QUADRUPOLE AND OCTUPOLE RADIATION FROM ^{16}O NEAR 39-MeV EXCITATION

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A determination of the distribution of high multipolarity strength in light nuclei requires that experimental measurements of separated multipoles be made over a range of energies extending to beyond 50 MeV in excitation.[1] The present investigation is intended to demonstrate that radiative capture of polarized protons can be used to accurately determine the distribution of dipole and quadrupole strength in this energy region, and can be used in addition to determine the much weaker octupole contribution through the measurement of analyzing powers at reaction angles near to 0° to 180°.

Measurements of the cross section and analyzing power for the reaction $^{15}N(\vec{p}, \gamma)^{16}O$ were made at IUCF using extracted proton beams at 20.0, 24.4 and 28.8 MeV, corresponding to excitation energies of 27.0, 31.0, and 39.0 MeV in ^{16}O. The magnitude of the beam polarization was typically 0.70, and was measured using elastic proton scattering from ^{4}He in a gas target. Gamma rays were detected in a NaI spectrometer designed and built at the University of Kentucky[2]. For the present experiment the detector included a core NaI element of diameter 20 cm and 25 cm length, surrounded on the front and sides by a 7-segment NaI annulus of 4 cm thickness. Both the core and the individual optically-isolated annulus segments were instrumented with individual ADC and TDC analyzers in a CAMAC system.

Data were collected from a forward angle of 23° to 155° in eight angular steps at target-to-detector spacing of about 91 cm. Differences in the time-of-flight were used to distinguish the gamma-rays from the background of direct neutron groups produced in the target. The TOF resolution of the core NaI detector was 800 psec. Further attenuation of slow neutrons was accomplished by placing boron around the lead shield of the detector.

The target consisted of a gas cell of 2.7 cm length pressurized to approximately 3 atm. with ^{15}N gas enriched to 99%, and operated at room temperature.

The angular distribution of cross section at $E_x = 39$ MeV for the ground state gamma-ray transition is shown in Fig. 1a. The data display the dominant dipole angular distribution, but the clear asymmetry about 90° is due to the interference between dipole and quadrupole components. In Fig. 1b the measured product of cross section and analyzing power at the same excitation energy is displayed. The departure from the $\sin(2\theta)$ distribution indicative of pure dipole radiation is again indicative of an interference between multipoles.

The curves in Figs. 1a and 1b show the results of fits to these data when the complex amplitudes associated with E1 and E2 radiation (dash-dot curve), and E1, E2, and E3

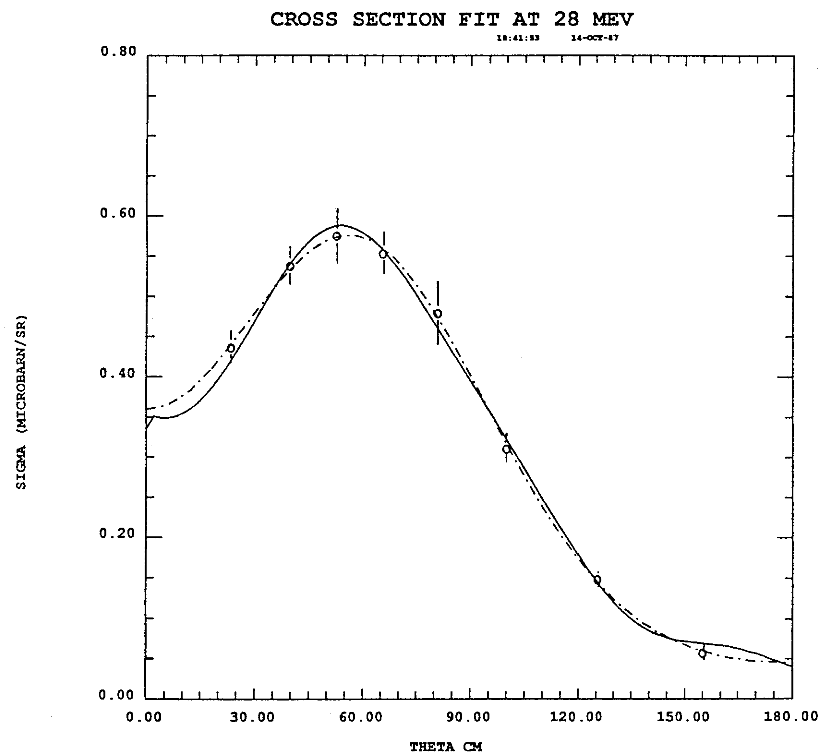

Figure 1a. Angular distribution of cross section at 39 MeV excitation. The curves show the best χ^2 fits obtained when E1 and E2 multipoles are included (dash-dot), and when E1, E2, and E3 radiations are included (solid curve).

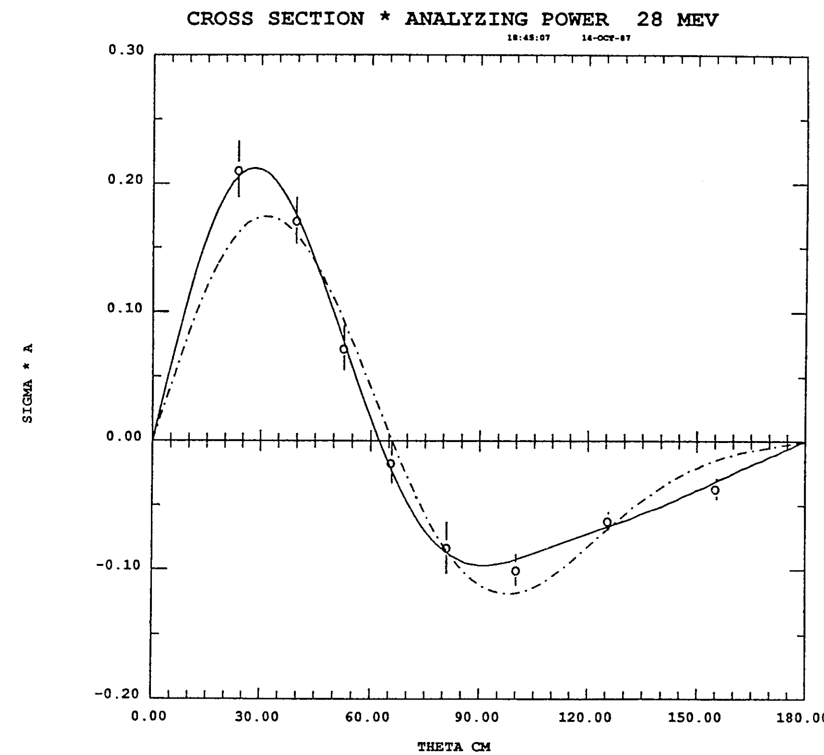

Figure 1b. Measured angular distribution of cross section times analyzing power at 39 MeV excitation. The calculated distributions corresponding to the χ^2 fits to the complex amplitudes are shown.

(solid curve) radiations are searched to minimize χ^2. The inclusion of one E3 partial wave lowers χ^2 from 19.8 to 1.6 and is strongly influenced by the data near to 0° and 180°. At 39 MeV excitation the E3 multipole contributes only about 0.5% of the total cross section.

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NEW EFFECTS IN ^{3}He-CAPTURE REACTIONS AT IUCF ENERGIES

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Although they have been somewhat neglected in recent years, studies of radiative capture reactions utilizing light composite projectiles such as deuterons and ^{3}He-particles have yielded valuable nuclear structure information in the low-energy domain.[1] States excited as resonances in these reactions,[2] as well as those strongly populated as final states, are presumably ones with sizable cluster configuration amplitudes. As we have shown in our earlier work, especially on the cluster capture reaction ^{3}H(^{3}He,γ)^{6}Li,[3] the direct capture mechanism is at least as important in cluster captures as it is in proton capture, at high enough γ-ray energies. Since this process, as well as initial-state semi-direct capture,[4] populates preferentially those final states with wave functions having a large overlap with bound states of target plus projectile, we expect deuteron capture to select states with strong 2-particle configurations, ^{3}He (or ^{3}H) capture to select 3-particle states, etc. We have therefore initiated a series of experiments aimed at exploring the same sorts of phenomena we have observed in (p,γ) capture,[5] but this time employing a ^{3}He projectile.