Possible experiments to search for the singlet deuteron

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Low energy nucleon-nucleon interactions are described usually with using effective range theory which leads to the conclusion that *np*-pair in $^1S_0$ state is unbound [1]. But this conclusion is not confirmed in any experiment.

There are number of another models to describe the low energy NN-interaction had been proposed. Ma had proposed to describe the NN-interaction with help of R-matrix theory. The resonance energy in his model is connected with scattering length *a* and effective range *r* [2]: $E_r = \frac{2}{ar}$,

and equals to the negative value for the singlet state (a_s = -23.7 Fm, r = 2.76 Fm). This idea is very similar to the F.L. Shapiro's idea to describe the neutron scattering and capture reaction on ^3He as the tail of the resonance with negative energy which correspond to the exited level of ^4He [3].

Several recent theoretical works based on quantum chromodynamics show that deuteron has the singlet metastable state with the mass which is little less than sum of masses of two nucleons [4,5].

We can say about the dibarion with spin 0 and isotopic spin 1, which can be observed in neutron-neutron, proton-proton and proton-antiproton interactions. Several experimental works which confirm this hipotethis were published [6-9].

If this state exists it is possible to observe it in the resonant scattering of gamma-quanta by the deutrons. The cross-section of this reaction for gamma-quanta with the energy less than deuteron binding energy (2.224 MeV) is described by the Breit-Wigner formula:

$$\sigma_{\gamma\gamma} = \frac{\pi}{k_\gamma^2} \frac{g\Gamma_\gamma\Gamma_\gamma}{(E - E_r)^2 + \frac{1}{4}\Gamma_\gamma^2} \quad (1)$$

where E_r is the resonance energy, Γ_γ is the radiative width (approximately 10 eV),.k_γ - gamma-quantum impulse.

The scattered gamma-quantum count rate is proportional to the photon flux density dΦ/dE, sample thickness n and detector efficiency ε:

$$N_\gamma = \frac{d\Phi}{dE} nS_r \frac{\Delta\Omega}{4\pi} \varepsilon t \quad (2)$$

Here S_r is the resonant integral:

$$S_r = \int \sigma_{\gamma\gamma} dE = \frac{2\pi^2 g\Gamma_\gamma}{k_\gamma^2} \quad (3)$$

If gamma-quanta energy equal to 2 MeV S_r = 300 eV.b. The experiment can be carried out on an electron exelerator with the current I = 100 μA, then dΦ/dE = $6 10^{12}/E_\gamma$ MeV^{-1}, number of deuteron nuclei in the sample n = 10^{21} cm^{-2}. The experiment needs a semiconductor detector with good resolution. The calculations taken into account the detecor efficiency give approximately gamma-quanta count rate 100 sec^{-1}.

Another way to search for the singlet deuteron is to search for neutron radiative capture with two gamma-quanta which correspond to transisions from unbound triplet state to investigated singlet state and to the basic state of deutron. The cross-section of this process is very small (less than 10^{-4} from direct transition to the basic deutron state) and this experiment needs very high neutron flux and good resolution gamma-detector [10].

Literature.

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