

Program for JINA Special School on “Methods of Direct Nuclear Reactions”

A. Ingredients – “the bits and pieces”

Tuesday 10th April 2007:

- a) Bound states in potential models: generic features, halos, the role of spin, independent-particle shell-model, level ordering, etc.
- b) Scattering states in potential models: phase shifts and the T- and S-matrix, specification of optical potentials, role of Coulomb, angular momentum, absorption, energy dependence, etc. Transmission coefficients. Coulomb and spherical Bessel function routines.

Wednesday 11th April 2007:

- c) Cluster transition strengths for single-particle excitations and/or breakup: $B(E1)$ and $B(E2)$ (nuclear and/or Coulomb) calculations for particle-core systems. Concept of a square-integrable *bin* and of continuum discretization as analog of (a).
- d) Resonances and virtual states in potential models, relationship to concepts in (a), (b) and (c). Definition of widths and scattering lengths.

B. Scattering basics – “begin to add the bits together”

Thursday 12th April 2007:

- a) Point-particle elastic scattering and elastic observables, differential cross-section, analyzing powers, dependence on energy, charge, etc. Potential fitting to elastic data, global/microscopic optical potentials. Total elastic, absorption, and total reaction cross-sections.

Friday 13th April 2007:

- b) Use of perturbation theory: elastic scattering estimates using Born, eikonal and DW Born approximation
- c) Semi-classical approximations for point-particle potential scattering. Their range of validity. Comparisons with exact.

Monday 16th April 2007:

- d) Fusion reactions, barrier penetration concepts, transmission coefficients, *Bohr-Wheeler* equation.
- e) Capture reactions: direct and resonant, S-factors, relation to $B(E1)$ and $B(E2)$, Behaviour at zero energy: poles, Coulomb and ang. Momentum barriers. ANC and $S(0)$.

C. Reactions – “more than two bodies”

Tuesday 17th April 2007:

- a) Interactions of composite systems. Optical potentials and folding models. Channel coupling interactions in non-diagonal case.
- b) Inelastic scattering using perturbation theory (DWBA) to connect with 1(c). Simple (2 channels) bound states coupled channels system.

Wednesday 18th April 2007:

- c) Adiabatic methods. Johnson and Soper. The special model for neutrons halos.
- d) Eikonal methods. Elastic scattering of composite systems. Inclusive reactions, unobserved channels. Eikonal methods for the *stripping* and *diffractive* breakup mechanisms, momentum distributions.

Thursday 19th April 2007:

- e) Transfer reactions (in zero-range approximation) and direct capture reactions. S-factors. Relationship of the latter to 1(c). DWBA and full three-body transition amplitudes. Adiabatic approximations as they apply to transfer reactions. Angular momentum matching. Extensions to finite range. Sensitivities: the ANC and rms radii.

Friday 20th April 2007:

- f) Breakup reactions. Alder and Winther; time dependent approaches; CDCC. Connection with astrophysical S-factors. Model spaces and sensible truncations. Nuclear and Coulomb considerations.
- g) Charge exchange reactions

JINA Special School on “Methods of Direct Nuclear Reactions”

General information

Schedule:

Lectures will be held daily, from 9:30am to 12:00pm with a coffee break around 10:30. Tutorials for the homework will be in the afternoon from 2pm to 4pm. Both morning and afternoon session will take place in the Michigami room at the Kellogg Center.

Social events:

A welcome reception, with finger food, will be held at the Kellogg Center on the 9th April, at 7pm. A registration desk will be open during the reception. The buffet school dinner will take place on Friday, the 13th of April.

Computer requirements

The school is based on hands-on experience. Those that have access to a laptop computer should bring one (there will be a few laptops available for those participants that do not have a laptop). A wireless connection will be available on site, and every participant will have an account at the NSCL and a shared directory to run the programs. If possible you should have **ssh** and **xwin** (or other similar free versions) installed.

Local support

JINA provides local support for all participants, including a shared room at the Kellogg Hotel (you should have an email with your reservation details) and a per diem flat rate which will be given at registration.

Transportation to the Kellogg Center

The Kellogg Center offers a courtesy shuttle that will pick you up at the Lansing airport if you arrive before 10:15 PM EDT. Please call the toll free Reservation Line at 1-800-875-5090 to give them the airline that you will be arriving on, your flight number, and time of arrival. The Kellogg Center requires 24 hour advance reservations for the shuttle.

If you will not be able to take advantage of the Kellogg Center shuttle, there is a courtesy phone located near the baggage claim at the Lansing airport that you can use to call a taxi.

If you have any questions, regarding transportation from the airport to the hotel contact Chasity Fudella at fudella@nscl.msu.edu.

Restaurants in downtown East Lansing

Please see the attached list.