POTENTIAL DESCRIPTION of ^{3}He and ^{4}He NUCLEI in p^2H and p^3H CHANNELS

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The nuclear part of the potential of intercluster p^2H and p^3H interactions is represented as

$$V(r)=V_0\exp(-\alpha r^2)+V_1\exp(-\beta r)$$

with a regular Coulomb potential at zero radius, V_0 - Gaussian attractive part, V_1 - exponential repulsive part. The potential of each partial waves of p^2H and p^3H systems were constructed so that it would correctly describe the respective partial phase shift of elastic scattering. Potentials of p^2H and p^3H interactions for scattering processes were received in our work [1] by using this data. Then "pure" phases were separated in the doublet channel and on this basis potentials of intercluster interaction - "pure" in accordance with Young schemes - were constructed.

Here, the parameters of "pure" potentials of doublet p^2H and singlet p^3H interactions were calculated for exact description of the experimental value of bound energy of ^{3}He and ^{4}He nuclei. The obtained parameters of the potential and calculated bound energy along with experimental values [2] are shown in Table. Such potential is deeper by 0.01305 MeV [1] and leads to a total agreement between calculated -5.49400 MeV and experimental -5.494 MeV bound energies [2].

System	L_J	V_0, (MeV)	α, (fm^{-2})	E_{BS}, (MeV)	E_{EXP} (MeV)
p^2H	Even	-34.76305	0.15	-5.49400	-5.494
p^3H	Even	-62.90714	0.17	-19.81400	-19.814

The asymptotic constants C_0 and C_W are calculated for controlling behavior of WF of BS at long distances - for the former of them the asymptotic is taken in exponential form and for the latter it is in the form of exact Whittaker function. The value of the first constant in the range 8-16 fm is equal to 2.0(1), that of the second - 2.4(1). The experimental data that are known for these constants give the values 1.8-3.0 [3].

The variational method is used for additional control of accuracy of bound energy calculations, which gives the energy of -5.49399 MeV for the grid having dimension 10 and independent variation of parameters. Asymptotic constant C_w of variational WF at distances of 6-15 fm remains at the level of 2.3(1) and residual error doesn't exceed 5.8 10^{-15}. For the real bound energy in such potential it is possible to use the value -5.493995(5) MeV, since the variational energy decreases as the dimension of a basis increases and the finite-difference energy increases as the step decreases.

The parameters of the ground state in p^3H system in ^4He nucleus were corrected in the process of calculation, the difference from the results of work [1] being 0.19289 MeV (see Table). It is basically due to the fact of using exact mass values of p and ^3H. Energy converges to the experimental value -19.81400 MэB [2] for finite-difference method when steps are lower than 0.004 fm; the same is true for p^2H system. The accuracy of calculation of the «tail» of BS WF of p^3H system is verified using asymptotic constant. The values of the two types of asymptotics (exponential and Whittaker) appeared to be C_0=4.1(1) and C_w=4.6(1) in the distance range 8-16 fm, while experimental data give the value from 4.2 to 5.1 [3].

For controlling calculation of bound energy of p^3H system the variational method was used, which allowed receiving the energy -19.81398 MeV with asymptotic constants C_0=4.1(1) and C_w=4.5(1) in the range 5-12 fm. These results lead to a conclusion that the exact energy for this potential equals -19.81399(1) MeV.