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1.31 65 MeV Polarized Proton Inelastic Scattering from ^{178}Hf, ^{180}Hf, ^{182}W, and ^{184}W and a Systematic Relation among Multipole Moments of Each Part of Optical Potential

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Differential cross sections and analyzing powers of polarized proton elastic and inelastic scattering from ^{178}Hf, ^{180}Hf, ^{182}W, and ^{184}W have been measured at 65 MeV using the high resolution spectrograph RAIDEN.[1] Coupled channel analysis has been performed for the $J^{\pi}= 0^{+}$-6^{+} states of ground state rotational band using the automatic search code ECIS79 of Raynal.[2] It was assumed that these states were members of $K^{\pi}=0^{+}$ rotational band of the axially symmetric rigid rotor. In this analysis, the geometry of the optical potential is usual form where the radial parameters $r^{j}(\theta)$ are angle dependent, according to

$$r^{j}(\theta) = r_0^{\,j}(1.0+\sum_{\lambda}\beta_{\lambda}^{\,j}Y_{\lambda 0}(\theta)), \qquad (1)$$

where suffix j represents each part of the deformed optical potential (DOP) ; real, volume imaginary, surface imaginary, and spin-orbit parts. The deformation parameters β_2 , β_4, and β_6 were used.

As discussed in our previous paper,[3] there is a problem of how to relate the deformation parameters of each part of the DOP in the coupled channel calculation. In the present case, we have performed such a coupled channel analysis that all the deformation parameters of the real, volume imaginary, surface imaginary and spin-orbit part of the DOP have been searched independently. As the result of this analysis, very excellent fits have been obtained for the 0^+, 2^+, 4^+, and 6^+ states.

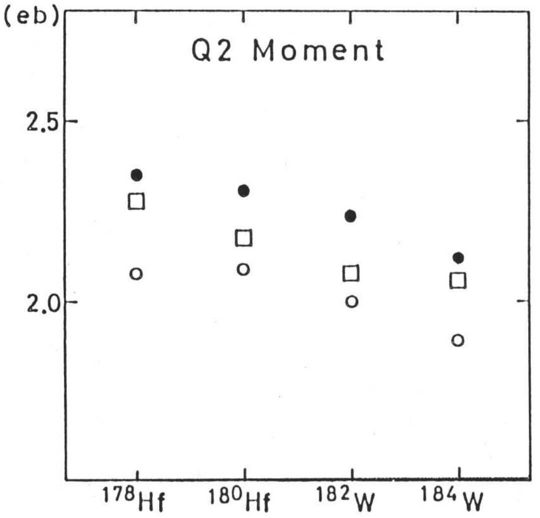
Hereafter in order to remove the ambiguities of the individual DOP parameters, we discuss the deformation of the each part of the DOP by means of the multipole moment.[4] The multipole moments of the DOP are given as follows,

$$Q\lambda = Ze\int V(r,\theta)Y_{\lambda 0}(\theta)r^{\lambda+2}drd\Omega/\int V(r,\theta)r^{2}drd\Omega, \qquad (2)$$

where $V(r,\theta)$ represents the each part of the DOP. For the real and spin-orbit part, the multipole moments were calculated by substituting the Woods-Saxon form factors of the real and spin-orbit part in $V(r,\theta)$ respectively. As for the imaginary part, those were calculated by substituting the sum of the volume and surface terms in $V(r,\theta)$. Fig. 1 represents the quadrupole (Q2) and hexadecapole (Q4) moment of the DOP. It is well known that in the region of hafnium and tungsten, the Q2 moment of nucleus decreases and the Q4 moment decreases to larger negative value as the target mass number increases.[5,6] As shown in Fig. 1, the Q2 and Q4 moments of the each part of the DOP exhibit the above mentioned trends. But the Q2 moments of the spin-orbit part are $\sim$10 % smaller and the Q2 moments of the imaginary part are $\sim$5 % smaller than those of the real one for all the measured nuclei. As for the Q4 moment, the real and spin-orbit parts exhibit very close values each other, but such a systematic relation as appeared in the Q2 moments is not found. The Q4 moments of the imaginary part are negatively larger than those of the real one.

We have carried out a folding model calculation using a realistic effective interaction CEG[7] in order to investigate whether above mentioned systematic relation among the multipole moments of the real, imaginary, and spin-orbit parts of the DOP can be reproduced by the folded potential considering the density dependence of the effective interaction. Since the spin-orbit force in CEG is density-independent and the multipole monents of the spin-orbit part are expected to be almost identical to those of the matter distribution. Therefore we substitute the multipole moments of the Woods-Saxon form factor of the spin-orbit part of the DOP obtained by the coupled channel analysis for those of the matter distribution at the folding calculation.

As the result of the folding model calculation, although the Q2 moment of the real part of the folded potential becomes ∿1 % larger for all the measured nuclei than that of the matter distribution, they cannot reproduce well the Q2 moment of the real part obtaind by the coupled channel analysis. As for the imaginary part, the Q2 moment of the folded potential becomes ∿20 % larger than that of the matter distribution and exceeds the result of the coupled channel analysis by ∿15 %.



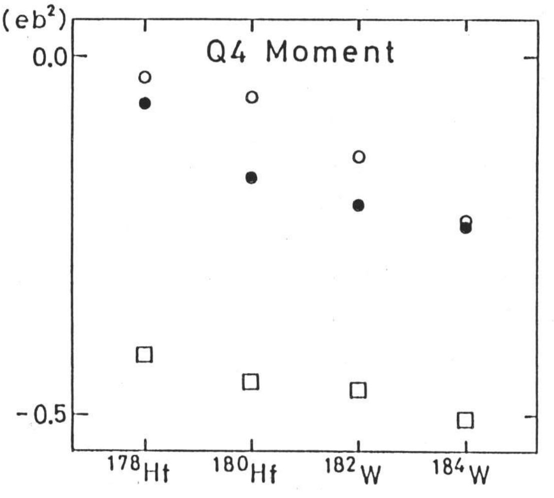


Fig. 1 The quadrupole (Q2) and hexadecapole (Q4) moments obtained by the coupled channel analysis. The closed circles, open circles and open squares represent those of the real, spin-orbit and imaginary parts respectively.

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