Coulomb excitation and transfer reactions with radioactive ion beams

A. Galindo-Uribarri[1,2,3]

[1]*Physics Division, Oak Ridge National Laboratory,*
Bethel Valley Rd, Oak Ridge TN 37831, U.S.A.
[2]*Department of Physics and Astronomy, Univ. of Tennessee,*
401 Nielsen Physics Bldg., Knoxville TN 37996, U.S.A.
[3]*Department of Earth and Planetary Sciences,*
University of Tennessee, 1412 Circle Dr, Knoxville TN 37996, U.S.A.

At HRIBF, we have made pioneer measurements of B(E2) values for several neutron-rich radioactive nuclei in the mass A = 80 and A =130 regions. We have repeated some of these measurements with increased statistics. Also we are revisiting some of the reported measurements of B(E2) and quadrupole moments using stable beams along chains of isotopes such as Ni, Ge, Se, Zr, Sn, and Te to resolve some existing discrepancies. The approach has been to do safe Coulomb excitation reactions between various projectile-target combinations that allow for consistency crosschecks, to keep the corrections to the data to a minimum (e.g. electronics deadtime), and to extract and compare the results obtained using various independent techniques (e.g. normalization to Rutherford vs. normalization relative to the target well known B(E2) values). Together with the results obtained with RIBs (and using the same techniques) these revisited data will allow and more meaningful comparison and a stringent test to theoretical predictions.

Another very successful program at HRIBF has been the study of transfer reactions using particle-gamma techniques. Transfer reactions give direct access to the microscopic shell structure of nuclei. One-nucleon pickup (p, d) and one-nucleon stripping (d, p) reactions are useful spectroscopic tools in inverse kinematics with RIBs. Their advantages include simplicity on the interpretation and large transfer cross–sections for single particle (or hole) states. Techniques for performing the above reactions in inverse kinematics with unstable beams are been developed however, substantial development is still required in both targets and detection systems to fully exploit the potential of transfer reactions in hydrogen isotopes. Alternative approaches include the use of heavy ion transfer reactions with RIBs which we are exploring at HRIBF as a technique to study the structure of nuclear states inaccessible or difficult to populate in light ion reactions. It is possible to reach the same final nucleus by using a wide variety of different projectiles and by transferring different number of nucleons. Much may then be deduced concerning the structure of a state simply from its population or non-population in a series of different reactions. An attractive feature of heavy ion reactions below the Coulomb barrier is their insensitivity to the nuclear interaction between the cores simplifying the analysis.

Another approach we are also pursuing is to develop techniques that allow us to measure more sensitive observables. The use of a polarized target in transfer reactions for example would allow the measurement of observables such as the analyzing power which gives an unambiguous determination of the total spin J.

The use of RIBs to do both Coulomb excitation reactions and transfer reactions presents serious challenges associated to their low intensities, potentially high backgrounds in the gamma-ray and charged particle detectors caused by the radioactivity of the beam, and isobaric contamination. Some of these problems can be solved with specially designed detection systems and with good quality beams.

Research sponsored by the Office of Nuclear Physics, U.S. Department of Energy.