Course Map Research Fields

Introduction

This part of the course map is supposed to help students to choose a field oof study, select corresponding courses and identify potential supervisors.

It is separated into the main fields represented at NTHU, that is astrophysics (ASTR), atomic, molecular and optical physics (AMO), condensed matter theory (CMT), experimental condensed matter physics (CME), microwave and plasma physics (PP), theory of particles and fields (PT) and experimental particle physics (PE). For some fields there are further subdivisions.

For each field we give a brief description on goals and contents of the field, provide a list of course recommendations and professors working in the field. The course recommendations are separated into undergraduate and graduate level. For each level we provide highly recommended and suggested courses.

Highly recommended courses are considered to represent core knowledge which is essential to do research in that direction. For students, who are unsure which direction to choose, we also recommend to choose from these courses to find out what field they prefer. Suggested courses are considered to provide either additional useful knowledge or further specialized courses which are not necessarily relevant for all students in that field.

We urge students who join NTHU only at the graduate level to take also undergraduate level courses, if they did not take a corresponding class before at their previous university.

Finally, we want to emphasize that this list can only provide rough recommendations. Especially, advanced students should discuss their course selections with their supervisors to receive an optimal and joyful education.

Atomic, Molecular and Optical Physics (AMO)

Experimental Aspect of AMO Physics (AMO-E)

Atomic, Molecular and Optical Physics is the study of matter-matter and light-matter interactions. Experimental AOM physicists study the interactions not only to find answers to critical scientific questions, but also to gain precise control of atoms, molecules, and photons. The frontier AMO experiments nowadays can help discover new physics beyond the standard model, create the world's most accurate clock, perform the most advanced quantum computing schemes, and more.

Course recommendations for undergraduate level

	3rd year	4th year
Highly recommended	• Optics I & II • Optics Laboratory • Applied Electronics	• Introduction to Atomic and Molecular Physics
Suggested	• Mathematical Methods for Physicists • Thermal and Statistical Physics II • Introduction to Optoelectronics	• Introduction to Solid State Physics I & II • Introduction to Quantum Information

Course recommendations for Graduate level

	5th year and higher
Highly recommended	• Atomic and Molecular Physics • Quantum Mechanics II • Seminar – AMO I & II
Suggested	• Optics and Photonics Laboratory • Laser Physics and Applications I • Nonlinear Optics • Quantum Optics

Professors working in this field

Ite Yu, Yi-Wei Liu, Li-Bang Wang, Chih-Sung Chuu, and Shih-Kuang Tung

Theoretical Aspect of AMO Physics (AMO-T)

Atomic, Molecular and Optical Physics is the study of matter-matter and light-matter interactions. Theoretical AMO physicists use mathematical models to explain and predict the behavior of matter and light as they interact. Their study can help explain experimental results and even provide guidance to the experimentalists.

Course recommendations for undergraduate level

	3rd year	4th year
Highly recommended	• Mathematical Methods for Physicists • Thermal and Statistical Physics II	• Introduction to Atomic and Molecular Physics
Suggested	• Optics I & II • Optics Laboratory • Numerical Analysis	• Introduction to Solid State Physics I & II • Introduction to Quantum Information • Computational Physics • Computational Physics Lab

Course recommendations for Graduate level

	5th year and higher
Highly recommended	• Atomic and Molecular Physics • Quantum Mechanics II • Seminar – AMO I & II
Suggested	• Nonlinear Optics • Many-body Physics I • Solid State Physics I • Quantum Optics

Professors working in this field

Daw-Wei Wang

Condensed Matter Theory (CMT)

Condensed Matter Theory is to use analytical and/or numerical method to investigate interesting collective behaviors in condensed matter systems, which include solid, liquid, metal, insulators, superconductors, electronic gases, cold atoms, or other types of interacting systems, both at room temperature and at low temperature regime. Most research subjects could be applied to industry or future technology.

Course recommendations for undergraduate level

	3rd year	4th year
Highly recommended	• Mathematical Methods for Physicists • Thermal and Statistical Physics II • Numerical Analysis	• Computational Physics • Intro. to Solid State Physics I & II • Undergraduate Research (II) • Intro. to Soft Matter Physics
Suggested	• Student Journal Club	• Computational Physics Lab • Intro. to Atomic and Molecular Physics • Intro. of two-dimensional (2D) materials • Intro. to Quantum Information • Intro. to Neurophysics • Intro. to Optoelectronics

Course recommendations for Graduate level

	5th year and higher
Highly recommended	• Condensed Matter Physics I & II • Statistical Mechanics I & II • Computational Condensed Matter Physics • Seminar - Condensed matter I & II
Suggested	• Special Topic: Quantum Information • Special Topic and Intro. to Nanoscale Physics • Many-Body Physics I & II • Physics of Superconductivity

Professors working in this field

Chung-Yu Mou, Tzay-Ming Hong, Hsiu-Hau Lin, Horng-Tay Jeng, Po-Chung Chen, Daw-Wei Wang, Kuo-An Wu, Po-Yao Chang, Yi-Ping Huang

Experimental Condensed Matter Physics (CME)

Researchers in this field mainly focus on measuring the different aspects of physics in solid-state systems, including optical, transport, magnetic, and superconducting properties. Due to the reduction of dimension, pursuing atomic-scale physics and emergent quantum phenomena becomes the main stream of studies in condensed matter physics.

Course recommendations for undergraduate level

	3rd year	4th year
Highly recommended	• Introduction to Modern Physics • Digital Smart Technology • Experimental Technique in Physics	• Introduction to Optoelectronics • Introduction of two-dimensional (2D) materials • Introduction to Solid State Physics I • Introduction to Quantum Information
Suggested	• Optics Laboratory	• Introduction to Solid State Physics II • Applications of Synchrotron Accelerator Light Source

Course recommendations for Graduate level

	5th year and higher
Highly recommended	• Physics of Superconductivity • Seminar--Condensed matter I
Suggested	• Condensed Matter Physics I • Special topics of nano physics and emergent quantum matters

Professors working in this field

Deng-Sung Lin, Jyh-Ching Chang, Jeng-Chung Chen, Tzay-Ming Hong, Shangjr Gwo, Germar Hoffmann, Io-Chun Hoi, Hsueh-Hsing Hung, Wei-Ting Hsu, Pin-Jui Hsu, Raynien Kwo, Chih-Ming Lin, Yen-Hsiang Lin, Shu-Jung Tang, Ming-Fong Tai, Tzu-Kan Hsiao

Microwave and Plasma Physics (PP)

This field is studying the physics of high frequency electromagnetic wave and its own applications. This includes Terahertz Sources, Microwave/Material Interaction and Characterization, Microwave Physics and Applications. In recent years, microwave technique also plays an important role in quantum technology.

Course recommendations for undergraduate level

	3rd year	4th year
Highly recommended	• Applied Electronics • Applied Electronics Lab	• Introduction to Optical Physics • Introduction to Solid State Physics I
Suggested	• Optics • Optics Laboratory • Experimental Technique in Physics	• Introduction to Solid State Physics II • Introduction to Quantum Information • Applications of Synchrotron Accelerator Light Source

Course recommendations for Graduate level

	5th year and higher
Highly recommended	• Electrodynamics (II) • Microwave Physics and Applications* • Plasma Physics*
Suggested	• Electro-optics Labs

*Not offered every year

Professors working in this field

Tsun-Hsu Chang

Theory of Particles and Fields (PT)

String Theory and Formal Aspects of QFT (PT-S)

Researchers in this field try to understand the properties of spacetime, matter and interaction at the fundamental level. They develop original concepts and models in order to resolve the limitations of current theories, with the goal to unveil new fundamental physics principle of the nature.

Course recommendations for undergraduate level

	3rd year	4th year
Highly recommended	• Introduction to Relativity I • Mathematical Methods for Physicists	• Introduction to Relativity II • Introduction to Modern Cosmology
Suggested	• Thermal and Statistical Physics II	• Thermal and Statistical Physics II

Course recommendations for Graduate level

	5th year and higher
Highly recommended	• Quantum Field Theory I and II • Seminar Particle Physics I and II • Introduction to Modern Cosmology
Suggested	• Special Topic course on anomaly, AdS/CFT, etc. • Computational Physics

Professors working in this field

Chong-Sun Chu

Phenomenological Aspects of (Astro-)Particles (PT-P)

Researchers in this field try to understand the basic constituents of our universe and how they interact with each other. They develop models to describe experimental results and calculate predictions, which can then be tested in other experiments.

Course recommendations for undergraduate level

	3rd year	4th year
Highly recommended	• Mathematical Methods for Physicists	• Intro. Elem. Particle Physics I • Intro. Elem. Particle Physics II
Suggested	• Thermal and Statistical Physics II • Computational Physics • Computational Physics Lab	• Introduction to Modern Cosmology • Special Topic: Neutrino Physics • Numerical Analysis • Astroparticle Physics

Course recommendations for graduate level

	5th year and higher
Highly recommended	• Quantum Field Theory I and II • Elementary Particle Physics I and II • Seminar Particle Physics I and II
Suggested	• Thermal and Statistical Physics II • Introduction to Modern Cosmology • Special Topic: Neutrino Physics • Computational Physics • Computational Physics Lab • Numerical Analysis

Professors working in this field

We-Fu Chang, Kingman Cheung, Martin Spinrath, Po-Yen Tseng

Experimental Particle Physics (PE)

We aim to look for signatures for beyond-SM physics in collider experiments and develop novel experimental ideas. Topics include (but not restricted to) analyses of data collected by the ATLAS detector, upgrade projects of the LHC, and application of machine learning techniques.

Course recommendations for undergraduate level

	3rd year	4th year
Highly recommended	• Special Relativity	• Intro. Elem. Particle Physics I • Intro. Elem. Particle Physics II
Suggested	• Thermal and Statistical Physics II • Computational Physics • Computational Physics Lab	• Other courses on C, Python and Unix/Linux OS

Course recommendations for Graduate level

	5th year and higher
Highly recommended	• Elementary Particle Physics I and II • Seminar Particle Physics I and II
Suggested	• Various "Special Topics" courses offered by HEP (theory) faculty members

Professors working in this field

Pai-Hsien Jennifer Hsu, Kingman Cheung