INVESTIGATION OF THE ISOVECTOR GIANT QUADRUPOLE RESONANCE IN ^{208}Pb AND ^{90}Zr

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Reliable, systematic data on the strength distribution for the isovector giant quadrupole resonance (IVGQR) are notably missing from the existing information on electric giant resonances.[1] Evidence for an IVGQR has been reported from (e,e') experiments on medium-mass and heavy nuclei. These data are subject to substantial systematic uncertainty because of very large backgrounds and possible contributions from a variety of other modes not differentiated by the experiments. A few more specific and sensitive experiments involving (n,γ) and (γ,n) reactions are available, along with one example of (HI, HI'). These latter experiments seem to confirm the basic results of the (e,e') analyses, but carry little detailed information about the distribution of ΔT=1 E2 strength.[1] On the other hand, studies employing the $(\pi^{\pm}, \pi^0)$ reaction, which should excite isovector states strongly, show no evidence of IVGQR strength at all.

Systematic analysis of resonance and continuum excitation by intermediate-energy heavy ions indicates that heavy-ion scattering in the bombarding energy range from 100 to 200 MeV/nucleon should be an excellent tool for studying the IVGQR. The systematics predict that (^{36}Ar,^{36}Ar') at 150 MeV/nucleon will excite the IVGQR in ^{208}Pb with a peak to continuum ratio of better than 1:1, which is substantially better than that of most of the data on which the systematics for the isoscalar GQR are based. The IVGQR cross-sections are large, so that experiments can be done in reasonable times, even for low beam intensities. Heavy-ion scattering excites the IVGQR almost exclusively by Coulomb excitation. Coulomb excitation cross sections for high-lying strength decrease rapidly with increasing multipolarity, providing a powerful filter against the broad structures with L>2 which probably occupy the same energy region as the IVGQR. Since the cross-section for target Coulomb excitation scales as Z^2 of the projectile, comparison of spectra obtained with two probes of significantly different Z can be used to isolate Coulomb-excited strength. These considerations imply that data acquired with two probes of different Z should provide enough information to unequivocally identify the IVGQR, and to reveal details of the strength distribution. The only ambiguity in this data will be between IVGQR and IVGDR strength. This ambiguity could be resolved by ground-state γ-decay branching measurements, but this is unnecessary if the photonuclear strength function (GDR strength) is available. An additional signature of the IVGQR strength would be the measurement of the γ-decay branching to the low-lying 3^- state in ^{208}Pb[2,3] expected to dominate the γ-decay of this state. Unfortunately, the small $\Gamma_{\gamma,3^-}/\Gamma_{total} = 7.5 \times 10^{-4}$ makes the signal quite small.

We have measured the excitation of the IVGQR in ^{208}Pb and ^{90}Zr, using the inelastic scattering of 150 MeV/nucleon ^{36}Ar with the S800. Our estimates of the cross-section for exciting the IVGQR in ^{208}Pb assumed a resonance energy of 22 MeV and a width of 5 MeV; in ^{90}Zr we assumed a resonance energy of 29 MeV and a width of 5 MeV.

We measured the angular distribution of the scattered ions from less than 1° to 2.5° in 0.1° bins, for excitations ranging from 4 MeV to 50 MeV in order to properly identify the background under the IVGQR strength. To identify the Coulomb excitation of the IVGQR, we made the same measurement using a beam of 150 MeV/nucleon ^{17}O for which we expect the Coulomb cross-section to be reduced by a factor of 5.

To normalize the data, calibrate the spectrometer and provide an optical potential, we also measured elastic scattering for each projectile, in the angular range from 1° to 2.5°.

All these measurements used the S800 spectrometer in dispersion matched mode, set at a central angle of 5°, with the standard chamber and the standard detection system. An elastic scattering block was mounted in the detector box, to reduce the elastic scattering count rate in the detectors for the inelastic scattering measurement. Our targets were 2 mg/cm^2 thick, self-supporting, isotopically enriched ^{208}Pb and ^{90}Zr, mounted on frames suitable for the S800. Preliminary spectra from our measurement indicate that the peak-to-background ratio in the ^{208}Pb is about unity for the excitation region near the IVGQR. These data are presently being analyzed.

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