

Important Note: Every effort will be made to avoid changing the course schedule, but the possibility exists that unforeseen events will make syllabus changes necessary. It is your responsibility to check Brightspace for corrections or updates to the syllabus. Any changes will be clearly noted in course announcements or through Stony Brook email.

Part 1: Course Information

Course title: Theoretical Particle Physics

Course catalog # and section: PHY612

Semester: Fall 2024

Prerequisites: Quantum Field Theory I

Instructor name: Professor Rouven Essig

Instructor's Stony Brook email: rouven.essig@stonybrook.edu

Office hours: By appointment (contact via email).

Location: ESS 183

TA Information: TBD

Course Description:

The Standard Model is an amazingly successful theory of the fundamental building blocks of matter and their interactions. This course will provide an introduction to the Standard Model of particle physics and some new physics not described by it. Prior knowledge of particle physics is useful, but not required. Some knowledge of quantum field theory is assumed (PHY 610 or equivalent). A tentative and incomplete list of possible topics is:

- Overview of the Standard Model of Particle Physics
- Symmetries: basics, Lie groups, Lie algebras, global symmetries, chiral symmetries, gauge symmetries (abelian and non-abelian)
- Spontaneous symmetry breaking
- Gauge theories: Abelian, non-abelian
- Quantum Electrodynamics (QED)



- The standard electroweak theory: discrete symmetries (P, C, CP) and their violation, the standard $SU(2) \times U(1)$ model, Higgs mechanism, tests, flavor physics
- Collider physics
- Neutrino masses and mixing, oscillations, MSW effect.
- Strong interactions and quantum chromodynamics (QCD)
- Chiral symmetry breaking in QCD
- Parton distribution functions
- Beyond the Standard Model: motivation, supersymmetry, grand unification, dark matter (all very brief)
- What's next in particle physics? (brief)

Required Course Textbook and Materials:

- M.D. Schwartz, "Quantum Field Theory and the Standard Model" (Cambridge, 2013)

Recommended Readings/Bibliography:

- Y. Grossman & Y. Nir, "The Standard Model (From Fundamental Symmetries to Experimental Tests)" (Princeton, 2023)
- P. Langacker, "The Standard Model and Beyond" (CRC Press)
- C. Quigg, "Gauge Theories of the Strong, Weak, & Electromagnetic Interactions" (Princeton, 2013)
- Additional material (including papers & review articles) may be suggested during the course.

How We Will Communicate:

Email or talking with me after class is best. I will use Brightspace to send information to the class. If you email me, **please allow between 24-48 hours for an email reply**. Your Stony Brook University email must be used for all University-related communications. You must have an active Stony Brook University email account and access to the Internet. All instructor correspondence will be sent to your SBU email account. **Plan on checking your SBU email account regularly for course-related messages**. To log in to Stony Brook Google Mail, go to <http://www.stonybrook.edu/mycloud> and sign in with your NetID and password.

Regular announcements will be sent from Brightspace. These will be posted in the course site and may or may not be sent by email.

Technical Requirements:

This course uses Brightspace for the facilitation of communications between faculty and students, submission of assignments, and posting of grades and feedback.

If you are unsure of your NetID, visit <https://it.stonybrook.edu/help/kb/finding-your-netid-and-password> for more information.

Part 2: Course Learning Objectives and Assessments

Upon completion of the course, students will be able to:

1. Describe the particle content of the Standard Model of Particle Physics and the interactions among the known particles.
2. Describe how fundamental symmetries determine the interactions among particles.
3. Calculate cross sections and decay rates for particle interactions.
4. Describe how observations and experimental data confirm the Standard Model, and how to go from the theoretical description of the Standard Model to experimental predictions.

How to Succeed in this Course:

- Attend all lectures.
- Complete all assigned readings in the course.
- Correctly complete all assigned homework on time.
- Perform well on the midterm and final exams.

Part 3: Course Schedule

The class will meet on Tuesdays and Thursdays at 2:00pm to 3:20pm.

Part 4: Grading, Attendance, and Late Work Policies**Assessment and Grading:**

There will be approximately 6 homework assignments that need to be completed over the semester (subject to change).

The course grade will be based on homework (35%), a midterm exam (25%), and a final exam (40%).

The midterm exam will be given during the official lecture period. The tentative date of the midterm exam is Thursday October 10 (10:00am-11:20am). The date of the final exam will be announced later.

Letter Grades:

Final grades assigned for this course will be based on the percentage of total points earned and are determined after evaluating the performance of the class overall, which depends on the difficulty of the assigned homework, midterm exam, and final exam.

Attendance Policy: You are strongly encouraged to attend all lectures.

Late Work Policy: Late work will not be accepted. However, you are free to discuss minor changes in the due date of an assignment with me well ahead of the due date. The new due date will then apply to all students.

Part 5: University and Course Policies**University Policies:****Student Accessibility Support Center Statement:**

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and the Student Accessibility Support Center. For procedures and information go to the following website: <https://ehs.stonybrook.edu/programs/fire->

safety/emergency-evacuation/evacuation-guide-disabilities and search Fire Safety and Evacuation and Disabilities.

Academic Integrity Statement:

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management:

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Student Conduct and Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.

Course Policies:**Understand When You May Drop This Course:**

It is the student's responsibility to understand when they need to consider withdrawing from a course. Refer to the Stony Brook Academic Schedule for dates and deadlines for registration: http://www.stonybrook.edu/commcms/registrar/calendars/academic_calendars.

- [Undergraduate Course Load and Course Withdrawal Policy](#)
- [Graduate Course Changes Policy](#)

Incomplete Policy:

Under emergency/special circumstances, students may petition for an incomplete grade. Circumstances must be documented and significant enough to merit an incomplete. If you need to request an incomplete for this course, contact me for approval as far in advance as possible.

Course Materials and Copyright Statement:

Course material accessed from Brightspace, SB Connect, SB Capture or a Stony Brook Course website is for the exclusive use of students who are currently enrolled in the course. Content from these systems cannot be reused or distributed without written permission of the instructor and/or the copyright holder. Duplication of materials protected by copyright, without

permission of the copyright holder is a violation of the Federal copyright law, as well as a violation of Stony Brook's Academic Integrity.

Part 6: Student Resources

Amazon @ Stony Brook: Order your books before classes begin. Phone: 631-632-9828; email: Bookstore_Liaison@stonybrook.edu; website: <http://www.stonybrook.edu/bookstore/>

Bursar: For help with billing and payment. Phone: 631-632-9316; email: bursar@stonybrook.edu; website: <http://www.stonybrook.edu/bursar/>

Career Center: The Career Center's mission is to support the academic mission of Stony Brook University by educating students about the career decision-making process, helping them plan and attain their career goals, and assisting with their smooth transition to the workplace or further education. Phone: 631-632-6810; email: sbucareercenter@stonybrook.edu; website: <http://www.stonybrook.edu/career-center/>

Counseling and Psychological Services: CAPS staff are available by phone, day or night. <http://studentaffairs.stonybrook.edu/caps/>

Ombuds Office: The Stony Brook University Ombuds Office provides an alternative channel for confidential, impartial, independent and informal dispute resolution services for the entire University community. We provide a safe place to voice your concerns and explore options for productive conflict management and resolution. The Ombuds Office is a source of confidential advice and information about University policies and procedures and helps individuals and groups address university-related conflicts and concerns. <http://www.stonybrook.edu/ombuds/>

Registrar: Having a registration issue? Let them know. Phone: 631-632-6175; email: registrar_office@stonybrook.edu; <http://www.stonybrook.edu/registrar/>

SBU Libraries: access to and help in using databases, ebooks, and other sources for your research.

- Research Guides and Tutorials: <http://guides.library.stonybrook.edu/>
- Getting Help: <https://library.stonybrook.edu/research/ask-a-librarian/>

Student Accessibility Support Center: Students in need of special accommodations should contact SASC. Phone: 631-632-6748; email: sasc@stonybrook.edu; <https://www.stonybrook.edu/sasc/>

Writing Center: Students are able to schedule face-to-face and online appointments. <https://www.stonybrook.edu/writingcenter/>