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THEORETICAL ANALYSIS OF NUCLEON INTERACTIONS BELOW 20 MeV WITH W ISOTOPES

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In this work elastic and inelastic proton scattering from even-even W isotopes is predicted from a deformed optical potential previously determined from neutron scattering data. Comparisons are made with experimental proton data at 16 MeV.

1. Introduction

The even-even tungsten isotopes $^{182,184,186}W$ are known from nuclear structure studies [1,2] to have large and negative hexadecapole deformations β_4. A part of our work consists in the determination of the quadrupole and hexadecapole nuclear deformations β_2 and β_4 from a coupled channel theoretical analysis of various neutron cross sections for these W isotopes. A comparison at 3.40 MeV between such calculations and recent neutron elastic scattering cross section measurements performed at Bruyères-le-Châtel was presented at the last Kiev Conference [3]. The deduced neutron potential parameters, including isospin terms and the deformations β_2, β_4, are used in the present work as a basis to deduce proton-W potential whose predictions are compared with (p,p) and (p,p') angular distributions [4] measured at 16 MeV.

2. Coupled channel analysis

In these coupled channel calculations, a (0^+, 2^+, 4^+) basis was chosen with complex coupling form factors [3]. The potential parameters including the deformation parameters β_2 and β_4 were mainly determined according to the SPRT method [5] supplemented by consideration of the scattering measurements at 3.40 MeV [3].

Below a few MeV, volume absorption is generally neglected [6] and the optical potential U can be written as :

$$U = -V f(r, a_V, R_V) + 4 i a_D W_D \frac{d}{dr} f(r, a_D, R_D) + 2 \tilde{\lambda}_\pi^2 V_{so} \frac{1}{r}\frac{d}{dr} f(r, a_{so}, R_{so})\, \vec{\ell}\cdot\vec{s}$$

where $$R_i = R_{oi}\left[1 + \beta_2 Y_2^0 + \beta_4 Y_4^0\right] \quad (i = V, D), \quad R_{oi} = r_i A^{1/3} \quad (i = V, D, so)$$

and $$f(r, a_i, R_i) = \left[1 + \exp\{(r - R_i)/a_i\}\right]^{-1} \quad (i = V, D, so)$$

The corresponding potential parameters are given in Table 1. The deformation parameters β_2 and β_4 which were found [3] have values close to Gogny's ones [7] issued from Hartree-Fock-Bogoliubov calculations and, to a lesser extent, to Möller's ones [2]. Comparisons are given in Table 2.

3. Proton potential

In this study proton nuclear potential was obtained from Table 1 by changing the sign of the asymmetry term $\frac{N-Z}{A}$ and adding a Coulomb correction nuclear term. In addition a deformed Coulomb potential has been taken into account. Moreover, at the proton energy E_p = 16 MeV, the volume absorption effects cannot be neglected [6]. Consequently, a volume absorption term W_V was included in the optical potential. The competition between W_V and W_D leads to a readaptation of the energy variation of the surface absorption at high energy. The proton potential so described was used to calculate at 16 MeV the angular elastic and inelastic scattering cross sections from $^{182,184,186}W$. As it can be seen from Figure 1, the calculated angular distributions from ^{184}W are close to the measurements by Kruse et al [4]. A comparable good agreement is also obtained at the same energy for (p,p') angular distributions from ^{182}W and ^{186}W.

4. Conclusion

By using nuclear deformations and geometry parameters (a_i,R_i) obtained from the analysis [3] of neutron scattering data available for W isotopes, it has been shown that good predictions can be made for (p,p) and (p,p') angular distributions at 16 MeV. In order to obtain satisfactory fits at such an energy it is important to use in addition adapted volume and surface absorption potentials along with a deformed Coulomb potential.

References

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TABLE 1

$V = 50.00-16\left(\frac{N-Z}{A}\right) - 0.25\,E_n$	$W_D = 4.93-8\left(\frac{N-Z}{A}\right) + 1.30\,E_n^{1/2}$	$V_{SO} = 6.00$
$r_V = 1.26$	$r_D = 1.28$	$r_{SO} = 1.26$
$a_V = 0.63$	$a_D = 0.47$	$a_{SO} = 0.63$

Neutron optical potential parameters for interactions with even-even W isotopes (strengths in MeV ; lengths in fm).

TABLE 2

Authors	^{182}W		^{184}W		^{186}W	
	β_2	β_4	β_2	β_4	β_2	β_4
Götz et al. 1)	0.240	-0.080	0.230	-0.090	0.230	-0.090
Möller 2)	0.235	-0.057	0.220	-0.059	0.213	-0.060
Gogny 7)			0.216	-0.060		
present work	0.223	-0.054	0.209	-0.056	0.203	-0.057

Deformation parameters β_2 and β_4 of even-even W isotopes. Comparison between various determinations.

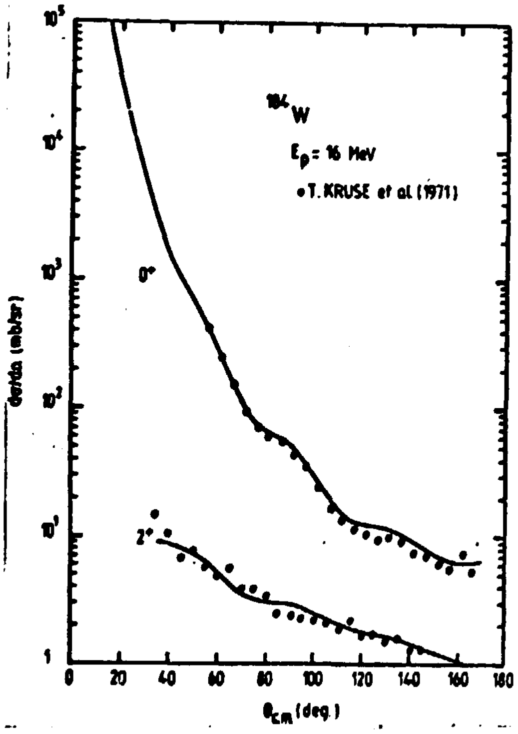

Fig. 1

Comparison theory-experiment for elastic (0^+) and inelastic (2^+) scattering of protons from ^{184}W at E_p = 16 MeV.