

MULTIPOLE MATRIX ELEMENTS FOR ^{208}Pb

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ABSTRACT

New measurements of inelastic proton scattering to low-lying states of ^{208}Pb at 200 and 400 MeV are reported. Deformation lengths extracted from angular distributions for the 3^- (2.614 MeV), 5_1^- (3.198 MeV), 5_2^- (3.209 MeV), 2^+ (4.086 MeV) and 4^+ (4.324 MeV) states are in good accord with values extracted at other incident proton energies. The fact that the deformation lengths are independent of incident proton energy within experimental uncertainty provides support for the validity of the collective DWBA for medium energy proton scattering to strongly excited states. Advantage is taken of this to extract statistically more precise values of the ratio of neutron to proton multipole matrix elements (M_n/M_p). Different methods of determining the appropriate average value of M_n/M_p are discussed.

RESULTS AND DISCUSSION

New high resolution measurements to several low lying states of ^{208}Pb have been made at 200 and 400 MeV. Angular distributions around the first diffraction peak have been made for the states at 2.614 MeV (3^-), 3.198 MeV (5_1^-), 3.709 MeV (5_2^-), 4.086 MeV (2^+) and 4.324 MeV (4^+). Deformation lengths have been extracted with the collective DWBA code ECIS79 and compared with results from other (p,p') experiments. Within uncertainties the results for these strongly excited states in ^{208}Pb are consistent with the picture of a deformation length that is independent of the energy of the incident proton, in agreement with our earlier work.¹

We now utilize the deformation length data to evaluate M_n/M_p , the ratio of neutron and proton transition multipole moments. These latter are interesting in that they are quite sensitive to details of nuclear structure models. The multipole moment ratio is expressed in terms of the deformation lengths by the relation

$$\frac{M_n}{M_p} = \left[\frac{1}{Z} \right] \left[\frac{\delta_H}{\delta_P} + \frac{Z}{(b_n^P/b_p^P)N} \left\{ \frac{\delta_H}{\delta_P} - 1 \right\} \right]. \quad (1)$$

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In this equation δ_n and δ_p are nuclear structure deformation lengths, δ_H is the value measured in our (p,p') experiment and b^{Pn} and b^{Pp} represent the interaction between the incident proton and the target nucleons. We have evaluated these using the Love-Franey³ representation of the nucleon-nucleon force.

Our values for $\tilde{M}_n/\tilde{M}_p = [M_n/M_p] [N/Z]$ are summarized in the second column of Table 1. This contains the average value of our results calculated using the measured values of δ_H at 200, 334 and 400 MeV. The appropriate force ratio b^{Pn}/b^{Pp} was calculated at each energy. The \tilde{M}_n/\tilde{M}_p values were corrected for different neutron and proton matter densities.³ For comparison, we tabulate in the third column the average value of \tilde{M}_n/\tilde{M}_p calculated from literature values of δ_H at lower energies between 60 and 135 MeV. In the last column the numerical results at 800 MeV³ are listed.

Table 1. Multipole Matrix Elements (\tilde{M}_n/\tilde{M}_p) for ^{208}Pb

STATE	Present (200-400)	Low Energy	800 MeV
3^-	1.04±0.04	1.06±0.04	1.12±0.03
2^+	1.00±0.04	1.01±0.03	1.28±0.05
4^+	0.95±0.07	0.93±0.12	1.10±0.06
5_1^-	0.93±0.11	1.03±0.08	1.18±0.07
5_2^-	0.72±0.10	0.89±0.06	1.10±0.07

Within uncertainties the values obtained by us in the 200- to 400-MeV energy range agree with those calculated using the measured lower energy deformation lengths. However, the values found from the 800-MeV measurements are 20% higher than the other results, on the average. Since \tilde{M}_n/\tilde{M}_p is a property of the target nucleus, it cannot vary with energy. Also, the difference cannot be due to the wrong choice of the force ratio. For the 3^- state for example, even if the force ratio were infinite (rather than 0.82 as used) \tilde{M}_n/\tilde{M}_p would still be 1.09. Thus, we conclude that a small normalization problem exists either for the 800-MeV data, or for the rest of the measurements at other energies.

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