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K.A.ISPIRIAN,A.T.MARGARIAN,S.G.MATINIAN

ARE THERE ADDITIONAL ENERGY LEVELS OF DEUTERON?

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СУЩЕСТВУЮТ ЛИ ДОПОЛНИТЕЛЬНЫЕ ЭНЕРГЕТИЧЕСКИЕ УРОВНИ В ДЕЙТРОНЕ?

Показано, что если в дейтроне есть примесь барионных резонансов, то возможны уровни с высокими (100 Мэв) и низкими (10 Мэв) значениями энергии, которые, в принципе, могут быть исследованы экспериментально.

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Ереван 1975

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It is shown that if baryonic resonance admixtures are present in deuteron then additional high ($\sim$ 100MeV) and low ($\sim$ 10MeV) energy levels are possible which in principle may be investigated experimentally.

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Recently the contribution of baryonic resonance admixtures to various properties of deuteron has been investigated theoretically (for review and references see /1,2/) as well as experimentally /3-5/. As a result a few percent resonance state in deuteron does not contradict the experimental data and improves the agreement between the theoretical and experimental results. The purpose of this short note is to draw attention to another interesting consequence of the possible existence of $\Delta(1236)\,\Delta(1236)$ $N(938)\,N'(1470)$ etc, configurations of nucleon pairs in nuclei, especially, in deuteron.

As it is well known /6/ the normal NN state of deuteron with a small $\sim (3 \div 7)\%\,{}^3D$ wave function and W=2,23 MeV binding energy does not allow any additional (excited) nuclear level besides the ground state. Considering the simplest case of the $\Delta(1236)\,\Delta(1236)$ state of deuteron with $W \simeq 600$ MeV one may show that high and low energy nuclear levels are possible in deuteron. Indeed, using a square potential well with a width $r_0 = 2.10^{-13}$ cm one may calculate that for a $\Delta\Delta$ configuration in S-state the depth of the well is $V_0 \simeq 660$ MeV and besides the ground state with $W \simeq 600$ MeV there are two other relatively high energy levels with $E_1 \simeq 220$ and $E_2 \simeq 580$ MeV. Of course, the number and the height of such energy levels depend strongly on the value of r_0. For example, for a $\Delta\Delta$ potential radius $r_0 = 1{,}4.10^{-13}$ cm one obtains $V_0 \simeq 720$ MeV and a single high energy level $E_1 \simeq 430$ MeV. Here we have used the conventional values for NN potential radii (see/2/). Of course, choosing r_0 small enough ($r_0 \lesssim 1.10^{-13}$cm) one may get a situation when only the ground state will be present in S-state.

For a $N(938)N'(1470)$ S state of deuteron with $W \simeq 520$ MeV one obtains $V_0 \simeq 580$, $E_1 \simeq 250$ MeV and $V_0 \simeq 640$ and $E_1 \simeq 480$ MeV for $r_0 = 2.10^{-13}$ and $r_0 = 1{,}4.10^{-13}$cm, respectively.

Besides these high energy levels the large binding energy of such virtual deuteron states makes possible rotational levels $(\ell \neq 0)$ with energy of the order of few tens of MeVs which may exist even if $r_0 < 1.10^{-13}$cm. Therefore, one may conclude that if baryonic resonance states are present in deuteron then in spite of the conventional point of view the deuteron has low and high (higher than all the known nuclear levels) energy states which may be excited in principle. At present it is impossible to predict the exact widths and the quantum numbers of these virtual levels. One may also mention that such additional levels must exist in heavier nuclei, and this represents a new scale of excitation of nuclear matter.

Trying to find out whether these unusual energy levels manifest themselves it is necessary to pay attention to the following facts. First of all the search of the deuteron levels with energy of some hundred MeVs is complicated by the fact that all the cross sections in this energy region are dominated by the contribution of resonance diagrams. Therefore, the effects of the above considered unusual levels may be find out in the low energy region ($<$100MeV) where the existing experimental data are very scarce except the data on the deuteron hotodisintegration. Unfortunately, the influence of the levels under investigation on the deuteron photodisintegration cross section is very small to be observed. Indeed, the photon resonance absorption cross section $\sigma_{abs} \simeq \alpha \lambda^2 \Gamma_{\Delta\Delta\gamma}/\Gamma_{tot}$ where α is the admixture of the resonance states in deuteron, $\sim 1\%$, λ is the photon wavelength corresponding to the energy level under investigation, $\Gamma_{\Delta\Delta\gamma}$ and Γ_{tot} are the partial and total widths of the same level. Assuming $\Gamma_{\Delta\Delta\gamma}/\Gamma_{tot} \simeq 1\%$, one obtains that already $\sigma_{abs} \simeq 3\cdot 10^{-29}$ cm^2 for a level energy of 20MeV, i.e. much less than the deuteron photodisintegration cross section for the same photon energy region /7/.

The usefulness of other processes as the compton scattering on deuteron, deuteron bremsstrahlung etc, for our purpose is limited by the possible narrowness of the above discussed levels, by the absence of monochromatic photon and neutron beams and other experimental difficulties. Nevertheless, we think that the detailed experimental investigation of the processes where these unusual levels may manifest themselves will be useful not only for the problem arisen in this work but also for the more general problem of the possible existence of the virtual resonance states in nuclei also.

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