learning Goals	To understand why synchrotron radiation is useful.
Requirements, Prerequisites	A knowledge of classical electrodynamics and quantum mechanics will be assumed.
Special Note	
Class Plan	【Course Content】 The topics covered in the course will include the principle of the emission of synchrotron radiation, technology of beamlines in the energy region from infrared to X-ray, and scientific topics. 【Class plan】 1. Fundamentals of synchrotron radiation 2. Fundamentals of spectroscopies from infrared to X-ray 3. Vacuum-ultraviolet spectroscopy (reflection/absorption, photoemission, emission) 4. X-ray spectroscopy (X-ray absorption spectroscopy, XANES, EXAFS, X-ray diffraction) 5. Infrared/terahertz spectroscopy (molecular vibration, reflection of metals, near-field spectroscopy/imaging)
Independent Study Outside of Class	To read some papers and textbooks that are announced in the lecture.
Textbooks	To be announced.
References	To be announced.
Grading Policy	By report.
Other Remarks	The course will be given in English.

(IPC)Condensed Matter Theory

Course Code	24P037
Course Number	24PHYS5F305
Credits	2
Instructor	Keith Slevin Office: H618 Email : slevin@phys.sci.osaka-u.ac.jp
Office Hours	
Eligibility	Optional
Schedule	Fall and Winter Term Period: Tue3
Room	理/E304 講義室
Type of Class	
Course Objective	The goal of this course is to introduce the basic concepts needed to explain the physical properties of solids.
Learning Goals	
Requirements, Prerequisites	A knowledge of classical and quantum mechanics, electricity and magnetism, and statistical mechanics will be assumed.
Special Note	
Class Plan	The topics covered will include the Einstein and Debye theories of the specific heat of solids, the Drude and Sommerfeld theory of metals, the periodic table, ionic, covalent and metallic bonding, crystal structure and the reciprocal lattice, wave scattering by crystals, electrons in periodic potentials (Bloch’ s theorem), semiconductors, and magnetism.
Independent Study Outside of Class	
Textbooks	Steven H. Simon/The Oxford solid state basics/Oxford University Press/978-0-19-968077-1
References	N. W Ashcroft and N. D. Mermin (1976). Solid state physics. H. Ibach and H. Lth (2009). Solid-state physics : an introduction to principles of materials science. C. Kittel (2005). Introduction to solid state physics.
Grading Policy	Reports (40%) and final examination (60%).
Other Remarks	

(IPC)Quantum Field Theory II

Course Code	24P026
Course Number	24PHYS5F308
Credits	2
Instructor	YAMAGUCHI Satoshi Office:
Office Hours	Anytime. It is better to make an appointment by e-mail.
Eligibility	
Schedule	Fall and Winter Term Period: Fri3
Room	理/B307 講義室
Type of Class	Lecture Subject
Course Objective	We will learn more on the quantum field theory. In particular we will learn loop corrections, renormalization, renormalization group, and quantization of non-abelian gauge theories.
Learning Goals	Students will be able to calculate the loop diagrams. Students will understand renormalization and be able to explain it. Students will be able to quantize gauge theory in the covariant gauge and derive the Feynman rule.
Requirements, Prerequisites	You should have taken Qunatum field theory I course and understand the content well.
Special Note	

Class Plan

1. Action and path-integral
2. Correlation function and path-integral
3. Effective action
4. Divergence and dimension counting
5. Calculation of 1-loop diagram by dimensional regularization
6. LSZ reduction formula
7. Renormalization 1: on-shell scheme
8. Renormalization 2: MS bar scheme
9. Renormalization group
10. Symmetry and Lie algebra
11. Action of gauge theory
12. Gauge fixing and Faddeev-Popov determinant
13. BRST symmetry
14. Perturbation in gauge theory 1: tree diagram
15. Perturbation in gauge theory 2: loop diagram
16. 作用と経路積分
17. 相関関数と経路積分
18. 有効作用
19. 摂動論とファインマンルール
20. １ループ図の次元正則化による計算
21. 繰り込み１：オンシェル・スキーム
22. 繰り込み２：MS バー・スキーム
23. 繰り込み群
24. LSZ 簡約公式
25. フェルミオン
26. Lie 群と Lie 代数
27. ゲージ理論の作用
28. ゲージ固定と Faddeev-Popov 行列式
29. BRST 対称性
30. ゲージ理論での摂動計算

Independent Study Outside of Class	Do the calculations which are skipped in the lecture. Solve the homework problems given in the class.
Textbooks	
References	Srednicki, Quantum Field Theory Peskin, Schroeder, An Introduction To Quantum Field Theory Weinberg, The Quantum Theory of Fields, Volume 1, 2
Grading Policy	The course grade will be based on the homework assignments.
Other Remarks	

(IPC)Quantum Many-Body Systems

Course Code	24P028
Course Number	24PHYS5F305
Credits	2
Instructor	KOSHINO Mikito Office:
Office Hours	
Eligibility	
Schedule	Spring and Summer Term Period: Wed2
Room	理/E304 講義室
Type of Class	Lecture Subject
Course Objective	We learn several problems in condensed matter physics in which the idea of topology plays an essential role. In the quantum Hall effect, for example, the precise quantization of the observed Hall conductivity is closely related to the geometrical phase (Berry's phase) in the quantum mechanical wave function. Using the elementary quantum mechanics, I introduce the ideas of various topological numbers appearing in quantum physics.
Learning Goals	
Requirements, Prerequisites	
Special Note	
Class Plan	1. Quantum Hall insulator – 2D electron gas / Landau levels / Hall conducitvity – Laughlin's argument / Berry's phase – Edge state / Edge-bulk correspondence 2. Graphene – tight-binding model and honeycomb lattice – 2D Dirac equation – Edge state 3. Various topological matters – Topological insulators – Weyl semimetals
Independent Study Outside of Class	
Textbooks	
References	
Grading Policy	Report assignments
Other Remarks	

(IPC)Quantum Field Theory I

Course Code	24P033
Course Number	24PHYS5F308
Credits	2
Instructor	HASHIMOTO Koji Office:
Office Hours	Anytime
Eligibility	Physics Department, graduate students Optional
Schedule	Spring and Summer Term Period: Thu3
Room	理/E304 講義室
Type of Class	Lecture Subject
Course Objective	Quantum field theory is universal language to describe wide area in physics including particle physics, statistical physics, and condensed matter physics. We learn basics of quantum field theory and master how to evaluate various physical quantities.
Learning Goals	First students master quantization of fields, symmetry and conservation laws, perturbation theory, Feynman diagrams.
Requirements, Prerequisites	Quantum mechanics and special relativity. It would be helpful to have knowledge in Dirac equation and covariant Maxwell equations.
Special Note	
Class Plan	1. Fields and the action principle, Euler equations. 2. Canonical quantization 3. Quantization of Schrodinger fields 4. Quantization of scalar fields 5. Quantization of Dirac fields 6. Symmetry and conservation laws. Noether's theorem 7. Interaction picture and invariant perturbation theory 8. Gell-Mann-Low relations 9. Wick's theorem and Feynman diagrams 1. 10. Feynman diagrams 2. 11. Cross sections 12. Evaluation of scattering amplitudes 13. Decay widths and lifetime 14. Many-body systems and quantum field theory 15. Summary
Independent Study Outside of Class	Homework sets are given.
Textbooks	David Tong, Quantum Field Theory, available online

References	Standard textbooks: 坂井典佑「場の量子論」裳華房 (2002) 江沢潤一「量子場の理論 素粒子物理から凝縮系物理まで」朝倉書店 (2008) Landau and Lifshitz 「Quantum Electrodynamics」Pergamon Press Advanced textbooks: M.Peskin and D.Schroeder: An Introduction to Quantum Field Theory (Addison-Wesley) V.P. Nair「Quantum Field Theory」Springer (2005) 九後汰一郎「ゲージ場の量子論」(I、II) 培風館
Grading Policy	Attendance Record + Homework (100%)
Other Remarks	

2 Doctor Course

(IPC)Topical Seminar I「Terahertz spectroscopy of elementary excitations in solids」

Course Code	24P019
Course Number	24PHYS5F300
Credits	1
Instructor	SHIMANO Ryou Office: KIMURA Shin-ichi Office:
Office Hours	before and after lecture time
Eligibility	Physics Department DC, MC optional
Schedule	Intensive Period: Other
Room	掲示により通知
Type of Class	Lecture Subject
Course Objective	Terahertz spectroscopy has been developed as a powerful tool to study the low energy electromagnetic responses in solids and molecular systems. From the viewpoint of condensed matter physics, various collective excitations and elementary excitations exist in the terahertz frequency range, such as phonon, plasmon, superconducting gap, spin density wave gap. Accordingly, terahertz spectroscopy is now recognized as an important tool for the spectroscopic study in a wide range of condensed matter systems. In this intensive course, starting from a basic introduction to the optical responses of solids, advanced studies of quantum materials with terahertz spectroscopy technique will be reviewed.
Learning Goals	To understand the possibility of terahertz spectroscopy and connection to solid-state physics
Requirements, Prerequisites	Basic knowledge of quantum mechanics, statistical physics, and solid state physics is desirable.
Special Note	TBA
Class Plan	1. Introduction to optical responses of solids 2. Time-domain terahertz spectroscopy 3. Excitons in semiconductors 4. Superconductors 5. Charge density wave, Spin density wave systems 6. Novel nonequilibrium light-induced phenomena
Independent Study Outside of Class	Reading papers and textbooks
Textbooks	none
References	1. Mark Fox, "Optical Properties of Solids" (Oxford University Press, 2001). 2. Martin Dressel and George Grüner, "Electrodynamics of Solids" (Cambridge University Press, 2002).
Grading Policy	Evaluation will be based on course attendance and submitted reports.
Other Remarks	none

2. Doctor Course

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