the width of the "resonance" region $(\Delta H)_{res}$. Integrating (1), we get $\Delta H = \alpha\Delta T/T_0)\Delta B$ (with (3) taken into account). Substituting here the value of $(\Delta B)_m$ we get $(\Delta H)_{res} \sim \delta B(\alpha\Delta T/T_0)^{3/2}$

An important role is usually played near phase transitions by nonlinear effects. An estimate shows that if $b > \delta B\sqrt{\alpha\Delta T/T_0}$, then the problem becomes nonlinear close enough to the critical point ($b > \Delta B$). If

$$\delta B\sqrt{\alpha\Delta T/T_0} < b < \delta B, \tag{4}$$

then the connection between h and b takes the form $h = (b^3/6)(\partial^3 H/\partial B^3)$, but if $b > \delta B$, then it is necessary to use the exact H(B) relation. The inequality (4) for the magnetic field h takes the form $\delta B(\alpha\Delta T/T_0)^{3/2} < h < \delta B$.[1)] When $T < T_0$, the analysis is carried out in similar fashion. It must be remembered, however, that a phase transition takes place at $H = H_0(T)$, and the value of the induction changes jumpwise from $B_1 = B_0 - \Delta B_1$ to $B_2 = B_0 + \Delta B_2$ [1]. Near the critical point, as is well known, we have $\Delta B_1 = \Delta B_2 = \sqrt{-3\alpha\Delta T/T_0}$ [2]. As a result, when

$$h \geq |H - H_0(T)|, \tag{5}$$

the magnetic permeability μ is determined in the linear approximation by the quantity $(\partial H/\partial B)_T^{-1}$ and depends only on the temperature. Thus, in that region of the magnetic field H where the inequality (5) is satisfied, the surface impedance is independent of the magnetic field, and consequently the derivative of the surface impedance experiences a jump on the boundary of the region.

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CONCERNING THERMONUCLEAR REACTIONS IN THE INTERIOR OF THE SUN AND SOLAR NEUTRINOS

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The negative results [1] of attempts to register solar neutrinos have made it necessary to review more critically the theory of stellar structure and evolution. Several papers published the last two years consider the causes of the disparity between theory and experiment.

At the 11th International Conference on Cosmic rays, we proposed [2] and analyzed qualitatively a new possibility of decreasing the flux of high-energy solar neutrions. In this paper we consider quantitative data for concrete models of the sun.

The analysis in [2] is based on the assumption that the sun contains a relatively large amount of He^3. The available experimental data not only do not exclude such a possibility, but even point [3] to the presence of several per cent of He^3 on the sun's surface. As to the theory, it was shown by Thorne [4] that in certain anisotropic models of the universe there

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[1)] It is known that nonlinear effects are usually significant under the condition that $h > \delta B$, but in this case the linear approximation remains the fundamental one [3].

can be produced an appreciable amount (≳20%) of deuterium and He^3. A qualitative analysis [2] shows that in regions far from the sun's center the He^3 should be preserved to this day. If there is at present circulation in the interior of the sun, then He^3 can flow regularly from the regions far from the center to the central region, so that the concentration of the He^3 in the region where the thermonuclear reactions take place may be larger than is customarily assumed. This leads inevitably to a decrease in the flux of the high-energy neutrinos. To ensure the observed luminosity of the sun it is necessary to burn approximately 10^{38} He^3 nuclei per second, i.e., about 10^{38} He^3 nuclei must flow into the thermonuclear-reaction region per second. If this region has a radius approximately 20% of that of the sun, then the necessary rate of He^3 influx is $10^{-6} - 10^{-7}$ cm/sec, which is readily attainable [2, 5] if differential rotation takes place in the interior of the sun.

Figure 1 shows plots of the density and temperature at the center of the sun on the He^3 weight concentration. The models of the sun were constructed under the assumption that the He^3 is uniformly distributed along the sun's radius. Naturally, the experimentally observed values were obtained in each case for the mass, luminosity, and radius of the sun. We see that the temperature in the central region of the sun decreases sharply with increasing He^3 concentration, and this leads to a strong decrease of the neutrino flux from the decay of B^8 and the reaction $Be^7(e^-, \nu)Li^7$.

Figure 2 shows the main characteristics of the solar model for an He^3 weight concentration $X_2 = 0.5\%$. The central temperature in this case is $T_c = 10.02 \times 10^6$ °K and the density of matter is $\rho_c = 23.5$ g/cm^3, the main fuel being not hydrogen but He^3: the reaction $He^3 + He^3 \rightarrow He^4 + 2p$ ensures 96% of the sun's luminosity, and the remaining 4% comes from the usual proton-proton cycle1). In this model, a convective nucleus of radius $0.23R_\odot$ is produced in the central region of the sun, containing 16% of the mass and providing 98.4% of the released energy.

Figure 3 shows the rates of generation of solar neutrinos from the reactions $p + p \rightarrow D + e^+ + \nu$ ($E_\nu^{max} = 0.42$ MeV) and $p + p + e^- \rightarrow D + \nu$ ($E_\nu = 1.44$ MeV) for the indicated model.

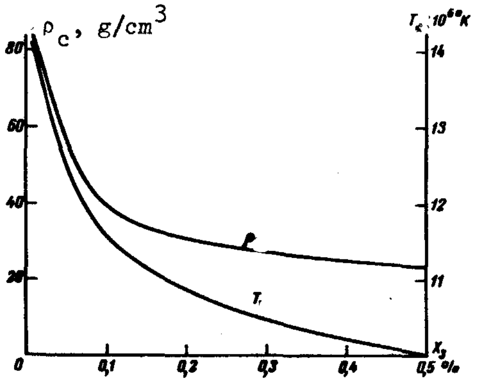

Fig. 1. Density ρ_c and temperature T_c vs. He^3 weight concentration X_3.

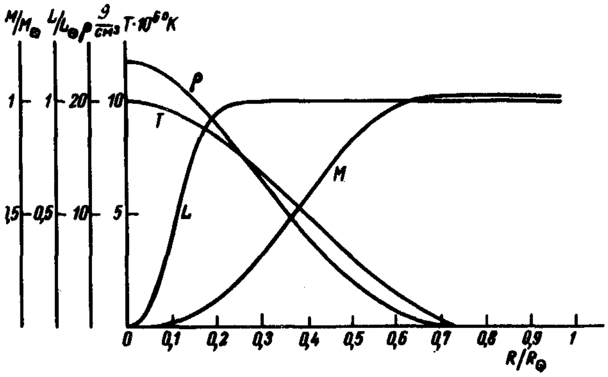

Fig. 2. Main characteristics of solar model for He^3 weight concentration $X_3 = 0.5\%$.

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1) It should be noted that the contribution of the He^3 to the released energy may be different at different stages of the sun's evolution.

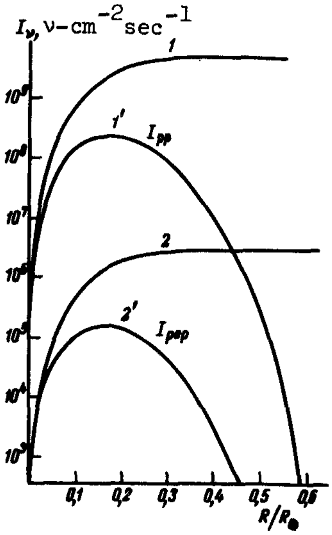

Fig. 3. Intensity of neutrino generation intensity in the interior of the sun for the model with X = 0.5%: 1 - integral neutrino flux I_{pp} from the reaction $p + p \rightarrow D^2 + e^+ + \nu$, 1' - neutrino flux I_{pp} from the corresponding regions of the sun of thickness $0.01R/R_⊙$, 2 - integral neutrino flux I_{pep} from the reaction $p + p + e^- \rightarrow D + \nu$, 2' - flux I_{pep} from the corresponding regions of the sun of thickness $0.01R/R_⊙$.

There are practically no other neutrino groups, owing to the low temperatures in the interior of the sun. For the model with X_3 = 0.5%, the neutrino fluxes on the earth's surface are $I(pp) = 5.04 \times 10^9$ and $I(pep) = 3.04 \times 10^6$ cm^{-2}sec^{-1}. This means that the rate of the reaction $Cl^{37}(\nu, e^-)Ar^{37}$ should be 5×10^{-39} sec^{-1}, which is 1/60 of the theoretical lower limit [6] within the framework of the usual concepts concerning the energy sources in the interior of the sun.

Thus, in spite of the prevailing opinion, if a negative result is obtained even after a tenfold increase of the sensitivity of the method based on the reaction $Cl^{37}(\nu, e^-)Ar^{37}$ compared with the sensitivity attained at the present time [1], this will still not mean that the fundamental hypothesis, namely that the stellar energy comes from thermonuclear sources, is not valid. The foregoing data show that the conclusion that can be drawn at the present time is that thermonuclear reactions in their usual form do not take place in the interior of the sun.

The character of this paper does not allow us to discuss all the pros and cons of the hypothesis that the sun contains a relatively large amount of He^3, and the ensuing consequences. We consider the main purpose of the article to be an indication that there is a new possibility of generating energy and neutrinos in the interior of the sun. This possibility calls for a detailed examination from various points of view.

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