A New Method for Measuring Neutron-skin Thickness by Exciting the Anti-analog Giant Dipole Resonance *

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A new method, based on the excitation of the anti-analog giant dipole resonance (AGDR) in (p,n) reaction, for measuring the neutron skin thickness has been tested. The γ-decay of the AGDR to the isobaric analog state (IAS) has been measured. The difference in excitation energy of the AGDR and IAS was calculated. By comparing the theoretical results with the measured one, the ΔR_{pn} value for ^{124}Sn was deduced to be 0.21±0.07 fm. The present method provides a new possibility for measuring neutron skin thickness of very exotic nuclei.

The experiments, aiming at studying the neutron-skin thickness of ^{124}Sn, were performed at GSI using 600 MeV/nucleon ^{124}Sn relativistic heavy-ion beams on CH_2 and C targets. This allowed us to subtract the contribution of the C to the yield measured from the CH_2 target during the analysis. The ejected neutrons were detected by a low-energy neutron-array (LENA) ToF spectrometer, which was developed in Debrecen [1].

The energy of de-exciting γ-transitions was measured in coincidence with slow neutrons by six large cylindrical ($\Phi = 3.5''$, $L = 8''$) state-of-the-art $LaBr_3$ γ-detectors. The Doppler shift was taken into account in the analysis. The precise energy and efficiency calibrations of the detectors were performed after the experiments by using different radioactive sources and (p,γ) reactions on different targets. The γ-ray energy spectrum measured in coincidence with the low-energy neutrons is shown in Fig. 1.

The direct γ-branching ratio of the AGDR to the IAS is expected to be similar to that of the GDR to the g.s. in the parent nucleus, which can be calculated from the parameters of the GDR [2]. In contrast, in the investigation of the electromagnetic decay properties of the spin dipole resonance (SDR) by Rodin and Dieperink [3] the γ-decay branching ratio was in the range of 10^{-4}. Therefore, the coincidence measurements deliver a precise energy for the AGDR.

The theoretical analysis is performed using the fully self-consistent relativistic proton-neutron quasiparticle random-phase approximation based on the relativistic Hartree-Bogoliubov model (RHB) [4] as described previously in Ref. [5].

By comparing the experimental result for E(AGDR) - E(IAS) to the theoretical energy differences, we deduce the value of the neutron-skin thickness in ^{124}Sn: $\Delta R_{np} =$ 0.21 ± 0.07 fm (including theoretical uncertainties). The very good agreement with previously determined values [5] reinforces the expected reliability of the proposed method.

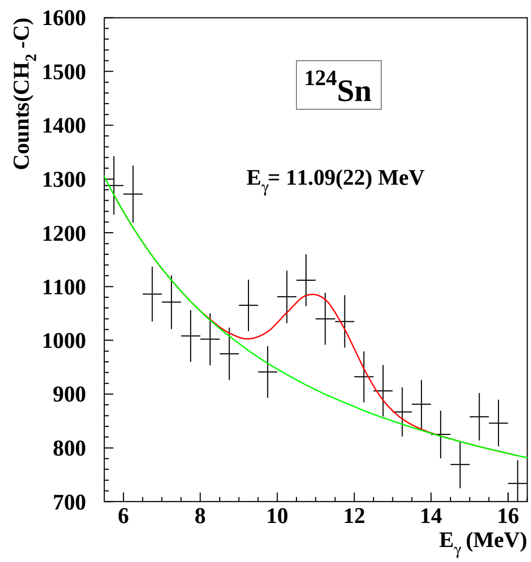

Figure 1: The γ-ray energy spectrum measured in coincidence with the low-energy neutrons that fulfill the conditions of $1.0 \leq E_n \leq 3.5$ MeV and $67^\circ \leq \Theta^n_{LAB} \leq 70^\circ$, which corresponds to the exciation of the AGDR in inverse kinematics. The calibrated energy scale was corrected already for the Doppler effect. The solid line shows the result of the fit using Gaussian line shape and a third order polinomial background.

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