PHYSICS DIVISION
ARGONNE NATIONAL LABORATORY
Physics Division Seminar

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Direct Evidence of Melting Shell-Gaps in the Neutron-Rich Nuclei via Coulomb Breakup

The magic numbers of atomic nuclei, proposed by Nobel laureates, Mayer, Jensen and Haxel are no more basic building blocks of the nuclear structure physics. Melting of the shell gaps at magic numbers of the nuclei with unusual neutron to proton ratio is one of the important observations in this century. This has been observed first in "island of inversion" nuclei through mass measurements. Later, it has been reported in many exotic nuclei via different experimental techniques using advanced detector systems and radioactive ion beam facilities. These observations clearly demonstrate a lack of understanding the fundamental property of the nuclei i.e., nucleon-nucleon interactions in the nuclei with unusual neutron to proton ratio. In this presentation, I would like to present new exciting experimental results on direct evidences of melting shell-gaps around N=20 and 28, via measurements of Coulomb breakup of the neutron-rich nuclei.

Coulomb breakup is a sensitive spectroscopic tool to probe the ground state properties, particularly the configuration with the quantum numbers of loosely bound exotic nuclei. Due to the large spatial extension of the loosely bound valence nucleon(s), enhanced electric dipole threshold strength of the nuclei can be observed through electromagnetic excitation. The observed threshold strength can be explained by a direct breakup mechanism. The shape and magnitude of this threshold strength is a direct finger-print of the quantum numbers of valence nucleon and its occupation probability for that particular quantum state in the ground state of the nucleus. Recently, using this method, an experiment (GSI-S306) has been performed to explore the ground state properties of a number of exotic neutron-rich nuclei around (N~20) where failure of the magic number was reported. The experiment has been performed using radioactive nuclei at energy 390-430 *MeV*/*u*. Invariant mass spectra of these nuclei have been obtained by measuring the four-momentum of all the decay products after one neutron removal of the exotic nuclei using a ^{208}Pb target. The shape of the differential Coulomb dissociation (CD) cross sections suggest that the predominant ground-state configurations for ^{29}Na ($3/2^+$) and ^{30}Na (2^+) are ^{28}Na $(1^+)\otimes\nu s,d$ and, ^{29}Na $(3/2^+)\otimes\nu s,d$, respectively. On the other hand, evidence for occupation of the valence neutron of ^{35}Al(N=22) in the $p_{3/2}$ orbital instead of only $f_{7/2}$ shell has been observed. This indicates the breakdown of magic number N=28 in this exotic nucleus. It is evident from present experimental data of CD of ^{31}Na(N=20), ^{33}Mg (N=21) that the ground state configurations are dominated by (~ 80%) core excited states of those isotopes. One may conclude that the *sd*-*pf* shell gap around N ~20 is reduced and around 80% of the ground state configurations of these isotopes are multi particle-multi hole configurations across the shell gap. This is direct evidence of substantially reduced shell gap at N=20 for ^{31}Na and ^{33}Mg.

I would like to discuss the limitation of present generation measurements and how one may overcome these limitations using future advanced instrumentation together with advanced RIB facilities.

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3:30 p.m.
Building 203 - Conference Room R-150