SEARCH FOR FERROMAGNETIC ORDERING IN LIQUID ^{3}He BY POLARIZED NEUTRONS

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In the papers /1,2/ the ferromagnetic ordering of nuclear spins in liquid ^{3}He contained in $\sim$1000 Å pores at a temperature of $\sim$0.3 K was predicted. This ferromagnetic state is metastable and separated from the equilibrium paramagnetic one by a potential barrier /3/. The evaluation of the barrier's height shows that there seems to be no possibilities to get into ordering state in the magnetic field H$\sim$100 kOe. Then the deviation of the ^{3}He nuclear polarization in high fields from the calculated one based on the known susceptibility of ^{3}He at low fields, can prove the existence of the ^{3}He ferromagnetic state. Moreover, we can get the low limit for the value of the potential barrier from our experimental data.

The polarization f of ^{3}He nuclei can be deduced from the polarization of neutrons passed through the polarized liquid ^{3}He /4/. The neutron polarization is due to the fact, that ^{3}He nuclei absorb neutrons predominantly with spins antiparallel to those of ^{3}He. We get for the neutron polarization p:

$$p = \text{th}\,(f\sigma Nt). \qquad (1)$$

Here: σ — absorption cross section of ^{3}He nuclei, N — number of ^{3}He nuclei per cubic cm, t — thickness of liquid ^{3}He.

Theory predicts f=0.007 for the nuclear polarization of ^{3}He.

In order to measure the value of f with a maximum accuracy, one needs to find the optimum thickness of liquid ^{3}He. This optimization corresponds to the maximum of $pT_f^{1/2}$ (T_f — neutron transmission of liquid ^{3}He) and gives t=0.37 mm. Note that the parameter σNt in the formula (1) was received from the transmission measurement.

Fig. shows the polarization of ^{3}He nuclei for the liquid contained in the narrow slit (a,b) for t= =0.48 mm and in pores (c) produceed with sintering Ag powder with a partical size of $\sim$900 Å. It follows from fig. that the ferromagnetic ordering is absent. At the same time nuclear polarization $\langle f \rangle$ averaged over the time of the experiment increases with the field growth.

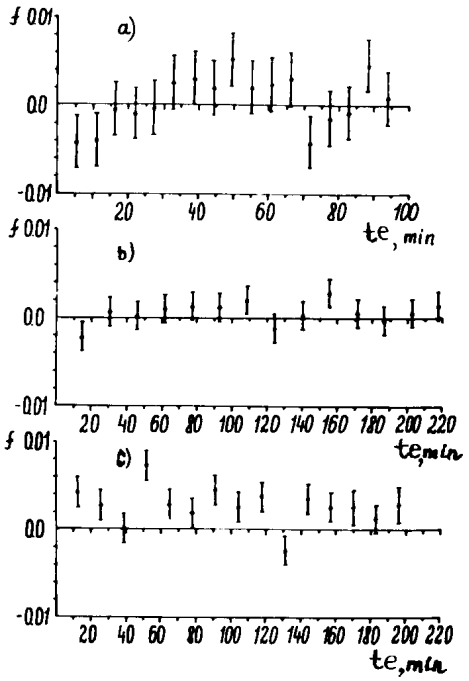

Fig. Polarization of ^{3}He nuclei versus experimental time t_e. Time is measured from moment of achieving ultralow temperature. Temperature increases continuously from 0,2K to 0,3K; *a*) H=2,6 kOe; *b*) H= =10 kOe; *c*) H=18 kOe

This corresponds to the increase of f_H that is polarization by applied magnetic field. It can be shown that

$$f_H = \chi H/\mu N = 0.003\,,$$

here χ — magnetic susceptibility, μ — magnetic moment of ^{3}He nucleus. Averaging the values of polarization in fig.c we find $<f>=0.0025\pm0.0004$, which is in a good agreement with f_H. Finally we have for the potential barrier $U>\chi H^2/2=5$ erg/cm^3.

REFERENCES

1. *Bashkin E. P.* Phys. Let. A, 1984. V. 101. 164.
2. *Bashkin E. P.* ZETP, 1984. V. 87. 1948.
3. *Bashkin E. P.* Theses of 24th Sov. Conf. on Low Temp. Phys., Tbilisi. 1986. 44.
4. *Zhuchenko N. K., Kiz'mina S. M., Tarovik E. G., Trunov V. A., Jagood R. Z.* Sov. J. Low Temp. Phys., 1989. V. 15. 344.