SEARCH FOR FRAGMENTED M1 STRENGTH IN ^{48}Ca

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The quenching of M1 (ΔL=0, ΔJ^{π}=1^{+}) strength remains one of the outstanding problems of nuclear physics. If configuration mixing within and across major shells is a dominant mechanism for the quenching, then one should in principle be able to locate fragmented M1 strength in states close to where the main strength occurs. In the case of ^{48}Ca(p,p′), 30% of the predicted total strength has been found concentrated in a single 1^{+} state with excitation energy 10.21 MeV.[1,2] No other 1^{+} states in ^{48}Ca have yet been positively identified using the (p,p′) probe, but a ^{48}Ca(e,e′) experiment suggests that eighteen small J^{π} = 1^{+} states exist with $E_{\rm ex}$=7–13 MeV, each having strength about 1–3% as large as that seen in the 10.21-MeV state.[3] IUCF experiment E269 was designed to look for small 1^{+} states such as these, making use of the good energy resolution of the K600 spectrometer.

Data were collected at IUCF during Jan. 22–28, 1993. The beam was 200 MeV unpolarized protons, an energy chosen for its high selectivity for M1 transitions. The primary target was a 4.0-mg/cm^2 self-supporting foil of 97.69 Atom% ^{48}Ca, manufactured at IUCF. The K600 was used in septum mode, with two x-position and two y-position wire-chamber detectors placed near the focal plane. Data from the ^{48}Ca(p,p′) reaction were collected at nominal laboratory angles of 5°, 6°, 8°, and 10°. Angle calibrations were performed by determining the kinematic crossover angle of the ^{1}H(p,p′) and ^{12}C(p,p′) (4.44 MeV) reactions from a CH_2 target, from which it was determined that the true angles were 0.88° smaller than the nominal spectrometer settings as read from the angle encoder. This large deviation from previous calibrations was verified by moving the spectrometer to an angle small enough to stop the beam on the entrance aperture of the septum, which is designed both to stop the beam and read the current. Energy dispersion at the focal plane was found using the positions of the 7.65 and 15.11 MeV ^{12}C peaks from the CH_2 target (yielding 4.68 keV per 0.1-mm channel), and excitation energy was extrapolated from the known value of the strong ^{48}Ca 1^{+} peak at 10.21 MeV. Replayed spectra appear in Fig. 1. The FWHM energy resolution obtained is about 34 keV. No background was subtracted in the spectra. Only standard conditions were set, e.g., particle identification, and acceptance limits in vertical position and scattering angle.

The signature of an M1 transition is a cross section which increases as the scattering angle approaches zero. Other transitions have a cross section predicted to decrease as the angle approaches zero (or at least not to increase as fast as an M1 transition). In the 4.1° spectrum, only the 10.21 MeV J^{π}=1^{+} peak remains strong, and contributions from higher multipoles are greatly diminished.

An expansion of the 4.1° spectrum reveals evidence for a number of small peaks (labelled "a–k", "m–o" in Fig. 2). The majority of these can be eliminated as potential 1^{+}

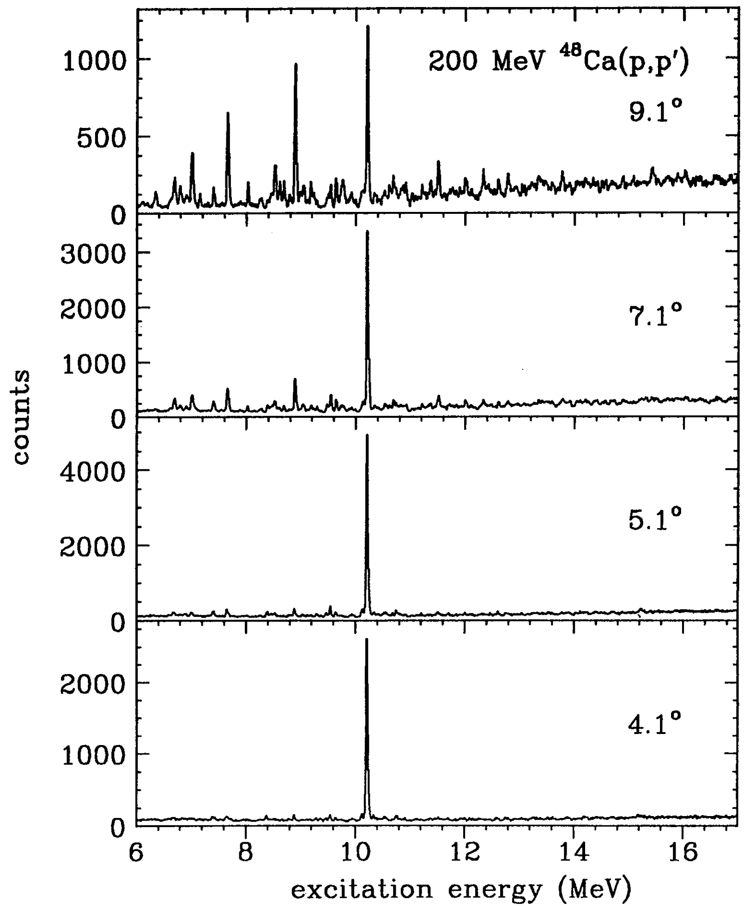

Figure 1. Spectra showing the range of ^{48}Ca(p,p′) data collected in the present experiment. The 10.21-MeV 1^+ state is plainly visible at all angles, while states from higher multipole transitions are diminished at the smaller angles.

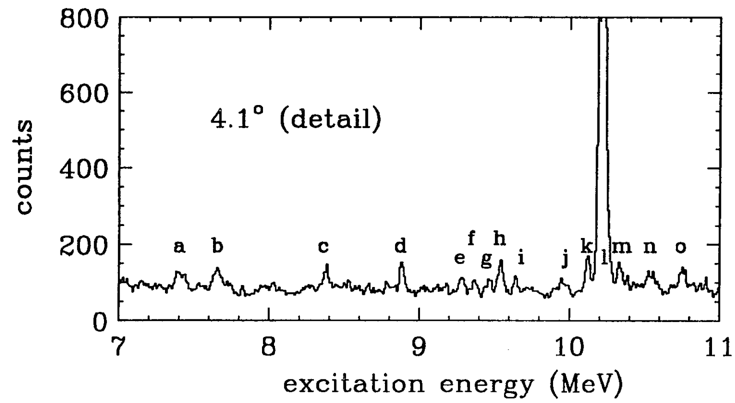

Figure 2. Detail from one of the panels of Fig. 1. Lower case letters serve to indicate visible peaks, a few of which are candidates for fragmented M1 strength.

states on the basis of their angular distribution. For example, "b" and "d" are certainly not 1^+, since they clearly decrease in proportion to the 10.21 MeV state as the angle decreases from 9.1° to 4.1°. The best candidates for 1^+ states seem to be "k" and "m", at 10.12 and 10.33 MeV, which maintain their proportion to the 10.21 MeV state at all angles. If these are indeed 1^+ states, then they have M1 strengths of about 3.5% and 2.5% as large as that found in the 10.21 MeV state. The above mentioned (e,e′) reference reports 1^+ states at 10.14 and 10.33 MeV with similar strength.[3] On the other hand, many of the other states reported in the (e,e′) reference are not evident in Fig. 2.

Data at smaller laboratory angles are needed to complete the investigation. If any of the small peaks persist at zero degrees, then they likely can be identified as fragmented M1 strength. To achieve such small angles, the K600 spectrometer must be operated in transmission mode. A test run of the transmission mode took place Jan. 29–Feb. 1. Although significant progress was made in achieving the necessary angular and energy resolution and background suppression, no ^{48}Ca data were collected during this test.

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