THE GIANT DIPOLE RESONANCE IN ^{20}O

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The detailed exploration of the structure of unstable nuclei is a new theme of nuclear physics research. An important part of this program is the systematic investigation of strong collective modes. One of the most important collective modes is the isovector giant dipole resonance (GDR). There has recently been a great deal of speculation concerning how the strength might evolve as one moves toward more neutron-rich systems. Theoretical studies are beginning to appear,[1–3] but there is as yet very little experimental data. The GDR in the stable oxygen isotopes show a very interesting evolution as one moves from ^{16}O to ^{17}O and ^{18}O.

We propose to extend these studies to ^{20}O. Our goal in this and other studies of GDR strength in unstable systems is to characterize the strength distribution as completely as possible, up to an excitation energy of about twice the peak of the strength. Details of the strength function can be compared with theoretical studies in an effort to understand, for example, explicit effects of valence nucleons. We also want to be able to construct moments of the strength distribution

$$m_k = \int_0^\infty \sigma(E) E^k \, dE$$

where $\sigma(E)$ is the photoabsorption cross section (strength distribution) as a function of excitation energy. The k = 0,-1 and -2 moments and ratios between them are of particular significance for the GDR.[4] The main point is that these moments contain physically significant information which can be interpreted in terms of macroscopic models, or provide important constraints on microscopic theories.

We have performed an experiment to determine the photoabsorption cross section as a function of excitation energy (GDR strength function) in the unstable nucleus ^{20}O. The experimental method can be thought of as a measurement of projectile Coulomb excitation and coincident, ground-state photon decay, or more properly, as the elastic scattering by the projectile, of photons from the virtual photon field of the target.[5]

Our experiment required the detection and identification in Z and A of the scattered projectile, determination of its energy, with a resolution of about 1 MeV FWHM, and its scattering angle with a resolution of about 0.1°, and the coincident detection of 1 to 40 MeV γ-rays. The scattered ^{20}O projectiles were detected in the S800 spectrometer operated in dispersion matched mode. The γ-rays were detected in the 152 element, ORNL-MSU-TAMU BaF_2 array. The γ-ray detector array was assembled as a wall in the forward scattering direction with the front face of the crystals 50 cm from the target (θ_γ = 13° to 44°) to optimize our efficiency for γ-rays emitted in the projectile rest frame. The efficiency was estimated to be about 25%.

The experimental yield for our technique is strongly dependent upon the bombarding energy. We ran at the highest energy practical, with an ^{20}O yield at 100 MeV/nucleon of 10^6 particles per second. We used a ^{208}Pb target thickness of 30 mg/cm^2, the thickness having been chosen based on simulations of energy-loss straggling which indicated an energy FWHM of about 1 MeV for this target.

In addition, we are in the process of developing high-efficiency, high-rate beam timing devices which are important for future radioactive beam experiments. We installed and tested two of these detectors during our experiment. Because of their relatively low efficiency of about 20%, we could not characterize each event, but the detectors provided excellent timing for the sampled events and a high-quality calibration for the cyclotron RF-based time monitor we used. These data are presently being analyzed.

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