A New Proposal to the High Intensity Gamma-Ray Source (HIγS) PAC-11

A Systematic Study of the Isovector Giant Quadrupole Resonance

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1. Experiment Summary

We propose to investigate the isovector giant quadrupole resonance (IVGQR) over a wide mass range across the periodic table. Earlier giant resonance studies in the 1970’s and 1980’s focused primarily on the giant dipole resonance (GDR), with E2 resonances garnering less attention. However, while the isoscalar GQR was studied in some detail via the ($\alpha,\alpha'$) reaction, the isovector GQR was much harder to study. Pithan [Pit80] did conduct a number of experiments using the ($e,e'$) reaction, but the extracted resonance parameters were quite uncertain due to the lack of selectivity of the particular reaction channel. Other groups have performed measurements using photoneutron or neutron capture reactions [Dra81, Mur87, Hak90], but there was not an extensive set of measurements based on this technique. There have also been a few attempts using proton capture reactions with unpolarized [Sno74] and polarized [Fel91, God94] proton beams.

While Compton scattering has been used in the past to study the GDR, polarized Compton scattering was attempted for the first time in 1992 by Dale et al. at Illinois [Dal92] to look for evidence of the IVGQR. In this case, the asymmetry of photons scattered parallel and perpendicular to the polarization plane of the incident photon is sensitive to the details of the IVGQR through its interference with the tail of the nearby GDR. Quite recently at HIGS, a new experiment based on the same technique was conducted to examine the IVGQR in $^{209}$Bi using the photon beam asymmetry obtained in Compton scattering with a linearly polarized photon beam [Hen10]. By obtaining data at both forward (55°) and backward (125°) angles, it was possible to unambiguously pin down the resonance position of the rather broad isovector GQR strength distribution. With excellent statistics provided by the high intensities of polarized photons available at HIGS, all three resonance parameters (energy $E_0$, width $\Gamma$, strength $S$) were able to be determined with far better precision than any previous experiment to date.

We propose to extend this polarized photon technique using the Compton scattering reaction to a broader range of targets, in order to perform a systematic study of the behavior of the IVGQR. We intend to investigate 5 targets in the mass range A = 60-240. For each target, we will obtain an excitation function covering the energy range $E_\gamma = 15-35$ MeV in energy steps appropriate for that particular target. According to the approximation for the resonance energy $E_0 = 135/A^{1/3}$, we would expect the resonance energy to vary from as high as 34 MeV for $A = 60$ down to as low as 22 MeV for $A = 240$. Most of the targets are easily obtainable solid metallic targets. We estimate that one week of running per target (~90 hours) would be sufficient to obtain good statistics for each target.