Figure 3 shows $d\sigma^{III}/dt$ at $p_L = 16$. The experimental data are taken from [1], $b_{OPE} = 6.5$ GeV^{-2}. The effective slope of the differential cross section of A_1 production, calculated from formula (3), yields $b_1 = 19$ GeV at $|t| \leq 0.05$. At a ratio $d\sigma^{OPE}(t = 0/d\sigma^{I}(t = 0) = 2$ [1], formula (4) results in very good agreement with experiment. The total slope of (4) at $|t| \leq 0.05$ is 11 GeV^{-2} (experiment [1] yields 11.5 ± 1 GeV^{-2}). Here

$$\frac{d\sigma^{I}}{dt}(t = 0) \approx 1.2 \text{ mb/GeV}^2, \quad \frac{d\sigma^{OPE}}{dt}(t = 0) \approx 2.4 \text{ mb/GeV}^2$$

and the total cross section of reaction III is of the order of 500 μb, which is in agreement with experiment [1].

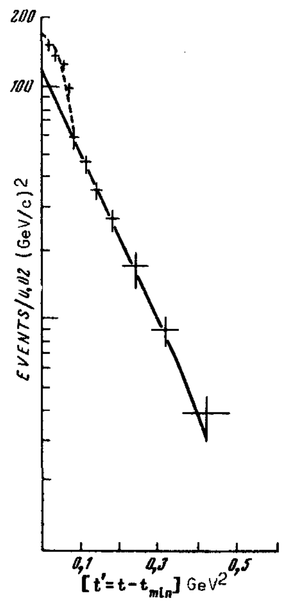

Fig. 3. Differential cross section of $\pi^- p \to \pi^-\pi^+\pi^- p$. Dashed curve - cross section at $|t'| \leq 0.15$. Solid curve - one-pion-exchange cross section [6].

We note in conclusion that an analogous comparison with the experimental data on diffraction production of $N^*_{1/2}$ is complicated to a considerable degree by the fact that, in addition to the already mentioned effects, an appreciable contribution can be made by Regge poles not connected with the f-meson exchange degeneracy in the baryon vertices (for example, ρ). The qualitative picture may correspond in this case to that considered in [7].

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DO THE EXPERIMENTS WITH SOLAR NEUTRINOS POINT TO THE EXISTENCE OF A RESONANCE IN THE $He^3 + He^3$ SYSTEM?

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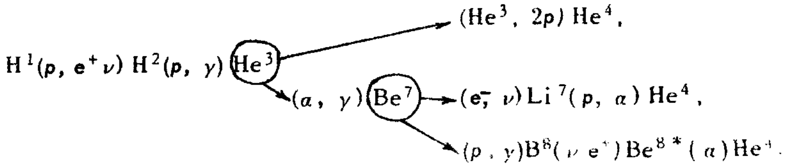
In their last series of experiments, Davis et al. [1], who registered neutrino fluxes from the sun with the aid of the reaction $Cl^{37}(\nu, e^-)Ar^{37}$, revealed a noticeable deviation from the predictions of the theory of solar evolution. The experimental counting rate of the Ar^{37} atoms is $(1.5 \pm 1) \times 10^{-36}$ sec^{-1} per Cl^{37} atom. The corresponding theoretical value obtained in the most realistic model of the sun for the product of the neutrino flux φ, averaged over the particle spectrum by the cross section of the reaction $Cl^{37}(\nu, e^-)Ar^{37}$

is much larger than the experimental one and equals $\overline{\phi\sigma} = (9 \pm 5) \times 10^{-36}$ $sec^{-1} atom^{-1}$ [2].

This discrepancy forces us to analyze methods of calculating the cross sections of the nuclear reactions of the hydrogen cycle on the sun, which lead to neutrino emission:



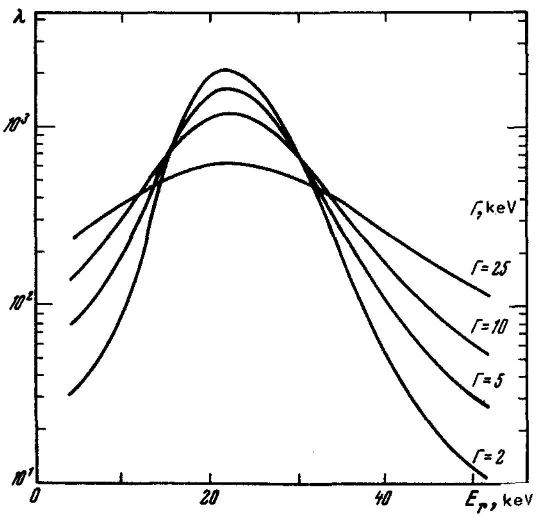
(1)

(2)

(3)

The usual nonresonant method of extrapolating the cross section of the process $He^3(He^3, 2p)He^4$, measured only up to 80 keV energy [3], into the region of lower energies raises some suspicions. We shall show that one can expect the existence of a narrow 0^+ level in the Be^6 nucleus near the threshold of disintegration into $2He^3$, and consequently a resonant energy dependence of the cross section of the reaction (1).

Let us turn to the experimental data on the level spectra of the nuclei Li^6 and He^4. According to the analysis in [4], there are in He^4 two dipole states with $J^\pi = 1^-$ and $T = 1$, having a shell configuration $|s^3p>$ in the excitation energy interval 27 - 30 MeV, and, below it, a monopole excitation with $J^\pi = 0^+$ and $T = 0$ at $E^* = 20.3$ MeV. From the experimental data on the photonuclear reactions on Li^6 [5] and from the experiments [6] on the quasi-free scattering of protons by Li^7 it is known that at $E^* \simeq 18 - 20$ MeV there are in the Li^6 nucleus excitations with configuration $|s^3p^3>$, corresponding in terms of the cluster terminology to dipole excitation of an α particle in Li^6 [7]. Using the data on the He^4 spectrum we find that on going over from the dipole internal excitation of the α cluster to the monopole one, the corresponding level with $J^\pi = 1^+$ and $T = 0$ in Li^6 falls in a region that is 7 - 10 MeV lower than the group of dipole levels, i.e., somewhere into the region of $E^* \simeq 12$ MeV. Since Be^6 and H^6 have a isospin $T = 1$, no analogous state exists in these nuclei. Each of the three nuclei with $A = 6$ should have a level of identical nature with $J^\pi = 0^+$ and $T = 1$, resulting from the excitation of the quasi-deuteron into a singlet cluster state with $T = 1$, while retaining the monopole excitation of the α cluster. In Li^6, the first 0^+ level with $T = 1$ and $E^*(Li^6) = 3.5$ MeV results precisely from a deuteron excitation of this type [8]. Adding 3.5 MeV to $E^*(Li^6)$ of the monopole excitation of the α cluster, we find that the 0^+ level of Be^6 or He^6 falls into the region of the threshold of production of $2He^3$ or $2H^3$. The reduced width of the decay of this state via the channel $2N + He^4$, owing to the disintegration of the cluster, should be much lower than the reduced width of the decay via the channels $He^3 + He^3$ and $H^3 + H^3$. We note in addition that the review [9] contains indications that



Ratio of the rates of the resonant and nonresonant reaction $He^3(He^3, 2p)He^4$ vs. the parameters E_r and Γ at $\ell = 0$.

Li^6 has a positive-parity level at $E^* = 15.8$ MeV.

Returning to the astrophysical aspect of the arguments developed in favor of the existence of new levels in nuclei with A = 6, we can assume that the 0^+ level of the nature indicated above falls in the region of the Gamow peak located in the region 20 keV above the threshold of the disintegration of Be^6 into $He^3 + He^3$. To estimate the influence of the resonance on the rate of the reaction [1] we have used in the calculation the value $T_c = 1.5 \times 10^7$°K for the temperature at the center of the sun, with the aid of which the value $\overline{\phi\sigma} = (9 \pm 5) \times 10^{-36}$ $sec^{-1} atom^{-1}$ was obtained in [2].

The figure shows the ratio $\lambda = \langle\sigma v\rangle_{res}/\langle\sigma v\rangle_{nonres}$ ($\langle\sigma v\rangle$ is the product of the cross section by the velocity, averaged over the Maxwellian distribution) of the rates of the resonant and nonresonant reactions as a function of the resonant energy E_r and of the total width Γ of the resonance. To obtain the maximum effect, the reduced width of the input channel should be assumed equal to the Wigner limit $3h^2/2\mu R^2$, where R = 3.4 F is the radius of the channel. It is seen from the figure that the maximum value of the ratio is $\sim 2 \times 10^3$ at E_r = 21 keV and $\Gamma < 6$ keV.

The decrease of the counting rate as a result of the strong enhancement of the rate of the reaction (1) can be estimated for the detector used by Davis with the aid of the formula [10] $(\overline{\phi\sigma})_{res} \simeq \lambda^{-0.37}(\overline{\phi\sigma})_{nonres}$. Under the most favorable case, the counting rate can decrease by a factor 16 and may turn out to be at the level of the sensitivity threshold of the detector, which is $\sim 0.4 \times 10^{-36}$ $sec^{-1} atom^{-1}$ [1].

We add that in the case of resonance with $\ell = 1$, in spite of the decreased penetrability of the P-wave by a factor $\sim 10^2$, a several-fold decrease of the counting rate is still obtained.

In connection with the indicated possibility of explaining the experiments of Davis et al., searches for an exact position of the levels 1^+ and 0^+ with isospin T = 0 and T = 1 in Li^6 in the region $E^* \sim 10 - 16$ MeV are of interest. In principle, one can attempt to observe these levels in the reaction of inelastic electron scattering, which can lead to a monopole excitation of the α cluster in Li^6, and also in the reaction $He^3(\alpha, n)Be^{6*}$ with the aid of the spectrum of the emitted neutrons.

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