EFFECTS ON THE ENERGY EIGENVALUES OF THE DIFFUSENESS PARAMETER OF THE WOODS–SAXON POTENTIAL IN HEAVY–ION FUSION

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The interactions between nuclei are commonly described using a potential which consists of the well-known repulsive Coulomb and the attractive nuclear potential. The latest potential type is usually taken to be of Woods–Saxon form, which is defined by three parameters: the depth, the radius and the surface diffuseness. For elastic scattering problems, the value of the diffuseness parameter extracted by fitting precise fusion cross sections is considerably larger than the value of ≈ 0.63 fm usually accepted as a typical value. Having obtained exact solutions of the Schrödinger equation with a generalized form of the deformed Woods–Saxon potential by referring Nikiforov–Uvarov method, energy eigenvalues for different values of this parameter are calculated numerically and effects on the bound states of the energy spectrum of it are discussed in heavy-ion fusion. In addition, within the framework of complex quantum mechanics formulation, we also investigated complex form of the deformed Woods-Saxon potential for which the corresponding energy eigenvalue problem can be solved exactly.

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DIFFERENTIAL CROSS SECTION MEASUREMENT OF RADIATIVE CAPTURE OF PROTONS BY NUCLEI ^{13}C

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The reaction $^{13}C(p,\gamma)^{14}N$ is the important one for the astrophysics, not only for nuclear synthesis of CNO elements, but and for nuclear synthesis of elements participating in subsequent combustion of helium [1]. The predominant yield of the reaction occurs at protons energies of less than 1 MeV. However, the clearness of the capture mechanism in this energy region is made difficult because of the superposition of the contribution of the low - energetical part of the resonance 1320 keV onto the cross section. Last experimental data for more wide energy region, informed in the work [1], and results of previous works, mentioned in that work, give reason for further continuation of the study of the reaction $^{13}C(p,\gamma)^{14}N$.

Measured data of the work [1] in the region of $E_P = (320 \div 900)$ keV at the angles of 0^0 and 90^0 are obviously insufficient.

In the present work measurements of differential cross sections of the reaction were carried out at protons energies E_P = 991, 558 and 365 keV, the accuracy is not worse then 10%. There was studied the most (from the astrophysical point of view) important process of protons capture by ^{13}C nuclei onto the ground state of the ^{14}N nucleus.

The ^{13}C (99%) targets, used in the experiment, were sprayed onto copper base. The target thickness was determined by incident protons energy losses in the target. The energy losses were clearly reflected in the corresponding spreading of transitions of radiation capture. The statement about the gamma-lines spreading is valid in this case, because energy losses in the target are here significantly more, than the energetical resolution of the detector. The peak width of the radiation capture gamma-line at half-height corresponds to energy losses of incident protons in the target. From the Table of brake values for protons in carbon [2] there was determined that the thickness of the target was 140 ± 5% $\mu g/cm^2$. The upper part of gamma-lines in the spectrum repeats the course of excitation function curve of the reaction $^{13}C(p,\gamma)^{14}N$ in this energy region. The correction for protons effective energy, during the measurements of excitation function at the expense of energy losses of protons in the target, was carried out by the formula $E_{eff} = E_P - 0{,}5\ \Delta_{lab}\ (E_P)$.

At the every energy there was measured the angular distribution of cross sections of the reaction at the angles of $\theta_\gamma = 0^0, 90^0$ and 135^0. For the angle of 135^0 data were obtained for the first time. There is experimentally affirmed the isotropy of angular distribution of the differential cross sections of the reaction $^{13}C(p,\gamma)^{14}N$ in the given region of protons energies. In regions, where measurements are overlapped, results of present experiments satisfactorily agree with data of work [1].

The theoretical investigation of the given reaction included calculation of cross sections and extraction of the astrophysical S-factor. The cross sections were calculated within the framework of model of direct capture with the using of optical potentials for the description of a channel of scattering. The wave functions of a bound state were generated in a potential reproducing bound energy of a proton in ^{14}N nucleus. Results of calculations were compared with the experimental data.

Reference:

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