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II–20 Elastic and Inelastic ^{4}He Scattering near the Coulomb Barrier from the Even Cd Isotopes

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Elastic and inelastic scattering of ^{4}He and heavier ions near the Coulomb barrier together with optical model analyses are providing information on the nuclear matter size and on the nuclear surface. These experiments are also very relevant to the extraction of matrix elements from Coulomb excitation measurements, since the interpretation of reorientation effect experiments, the measurement of higher order deformations, and the extraction of precise $B(\mathrm{E2}; 0 \rightarrow 2)$ values all depend critically on the absence of interference from nuclear interactions. The restraint on non-penetration of the nuclear surface by the bombarding projectile is particularly severe for measurements of the reorientation effect. Herein we consider the results of a study of interference between nuclear and Coulomb elastic and inelastic scattering of ^{4}He ions from the even Cd isotopes. There has been a continuing controversy[1,2,3,4] involving these nuclei, regarding the level of nuclear interactions for ^{4}He scattering below 10 MeV, and the effect of such interactions on the deduced $B(\mathrm{E2}; 0 \rightarrow 2)$ values and quadrupole moments for the 2^{+} states. The results presented on ^{4}He scattering from ^{110,112,114,116}Cd are an effort to resolve these controversies. In addition, analyses of the inelastic excitation probabilities have yielded a set of $B(\mathrm{E2}; 0 \rightarrow 2)$ values with assessed errors smaller than 1.5%.

Using the $^{4}\mathrm{He}^{++}$ beam of the Cologne FN-tandem, particle spectra were measured over an energy range of 8 to 17 MeV, at scattering angles of 176°, 120°, 60°, and 30°. Determination of the elastic cross sections was made with a precision of better than 1%. The normalization of the cross section was determined by comparing Cd and Pb elastic peaks from a target consisting of thin layers of isotopically enriched Cd and Pb. At a given angle the inelastic excitation functions were obtained from the ratio (R) of inelastic (first 2^{+} states) to elastically scattered particles.

The elastic excitation functions at 176°, plotted as a ratio of the inelastic plus elastic differential cross sections to Rutherford, are shown in Fig. 1. Deviations from Rutherford, at the 1 percent level, occur at energies greater than 10 MeV for all isotopes studied. The ratio of the inelastic ratio R_{exp} to the Coulomb excitation probability calculated in first order, is exhibited in Fig. 2. The ^{114}Cd and some of the low energy ^{110}Cd data are taken from previous work.[3] Figure 2 demonstrates that all the isotopes have essentially the same energy dependence, and to within the accuracy of the data points ($\approx 2.0\%$) significant deviations from the pure Coulomb interaction occur only at energies greater than 10 MeV. The $B(\mathrm{E2}; 0 \rightarrow 2)$ values have therefore been determined by analyzing the 176° data up to and including 10 MeV. The preliminary results, as obtained from a first order analysis, are 0.486 ± 0.008 $e^{2}\mathrm{b}^{2}$ and

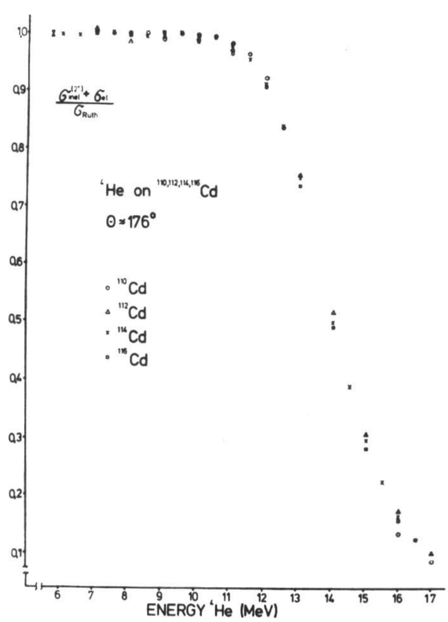

Fig. 1

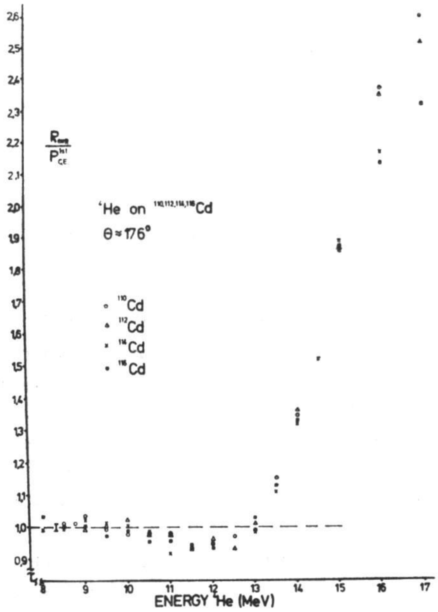

Fig. 2

$0.533 \pm 0.008\ e^2b^2$ for ^{112}Cd and ^{116}Cd respectively. The corresponding results from the work of ref. 3 are $0.432 \pm 0.006\ e^2b^2$ and $0.513 \pm 0.005\ e^2b^2$ for ^{110}Cd and ^{114}Cd respectively.

References

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