Physics 340A - Prof. Oberacker

Suggested topics for term papers or PowerPoint presentations
last update: January 02, 2012

Please study the bibliography section of our course Website to make an informed choice about your term paper. Below, I suggest several topics (experimental, theoretical, computational, and nuclear astrophysics).

Exp. Project 1: Production of new superheavy elements

Describe the production of new superheavy elements using "cold fusion" (E* small) with spherical projectile + spherical target nuclei, and "hot fusion" (E* large) with spherical projectile + deformed target nuclei.
references:
1) S. Hofmann and G. Münzenberg, Reviews of Modern Physics, Vol. 72, No. 3, July 2000, p. 733-767.
2) Oganessian et al., Phys. Rev. Lett. 104, 142502 (2010)

Exp. Project 2: Gamma-ray detector arrays: GAMMASPHERE and GRETA

Describe the basic components and operating principles of current gamma-ray detectors such as GAMMASPHERE. Then discuss the next-generation gamma-ray detectors (GRETA/GRETINA). What are the main advantages of the new detectors?
reference: Gretina Homepage http://grfs1.lbl.gov/

Exp. Project 3: Radioactive Ion Beam facilities

Describe the basic components and operating principles of current and future Radioactive Ion Beam facilities (e.g. HRIBF and FRIB). Discuss in some detail the ISOL vs. projectile fragmentation method.
reference: Lecture materials section 2.1d (RIB facilities slides) which contain URLs for RIB facilities Websites

Theory Project 1: electric and magnetic moments of nuclei

Electric and magnetic moments of nuclei and EM transitions
references:
1) textbook by K. Heyde, second edition, chapters 1.6, 1.7, and Box 1d
2) textbook by Ring and Schuck, chapter 2.7.2 (I have a copy of these textbooks in my office).

Theory Project 2: relativistic mean field theory

Introduction to relativistic mean field theory (Dirac field for nucleons, and "classical" Klein-Gordon fields for mesons).

references:
1) textbook by Greiner and Maruhn (I have a copy in my office), chapter 7.4 and references therein.
2) Bender et al., Phys. Rev. C 60, 034304 (1999).

Theory Project 3: ab initio coupled-cluster theory

Ab initio coupled-cluster theory (for light nuclei)
references:
1) G. Hagen et al., Phys. Rev. C 76, 044305 (2007)
2) G. Hagen et al., Phys. Rev. Lett. 101, 092502 (2008)

NOTE: This project is mathematically challenging and is recommended only to students who intent to do Ph.D. research in theoretical physics.

Computational Project: shell model wave functions

Write a computer program (Fortran-95 or C/C++) to calculate wave functions for the spherical or deformed nuclear shell model on a 3-D Cartesian grid, i.e. $\psi_\alpha(x, y, z)$. Calculate associated probability densities $\rho_\alpha(x, y, z)$ and produce a 2-D contour plot of $\rho_\alpha(x, y = 0, z)$.
references:
1) For shell model wave functions, see Section 3.1 of our course website.
2) contact Prof. Oberacker to get you started about scientific computing (Fortran-95 compilers and sample codes)

Nuclear Astrophysics Project 1: r-process and rp-process

Describe the utilization of radioactive ion beams for nuclear astrophysics studies. Discuss in particular the formation of heavier elements in novae explosions via the rapid proton capture (rp) process, and in supernovae via the rapid neutron capture (r) process.
references (see Bibliography section of our course website):
1) RIA Theory Blue Book
2) ORNL astro website, and in particular Michael Smith's review article

Nuclear Astrophysics Project 2: Supernova explosions

Describe the theory (relativistic hydrodynamics + nuclear equation of state) and the modelling of supernova explosions.
references:
1) "How a supernova explodes", H.A. Bethe and G. Brown, Scientific American (May 1985) p. 60-68
2) RIA Theory Blue Book, see Bibliography section of our course website
3) Terascale Supernova Initiative Website: http://www.phy.ornl.gov/tsi/