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ON THE TOTAL MUON CAPTURE RATE IN Li^6 AND NUCLEAR CLUSTER STRUCTURE

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Л. ПАЛЬГИ. К ПОЛНОЙ ВЕРОЯТНОСТИ МЮ-ЗАХВАТА В Li^6 И КЛАСТЕРНОЙ СТРУКТУРЕ ЯДРА

The total muon capture rates for Li^6 and Li^7 were measured by Eckhause et al. [1, 2]: $\Lambda(Li^6)=5700\pm1200$ sec^{-1} and $\Lambda(Li^7)=1300\pm900$ sec^{-1}. The theoretical investigation of these quantities was performed by Lodder and Jonker [3] in two ways: by means of the closure approximation and by making use of the method of Foldy and Walecka [4]. The total capture rate for Li^7 proves comparable with experiment, but the total capture rate for Li^6 (<4000 sec^{-1}) turns out to be too low.

Here we consider the total capture rate for Li^6 assuming the nuclear clustering.

There is both theoretical and experimental evidence for the alpha-deuteron cluster structure of the ground state of Li^6 [5–7]. These clusters are weakly, by 1.45 MeV, bound together and they behave more or less like free particles. The variational calculation by Schmidt et al. [6] confirms the statements. Good values for the ground state energy and rms radius were obtained. The wave function of the α-cluster is the same as of the free α-particle. The deuteron cluster wave function compared with free deuteron wave function is only slightly distorted.

We suppose that muon capture by alpha and deuteron clusters inside the nucleus of Li^6 occurs in the similar way as by free α-particles and deuterons. We only take into account that the probability of finding muon in the α- or d-cluster in lithium mesic atoms is greater than that in alpha or deuteron mesic atoms. Then we get

$$\Lambda(Li^6)=P(Li^6)[\Lambda(\alpha)/P(\alpha)+\Lambda(d)/P(d)] \qquad (1)$$

for the total capture rate in Li^6, where P is the probability of finding the muon inside the nucleus of a mesic atom

$$P=(Z_{eff}/Z)^4\,(\alpha Z m'_{\mu})^3\,1/\pi$$

and Λ is the total capture rate in mesic atoms.

The total capture rates in alpha and deuteron mesic atoms are measured and calculated. The values of theoretical calculations in the framework of the Universal Fermi Interaction are in correspondence with the experimental ones. We shall use the experimental values not to have any need in additional assumptions.

Using the data of [8] we get $\Lambda(d) = 132 \pm 32$ sec^{-1} for the total capture rate in deuteron mesic atoms. For the total capture rate in α-particles we use the weighted mean of the measured values [2] 369^{+25}_{-40} sec^{-1}. Using these quantities we get

$$\Lambda(Li^6) = 4900 \pm 1000 \text{ sec}^{-1} \qquad (2)$$

for the total capture rate in Li^6. This is comparable with the measured capture rate.

The nuclei C^{12}, $O^{16} \ldots Ca^{40}$ may also have the α-cluster structure. It is clear that the clustering in these nuclei is less characteristic and it is more probable that the properties of α-clusters inside these nuclei differ from their properties in free state. It seems that we can hardly make use of the free α-particle capture rate for calculating the total capture rates in these nuclei. In spite of that, the formula

$$\Lambda(A=4n) = P(A=4n) \cdot n \cdot \Lambda(\alpha)/P(\alpha) \qquad (3)$$

gives unexpectedly good total capture rates for these nuclei. One may think that this coincidence is fully occasional, for the Z-dependence of (3) is $\Lambda(A=4n) \sim Z^4_{eff}$ as in Primakoff formula for these nuclei. But it may have a deeper ground.

For example, considering N^{14} as the $3\alpha+d$ association this rough approximation gives the total capture rate for N^{14} comparable with the measured one. It is more probable that the cluster structure has some importance in muon capture in light nuclei.

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