Reaction tools for the study of exotic nuclei: theory and applications

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Atomic nuclei are complex many-body quantum systems composed, uniquely, of two Fermi fluids. Exotic nuclei, with very different neutron (N) to proton (Z) number ratios from the stable nuclei, provide an opportunity to study this strongly-interacting quantum behaviour in systems with large Fermi-surface asymmetries. These two lectures will discuss specific aspects of this highly international activity. Since the exotic nuclei are short-lived and produced most efficiently as fast secondary particle beams, this involves the interface between experiment and theoretical nuclear structure and reactions models. The first lecture will review essential features of nuclear shell structure and introduce why evolution from normal neutron to proton number ratios leads to changes to (i) our (textbook) understanding of nuclear stability and structures, (ii) to novel features such as the nuclear halo and (iii) that these changes are of importance astrophysically. The lecture will then concentrate on the simplifications to the description of nuclear collisions that arise at intermediate energies (100 MeV per nucleon, or more) and how these can be exploited to deduce structure information on short-lived nuclei; e.g. the occupation of quantum orbitals by nucleons or pairs of nucleons near the two (displaced) Fermi surfaces. The second lecture will then show how these ideas are being used. It will discuss a number of specific recent reaction studies, including one- and two-nucleon removal from and nucleon pickup by exotic nuclei. These are chosen to illustrative the capability of the techniques to (a) determine structure information, e.g. the reduction of shell gaps, the ordering of the nucleonic quantum levels and (b) to also assess nuclear structure models, such as the shell model and its effective interactions.
An introduction can be found at: http://www.nucleartheory.net/NPG/papers/NPN.pdf