

# PHYSICS 492/802: SURVEY OF NUCLEAR PHYSICS

<https://people.nsl.msu.edu/~witek/Classes/PHY802/NuclPhys802-2018.html>

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Instructor: Witold Nazarewicz and guest stars

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## **Description:**

### A. Introduction

- Nuclear scales (From Big-Bang to galaxy clusters)
- Overarching questions
- Roadmap of nuclear science

### B. Nuclear Properties

- Symmetries of the nuclear Hamiltonian
- Global properties of the atomic nucleus
- Excited states
- Decay modes
- Nuclear reactions, general overview

### C. Frontiers in Nuclear Physics

- Nuclear building blocks
  - Quark and gluons, QCD
  - Quark models of hadrons.
  - Lattice QCD
  - Internal structure of the nucleon
- Nuclear Hamiltonian
  - Quark-gluon origin of the nuclear force
  - Nucleon-nucleon interaction, general properties
  - Deuteron
  - Three- and many-nucleon forces
  - Effective forces in nuclear medium.
- Nuclear structure
  - Single-particle and collective modes
  - Models of nuclear structure
  - Nuclei far from stability. Physics of radioactive beams.
  - Nuclear matter. Nuclear equation of state.
- Nuclear matter at extreme densities.
  - Relativistic heavy Ion collisions
  - QCD phase diagram and quark-gluon plasma
  - Color superconductivity.
- Nuclear physics of the Universe
  - Nuclear astrophysics
  - Origin of the elements
  - Neutrino physics
  - Supernova

- Neutron stars
- Nucleus as a laboratory of fundamental symmetries
  - The Standard Model
  - Symmetry tests in nuclear physics
- Emergent phenomena in nuclear systems; Intersections with other many-body systems
- Nuclear physics and society

### **Recommended textbooks:**

*Nuclear Physics: Exploring the Heart of Matter* (2013)

National Research Council Report, National Academy Press, Washington D.C. 2013.

Can be downloaded from

<http://www.nap.edu/catalog/13438/nuclear-physics-exploring-the-heart-of-matter>

*2015 NSAC Long Range Plan: Reaching for the Horizon*

Can be downloaded from

[http://science.energy.gov/~media/np/nsac/pdf/2015LRP/2015\\_LRPNS\\_091815.pdf](http://science.energy.gov/~media/np/nsac/pdf/2015LRP/2015_LRPNS_091815.pdf)

### **Supplementary texts:**

- *Introductory Nuclear Physics*  
Samuel S. M. Wong (Wiley-Interscience, 1998/99), ISBN: 0471239739
- *Basic Ideas And Concepts In Nuclear Physics: 3rd Edition*  
Kris Heyde (CRC Press, 2005), ISBN: 0750309806

### **Requirements/grading criteria:**

- Attendance and participation [40%]
- Answers to the problems [35%]
- Final presentation [25%] (PHY 802) or essay (PHY 492; tier II writing requirement)  
– based on 1-2 selected nuclear physics papers from Physical Review Letters, Science, or Nature

### **Contact:**

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