Communications

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Imaginary optical potential in ^{206}Pb and its comparison to ^{208}Pb†

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The imaginary optical potential and absorption cross section for neutrons on ^{206}Pb are calculated within the particle-vibration model using intermediate structure. The results are compared to those for ^{208}Pb and are quite similar. The relationship to the nuclear spreading width is discussed.

[NUCLEAR REACTIONS ^{206,208}Pb(n,n), $E=0$–12 MeV; calculated imaginary optical potential and absorption; discussed relation with $\Gamma^{\downarrow}$. Particle-vibration doorways.]

In recent publications[1,2] we calculated the imaginary optical potential and absorption cross section for neutrons on ^{208}Pb. Our model is that of intermediate structure with particle-vibration doorways. The purpose of the present paper is to discuss qualitatively the dependence of the imaginary potential on the spreading width and to study to what extent this potential can be applied to other nuclei in the same shell region. Towards this goal, new calculated results for ^{206}Pb are compared to our previous ^{208}Pb results.

In the doorway formalism the imaginary optical potential is[3]

$$W_{ljE}(r,r') = -\frac{1}{2}\sum_d \Gamma_d^{\downarrow} \frac{\langle r, lj|V|d\rangle\langle d|V|r', lj\rangle}{(E-E_d)^2+\frac{1}{4}\Gamma_d^{\downarrow 2}}, \tag{1}$$

where V is an interaction which connects the doorway states $|d\rangle$ with the open channels, and E_d and $\Gamma_d^{\downarrow}$ are, respectively, the doorway energy and spreading width. The channel vectors $\langle r, lj|$ and $|r', lj\rangle$ are defined as in Refs. 1 and 2 and in Auerbach *et al.*[4] The spreading width of a doorway arises from its interaction with more complicated compound nuclear states $|q\rangle$. The potential $W_{ljE}(r,r')$ displays a resonant shape at the doorway energies, and it is clear from Eq. (1) that the larger $\Gamma_d^{\downarrow}$, the lower and wider these resonances.

In our model the doorways are particle-vibration states in the target-neutron system, V is the weak coupling particle-vibration interaction, and the states $|q\rangle$ are particle-2 vibration, particle-3 vibration etc. states.

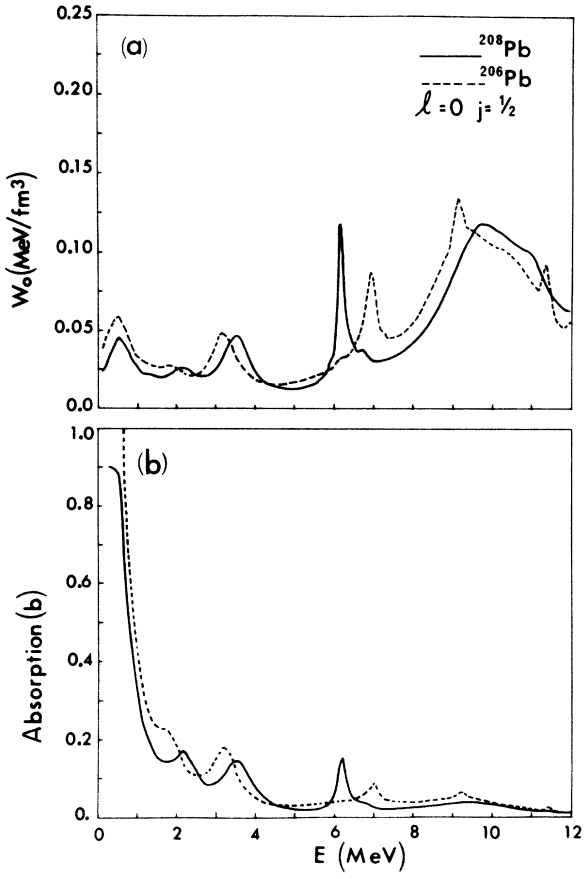

FIG. 1. (a) The calculated imaginary potential peak W_0 [Eq. (2)] for ^{208}Pb and ^{206}Pb. (b) The calculated absorption cross section for ^{208}Pb and ^{206}Pb.

The imaginary potential $W_{ljE}(r, r')$ is nonlocal and energy and angular-momentum dependent. We have shown[1,2] that in our model $W_{ljE}(r, r')$ is peaked near $r \simeq r' = R$, where R is the nuclear radius, and we have used the quantity

$$W_0 = -W_{ljE}(R, R) \tag{2}$$

to display the energy dependence. Using the same notation we present in Fig. 1(a) a plot of W_0 vs E for scattering of $s_{1/2}$ neutrons from ^{208}Pb and ^{206}Pb. The energy range is 0–12 MeV and $\Gamma_d^{\downarrow} = 0.75$ MeV was used for both nuclei for all doorways, except those based on giant resonances where $\Gamma_d^{\downarrow} = 2$ MeV was employed. In part (b) of the figure we give the absorption cross sections obtained from these imaginary potentials using Eq. (15) of Ref. 2. The figure shows that the imaginary potentials and the calculated absorptions for the two targets are quite similar. It thus appears that one can apply to ^{206}Pb the potential obtained for ^{208}Pb. This conclusion, while not *a priori* obvious, is very satisfactory, in that one would like to be able to use the same potential for neighboring nuclei. We now elaborate on why the potentials are so similar.

We have found 21 doorways for s-wave scattering from ^{206}Pb vs only 10 for ^{208}Pb in the same energy range. The extra doorways in ^{206}Pb are due to the greater number of vibrations and the availability of the $3p_{1/2}$ single particle state. The doorways in ^{206}Pb which are not present in ^{208}Pb have less strength and merely provide a background of additional structure. This is consistent with the experimental[5] and theoretical[6] results that the spreading width for ^{206}Pb is much greater than that for ^{208}Pb at low energies. Specifically, $\Gamma_d^{\downarrow}$ for ^{206}Pb is of the order of several hundreds of keV while $\Gamma_d^{\downarrow}$ for ^{208}Pb is less than about 50 keV. The use of $\Gamma_d^{\downarrow} = 750$ keV for the ^{206}Pb calculation is therefore reasonable. This results in fairly wide resonances whose effects are to average out the additional structure, while retaining the features due to the strong basic doorways common to both ^{206}Pb and ^{208}Pb. Had we used a smaller value of $\Gamma_d^{\downarrow}$ for ^{206}Pb, the additional structure would have remained and the potentials would not have been so similar. While 750 keV is also a reasonable value of $\Gamma_d^{\downarrow}$ for ^{208}Pb at energies above a few MeV, we really should have used a smaller spreading width at lower energies. However, this would only have resulted in sharper resonances at the same energy positions with no new resonances, and would not have seriously affected the similarity of the two potentials.

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