Study of the pygmy dipole resonance of ^{132}Sn and ^{128}Sn in inelastic α-scattering

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The pygmy dipole resonance in neutron-rich isotopes can be pictured as a vibration of the excess neutrons against an isospin symmetric core in the nucleus. This vibration corresponds to a dipole mode. Due to the nature of the resonance, the phenomenon should be a function of the neutron-skin thickness and also of the neutron excess. The resonance has an isoscalar and an isovector part. To distinguish between both of them experimentally one can use two different probes. The α-particle is isoscalar and will excite exclusively the isoscalar part in contrast to photon-excitation, which excites mainly the isovector part of the resonance. As the experimental data for this dipole mode is rare, even for stable nuclei[1)], interesting open questions remain. One of them is the isospin character and strength of the low-lying dipole mode. In an experiment with the stable ^{124}Sn[2)], it has been observed that a large fraction of the pygmy strength is of isoscalar character, however significant differences in the strength distribution with photo-excitation have been observed.

In October 2014, an experiment to investigate further the isoscalar character of the pygmy dipole resonance in ^{128}Sn, and ^{132}Sn was performed with inelastic α-scattering in inverse kinematics at RIKEN. The isotopes were produced with a high-intensity primary ^{238}U beam impinging with 345 MeV/u on a beryllium target. The secondary beam with approximately 220 MeV/u was transported towards the liquid-helium target, with a thickness of approximately 320 mg/cm^2. At the target position, emitted γ-rays were measured by 8 large-volume 3.5" $\times$ 8"$LaBr_3$:Ce crystals from Hector-array at INFN Milano[3)] and 95 large-volume NaI DALI2[4)] crystals. The 8 $LaBr_3$:Ce crystals were placed at an angle θ of 30° and the DALI2 crystals covered a range in θ from about 45° to about 150°. Both detector types are distributed over 360° in ϕ. The registered hits in the γ-array are selected within a coincidence time-window with the beam to suppress background stemming from the intrinsic radiation of the 8 $LaBr_3$:Ce crystals, and other random background.

The particle identification and separation was done using BigRIPS and the ZeroDegree spectrometer. Those devices are using a combination of energy loss, magnetic rigidity, and time-of-flight measurements[5)]. The purity of the secondary ^{132}Sn-beam was about 28% with about 41 million registered events.

With further investigation of the γ-spectra, the strength of the (isoscalar) pygmy dipole resonances can be determined. In addition, the obtained information will allow the isovector and isoscalar parts of the pygmy dipole resonance to be separated in comparison with data of experiments already performed at GSI Darmstadt with the R^{3}B setup, as in those experiments the isovector part is predominantly excited by relativistic coulomb excitation.

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References

1) D. Savran et al.: Prog. Part. Nucl. Phys. **70**, p.210 (2013).
2) J. Endres et al.: Phys. Rev. Lett. **105**, 212503 (2010).
3) A. Giaz et al.: NIM A**729**, 910 (2013).
4) S. Takeuchi et al.: NIM A **763**, 596 (2014).
5) T. Kubo et al.: Prog. Theor. Exp. Phys. 03C003 (2012).