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Radii measurements of exotic nuclei

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With large neutron-to-proton ratios far from the line of stability, nuclei develop exotic structures. Systematic studies of nuclear radii closer to the drip line have demonstrated the change of nuclear properties, such as the emergence of nuclear halo, development of neutron skin and the nuclear deformation. Halo nuclei show unexpected behavior, such as, large interaction cross section which in turn, points to large matter radius [1] and narrow momentum distribution of the valence neutrons. In this context, nuclei with two neutron halo are intriguing systems to understand the correlation between the two halo neutrons and the core. Borromean nuclei are such systems where the nucleus is bound with two halo nucleons but the combination of core and one halo nucleon is unbound. Two-neutron halos in Borromean nuclei have been identified along the dripline in the p-sd shell in 6He, 11Li, 14Be, 17,19B and 22C but its occurrence beyond the sd-shell, has not been fully investigated. Beyond sd-shell, in the $N = 20$ island of inversion region, one neutron halo configuration was found in 31Ne [2, 3] and 37Mg [4, 5].

An important question is how unusually the large extension of the neutron wave function influences the protons. This can be investigated by measuring the root mean square (rms) radii of the proton distribution. Charge radius which is a fundamental nuclear ground-state property, seems to be changing with the increase of valence neutrons. The proton radius is also necessary to understand the spatial correlation between the halo and the core. Furthermore, it is also crucial to determine the neutron-skin thickness if the matter radius is known. Complimentary to the traditional methods for determining the charge radius (or proton radius) which are isotope shift measurements and electron scattering measurements, charge-changing cross section measurement is a new tool which can be applied very well for stable nuclei and as well as for exotic nuclei far from the beta-stability line [6-8]. The radii are obtained from the cross sections through finite range Glauber model analysis of the reaction.

The rare isotope facility at GSI is unique in having energies up to 1 A.GeV. Experiments for precise radii measurements are best suitable at this energy as a wide variety of isotopes of interest could be fully ionized. It is also possible to perform such studies for light nuclei at beam energies around 200-300 MeV/u that are available at RIKEN.

In this presentation, I will discuss how the proton and matter distribution radii measurements of nuclei far from the line of stability can unfold the exotic structures.

References:

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