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DIFFERENTIAL ELASTIC SCATTERING CROSS SECTIONS OF CADMIUM ISOTOPES AND p-NEUTRON STRENGTH FUNCTIONS IN THE RANGE $50 < A < 130$

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In[1] a possibility was demonstrated of the extraction of neutron strength functions and the potential scattering phase shifts from the measurements of the averaged differential elastic scattering cross sections. Preliminary results of the experimental data analysis for a group of nuclei in the range $50 < A < 130$ were given in[2]. The present paper contains the results of differential cross section measurements for even-even cadmium isotopes and revised parameters for all the investigated by the authors nuclei.

Let us remind that the cross section at a neutron energy below 400 keV is described by the expression

$$\sigma(\theta) = \frac{\sigma_s}{4\pi}[1 + \omega_1 P_1(\cos\theta) + \omega_2 P_2(\cos\theta)].$$

Using the R-matrix one-level approximation and carrying out the averaging over the nonoverlapping resonances one easily obtains for even-even targets the formulas[1], which express σ_s, ω_1, and ω_2 through neutron strength functions S^0, $S^1_{1/2}$, $S^1_{3/2}$ (j = 1/2, 3/2 - neutron total angular moment) and phase shifts

$$\delta_\ell = \phi_\ell + \mathrm{arc\,tg}\frac{P_\ell R^\infty_\ell}{1 - (S_\ell - B_\ell)R^\infty_\ell},$$

where ϕ_ℓ is the hard sphere phase shifts, P_ℓ, S_ℓ, B_ℓ are respectively the penetration factors, shift factors and boundary conditions. When separating the R^∞ term in the R-matrix an additional energy dependence of neutron widths arises determined by the factor $d_\ell = (P_\ell R_\ell)^2 + [1 - (S_\ell - B_\ell)R^\infty_\ell]^2$ [3] which must be taken into account while the strength function evaluation.

The boundary conditions used, i.e., $B_\ell = 0$ and $B_\ell = -1$ give different values of S^1_j for the nuclei with $R^\infty_1 \neq 0$. The R-matrix theory requires to choose B_ℓ so that the one-level approximation is the most exact. This requirement is met, in particular, if the choice of B_ℓ ensures the fulfilment of $d_\ell = 1$ [3]. i.e.,

$$B_\ell = -(R^\infty_\ell)^{-1} + S_\ell \pm \sqrt{(R^\infty_\ell)^{-2} - P_\ell^2}.$$

Under condition that R^∞_ℓ is constant at all energies and B^∞_ℓ is constant only inside the interval of averaging B_ℓ changes from $-\ell$ at $kR \ll 1$ to $= S_1$ at $kR \sim 1$ and the expression for phases

Table 1

Differential neutron scattering cross section parameters of cadmium isotopes

E_{keV}	σ_s	ω	ω_2	σ_s	ω_1	ω_2
		^{106}Cd			^{108}Cd	
I.8	6.74(45)	-.0I2(I7)	.054(27)	6.63(40)	-.008(43)	-.0I0(48)
4.I	6.45(45)	-.026(2I)	.002(52)	6.35(40)	.046(22)	.059(59)
8.3	6.56(45)	.050(25)	.03I(40)	4.94(40)	.I40(56)	-.023(83)
II.7	6.94(45)	.03I(42)	.002(75)	5.93(40)	.036(57)	.I49(79)
I4.3	6.20(45)	.072(4I)	.234(64)	6.40(40)	.077(7I)	.I68(7I)
I8.0	6.59(45)	.I49(36)	.065(59)	6.24(40)	.I0I(I36)	.068(6I)
23.I	6.36(45)	.II3(29)	.I20(45)	6.03(40)	.I48(43)	.I8I(I08)
29.4	6.82(45)	.I82(48)	.I78(77)	6.I2(40)	.I76(38)	.I64(70)
4I.I	8.I8(45)	.253(79)	.I65(86)	7.05(40)	.299(95)	.2I4(I38)
48.3	7.53(45)	.276(56)	.I25(60)	7.2I(40)	.3II(55)	.243(94)
58.4	7.59(45)	.302(32)	.222(50)	7.03(40)	.30I(5I)	.245(I04)
72.0	7.33(45)	.32I(29)	.I7I(45)	7.22(40)	.260(28)	.25I(5I)
95.0	7.94(45)	.366(47)	.259(84)	7.49(40)	.434(53)	.2I5(62)
I20.0	7.6I(45)	.4I6(37)	.227(58)	7.26(40)	.4I7(54)	.34I(67)
I38.0	7.68(45)	.485(32)	.I28(49)	7.2I(40)	.60I(32)	.35I(50)
I64.	7.59(45)	.534(3I)	.375(56)	7.I4(40)	.549(3I)	.286(49)
20I.	7.47(45)	.645(35)	.326(45)	7.24(40)	.629(32)	.363(59)
253.	7.88(45)	.684(25)	.308(69)	7.74(40)	.739(32)	.32I(37)
		^{110}Cd			^{112}Cd	
I.8	6.II(45)	.020(I6)	.007(38)	6.43(40)	-.002(2I)	.0I7(30)
4.I	5.97(45)	.042(I2)	.035(24)	6.44(40)	.033(I4)	.066(22)
8.3	5.97(45)	.044(I6)	.057(32)	6.I5(40)	.086(I8)	.024(28)
II.7	6.55(45)	.073(25)	.069(44)	6.90(40)	.040(28)	.II0(62)
I4.3	6.23(45)	.I44(35)	.069(66)	5.85(40)	.I56(44)	.I3I(46)
I8.0	6.9I(45)	.I50(I9)	.073(39)	6.5I(40)	.I30(24)	.I22(66)
23.I	6.42(45)	.I64(I9)	.I33(38)	6.28(40)	.I09(22)	.II8(34)
29.4	7.I2(45)	.I9I(20)	.08I(75)	6.68(40)	.I95(24)	.I26(39)
4I.I	7.45(45)	.235(39)	.046(5I)	6.97(40)	.238(42)	.I50(70)
48.3	7.68(45)	.237(26)	.089(33)	7.27(40)	.256(39)	.I66(5I)
58.4	8.02(45)	.293(25)	.209(27)	7.50(40)	.296(23)	.200(5I)

died nuclei under new boundary conditions. There are a number of targets with odd A in the Table and their parameters do not at all get out of common picture, though our cross section parametrization is applicable to spinless nuclei. It is worth saying that $R' = R(1 - R_0^\infty)$ as usual, but in the case of the p-wave one has $R'_1 = R(1 - 3R_1^\infty)$. We took $R = 1.35A^{1/3}$ Fm. The values of $g\Gamma_n$ from [4] were included in the fitting procedure as in [2].

Let us note that the variation of boundary conditions having influence on S_j^1 values does not practically affect the j-splitting effect reported by the authors in [5]. One may expect the same splitting for R_1^∞, but more experimental data are still required for the independent extraction of both $R^\infty_{1,1/2}$ and $R^\infty_{1,3/2}$.

The obtained results confirm the existence of spin-orbit splitting of the one-particle 3p-resonance and the information presented in Table 2 may find its application, for example, in the calculation of total cross sections

$$\sigma_t = \frac{4\pi}{k^2}(\sin^2\delta_0 + 3\sin^2\delta_1) + \frac{2\pi^2}{k^2}\sqrt{\frac{E}{1\text{ eV}}}\left[S^0\cos 2\delta_0 + \frac{3(kR)^2}{1+(kR)^2}S^1\cos 2\delta_1\right].$$

Table 2 completes the available data on S^1 and R' and practically for the first time allows one to obtain the experimental values of δ_1. Thus the p-wave component of potential scattering at 400 keV is 0.18 and 1.6 b for A about 50 and 120, respectively, decreasing almost to null down at $A \simeq 75$.

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Дифференциальные сечения упругого рассеяния изотопов кадмия и p-нейтронные силовые функции в области 50 < A < 130

На реакторе ИБР-30 проводятся измерения угловых распределений упруго рассеянных нейтронов с энергией до 440 кэВ на ядрах в области 3p-максимума нейтронной силовой функции. При этих энергиях сечение хорошо описывается формулой

$$\sigma(\theta) = \frac{\sigma_s}{4\pi}[1 + \omega_1 P_1(\cos\theta) + \omega_2 P_2(\cos\theta)].$$

Получены экспериментальные значения σ_s, ω_1 и ω_2 для ^{106}Cd, ^{108}Cd, ^{110}Cd, ^{112}Cd и ^{116}Cd, которые представлены в таблице для 19 значений энергий нейтронов. Из анализа $\sigma_s(E)$, $\omega_1(E)$ и $\omega_2(E)$ определены силовые функции и параметры потенциального рассеяния: S^0, $S^1_{1/2}$, $S^1_{3/2}$, R_0^∞ и R_1^∞. В работе приведены также данные о $S^1_{1/2}$ и $S^1_{3/2}$, полученные для ядер в области 50 < A < 130 и демонстрируется спин-орбитальное расщепление p-нейтронной силовой функции.

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