Nuclear Physics courses, FRIB theory center and Nuclear TALENT

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First FRIB-China Workshop on Physics of Nuclei and Hadrons, May 28-30 2015

Motivation

- Develop structured modules which will provide our students with a modern education in nuclear physics

- Modules/courses should contain a high-level of synchronization

- A computational perspective is essential

- The FRIB theory center can function as the national coordinating unit

- Coordination with the Nuclear TALENT initiative

Local situation at MSU

We have at MSU a

- basic survey course PHY802 and three basic nuclear physics courses

- structure,

- reactions and dynamics and

- **Nuclear Astrophysics**.

These three basic courses have a duration each of 30-40 hours (2-3 credits).
They can be taught as a regular one-semester course or half-semester course. There are also experimental courses not discussed here.

Nuclear structure course/module PHY981

- Experimental information

- Single-particle properties and mean-field

- second quantization

- Hartree-Fock theory

- Nuclear forces

- Shell model

- Transitions (EM and β-decays

- Computational elements: build a Hartree-Fock code and/or a shell model code (diagonalization)

- etc

Nuclear dynamics course/module PHY982

- Direct reaction theory and applications

- Reactions of light and heavy ions, from low to relativistic energies

- Single-channel scattering

- Integral forms for scattering. Generalizing to many channels

- Collective couplings. Single-particle couplings. Coupling to the continuum

- Transfer reactions. Breakup reactions

- Adiabatic reaction models. Semiclassical approximations (Eikonal and time-dependent approaches)

- Capture and fusion reactions

- R-matrix methods

- Microscopic models for reactions

- Several computational exercises

- etc

Nuclear astrophysics course/module PHY983

- Neutrinos

- Equation of state for dense matter

- Masses - Stability and Decay

- Reaction Rates

- Beta decay Rates

- The Life of Stars: Stellar burning stages, Hydogen burning, Other burning stages

- The Death of Stars: Supernovae, Neutron Stars and White Dwarfs

- Beyond Iron I: r-process, s- and p-process

- Hydrogen burning at the extremes, the rp process

- etc

Advanced modules, Nuclear Talent

1. Nuclear forces (INT 2013, new version 2017)

2. Many-body methods (**GANIL July 2015**)

3. Few-body methods for nuclear physics (**ECT* July-August 2015**)

4. Density functional theory and self-consistent methods (ECT* 2014 and **York 2016**)

5. Theory for exploring nuclear structure experiments (GANIL 2014)

6. Theory for exploring nuclear reaction experiments (GANIL 2013)

7. Nuclear theory for astrophysics (MSU 2014 and **INT 2015**)

8. Theoretical approaches to describe exotic nuclei (planned for 2016, Chalmers, Gothenburg)

9. High-performance computing and computational tools for nuclear physics

    - ECT* 2012, Shell model and variational Monte Carlo
    - LANL/ORNL in 2016, Monte Carlo methods

For all courses (till this year) we have had on average 40 applicants per course.

To think of

- How many basic courses can an institution offer, and which courses should be offered?

- How can the coming FRIB theory center be used to coordinate an advanced training in nuclear physics?

- Can we integrate the (*ad hoc*) Nuclear Talent courses/initiative in our education?

- **Nuclear Talent initiative and Asia**

- Most courses offered are theoretical ones. We need a better coordination between theory and experiment. Should we think of an experimental Talent initiative?

- Is it possible to integrate material developed in different Talent courses, offering thereby a coherent source for educating the next generation of nuclear physicists? Keyword: Modularization of topics.