Program for Nuclear Talent course on Many-body methods for nuclear physics

Scott Bogner[1]   Gaute Hagen[2]   Heiko Hergert[1]   Morten Hjorth-Jensen[1]   Gustav Jansen[3]   Thomas Papenbrock[4]

National Superconducting Cyclotron Laboratory and Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA[1]

Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA[2]

National Center for Computational Sciences and Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA[3]

Oak Ridge National Laboratory and Department of Physics and Astronomy, University of Tennessee, Knoxville, TN 37996-1200, USA[4]

Jun 22, 2017

Motivation and introduction

To understand why matter is stable, and thereby shed light on the limits of nuclear stability, is one of the overarching aims and intellectual challenges of basic research in nuclear physics. To relate the stability of matter to the underlying fundamental forces and particles of nature as manifested in nuclear matter, is central to present and planned rare isotope facilities.

Important properties of nuclear systems which can reveal information about these topics are for example masses, and thereby binding energies, and density distributions of nuclei. These are quantities which convey important information on the shell structure of nuclei, with their pertinent magic numbers and shell closures or the eventual disappearence of the latter away from the valley of stability.

During the last decade, the study of nuclear structure and the models used to describe atomic nuclei are experiencing a renaissance. This is driven by three technological revolutions: accelerators capable of producing and accelerating exotic nuclei far from stability; instrumentation capable of detecting the resulting

Aims and Learning Outcomes

This three-week TALENT course on nuclear theory will focus on the **Format:** We propose approximately forty-five hours of lectures over three weeks and a comparable amount of practical computer and exercise sessions, including the setting of individual problems and the organization of various individual projects.

The mornings will consist of lectures and the afternoons will be devoted to exercises meant to shed light on the exposed theory, and the computational projects. These components will be coordinated to foster student engagement, maximize learning and create lasting value for the students. For the benefit of the TALENT series and of the community, material (courses, slides, problems and solutions, reports on students' projects) will be made publicly available using version control software like *git* and posted electronically on github. As with previous TALENT courses, we envision the following features for the afternoon sessions:

- We will use both individual and group work to carry out tasks that are very specific in technical instructions, but leave freedom for creativity.

Course Content and detailed plan

Lectures are approximately 45 min each with a small break between each lecture. The morning sessions are scheduled to end around 1230pm.

Week 1.

Day		Lecture Topics and lecturer	Projects and exercises
Monday	9am-1230pm		
	1230pm-230pm	Lunch +own activities	
	230pm-6pm		
Tuesday	9am-1230pm		
	1230pm-230pm	Lunch +own activities	
	230pm-6pm		
Wednesday	9am-1230pm		
	1230pm-230pm	Lunch +own activities	
	230pm-6pm		
Thursday	9am-1230pm		
	1230pm-230pm	Lunch +own activities	
	230pm-6pm		
Friday	9am-1230pm		
	1230pm-230pm	Lunch +own activities	
	230pm-6pm		

Week 2.

Teaching and projects

The course will be taught as an intensive course of duration of three weeks, with a total time of 45 h of lectures, 45 h of exercises and a final assignment of 2 weeks of work for those of you wish to receive 7 ECTS credits for the course. The total load, with the additional project to be handed in later, will be approximately 160-170 hours, corresponding to **7 ECTS** in Europe.

The final assignment will be graded with marks A, B, C, D, E and failed for Master students and passed/not passed for PhD students. A course certificate will be issued for students requiring it from the University of Trento. This certificate states that you have completed the equivalent of 7 ECTS at the graduate level. We plan also to issue a certificate for those of you who have attended the course but did not want to do the final project. This certificate will most likely correspond to 4 ECTS at the graduate level.

The organization of a typical course day is as follows:

Time	Activity
9am-1230pm	Lectures, project relevant information and directed exercises
1230pm-230pm	Lunch
230pm-6pm	Computational projects, exercises and hands-on sessions

Teachers and organizers

The organizers are

1. Alex Brown, National Superconducting Cyclotron Laboratory and Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA
2. Morten Hjorth-Jensen, National Superconducting Cyclotron Laboratory and Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA and Department of Physics, University of Oslo, N-0316 Oslo, Norway

Morten Hjorth-Jensen will also function as student advisor and coordinator.

The teachers are

1. Alex Brown, National Superconducting Cyclotron Laboratory and Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA
2. Alexandra Gade National Superconducting Cyclotron Laboratory and Department of Physics and Astronomy

Audience and Prerequisites

You are expected to have operating programming skills in in compiled programming languages like Fortran or C++ or alternatively an interpreted language like Python and knowledge of quantum mechanics at an intermediate level. Preparatory modules on second quantization, Wick's theorem, representation of Hamiltonians and calculations of Hamiltonian matrix elements, independent particle models and Hartree-Fock theory are provided at the website of the course. Students who have not studied the above topics are expected to gain this knowledge prior to attendance. Additional modules for self-teaching on Fortran and/or C++ or Python are also provided.