Giant Resonances and the Neutron Skin of Nuclei

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There is a renewed interest of the accurate measurement of the neutron-skin thickness of different nuclei [1–4], because it makes possible to constrain the symmetry-energy term of the nuclear equation of state. The precise knowledge of the symmetry energy is essential not only for describing the structure of neutron-rich nuclei, but also for describing of the properties of the neutron-rich matter in nuclear astrophysics, so measuring the neutron-skin thickness of extremely neutron-rich nuclei nowadays has a special actuality.

The highly collective nuclear giant resonances are turned out to be good tools for studying the neutron-skin thickness. In one of our previous works on inelastic alpha scattering, excitation of the isovector giant dipole resonance was used to extract this quantity of nuclei [5]. The cross section of $(\alpha, \alpha$') process depends strongly on ΔR_{pn}. Another tool, we used earlier, for studying the neutron-skin thickness is the excitation of the isovector spin giant dipole resonance (IVSGDR). The L=1 strength of the IVSGDR is sensitive to the neutron-skin thickness [6]. In my talk I am planning to review a few different experimental methods, which could be used also in radioactive beams.

In our recent experiment the anti-analog of the giant dipole resonance (AGDR) [8] has been excited in the ^{124}Sn(p,n) reaction performed in inverse kinematics using ^{124}Sn beam with an energy of 600 MeV/A. The energy and angle of the neutrons were measured with a novel low-energy neutron time-of flight array (LENA). The energy difference of the AGDR and the isobaric analog state (IAS) turned out to be very sensitive to the neutron-skin thickness (ΔR_{pn}). Our calculations performed with state of the art self-consistent random phase approximation (RPA), based on the framework of relativistic energy density functionals supports also such strong ΔR_{pn} sensitivity of the energy of the AGDR [9]. By comparing the theoretical results calculated as a function of ΔR_{pn} and the measured energy of the AGDR, the ΔR_{pn} value was deduced to be 0.21 $\pm$ 0.07 fm, which agrees nicely with the previous results. The energy of the AGDR measured previously for ^{208}Pb [7] was also used to determine the ΔR_{pn} for ^{208}Pb. In this way a very precise ΔR_{pn} = 0.161 $\pm$ 0.042 fm neutron skin thickness has been obtained for ^{208}Pb. The present method offers new possibilities for measuring the neutron-skin thicknesses also in rare isotope beams.

References

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