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INVESTIGATION OF Fe_3O_4 COLLOID BEHAVIOUR IN A MAGNETIC FIELD BY POLARIZED NEUTRON TRANSMISSION

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Magnetic colloids exhibit various static magnetic properties [1,2]. They can be explained if the magnetic field induction microdistribution is known. Neutrons are an irreplaceable instrument here, but up to now their utilization has been restricted mostly to small-angle scattering [3-5] techniques. Transmission of polarized neutrons through a sample makes it possible to study magnetic colloids by measuring the beam depolarization from magnetic clusters or by observing the coherent motion of the polarization vector in a magnetic field, which varies over the distance of the sample dimension scale. In this case, the normalized polarization $P_s(\lambda) = P(\lambda) / P_0(\lambda)$ of a beam that was transmitted through the sample is determined by the spin-flip cross-section [6].

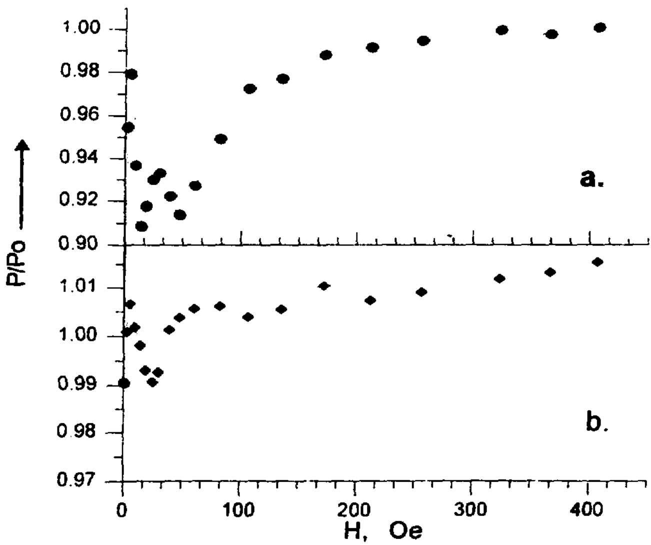

Fig.1. Integral over neutron wavelength interval 1÷12Å polarization P_s via magnetic field : a)-colloid concentration $c = 20\%$; b)-colloid concentration $c = 10\%$

Figure 1a shows $P_s(H)$ for a colloid with a solid phase concentration of $c = 20\%$. $P_s(H)$ has minima at H=15, 45, 130, and 370 Oe. Figures (2a-2c) show the $P(\lambda)$ dependences for the same concentration at H=15, 45, and 130 Oe. Within the interval of 1÷4Å this dependence has a sine character. The sinusoidal period decreases as the magnetic field strength increases. The data presented in Figs. 1, 2 show that a coherent change in neutron polarization takes place.

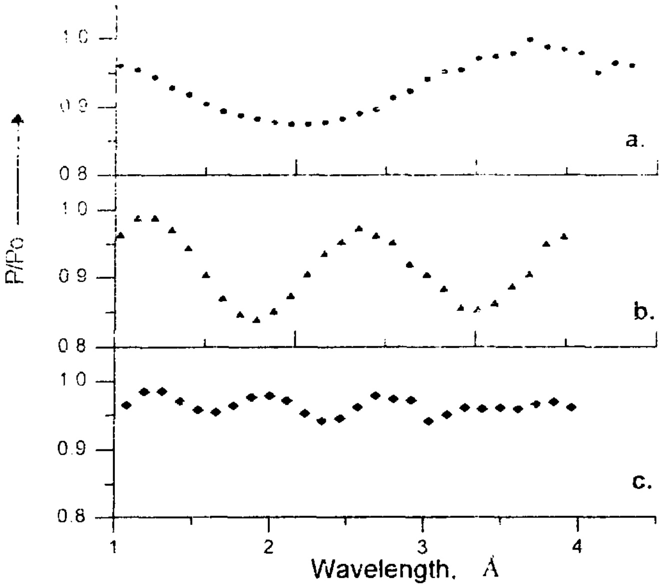

Fig 2. $P_s(\lambda)$ dependence for the concentration c = 20% at magnetic field a) H=15 Oe; b) H=45 Oe; c) H=130 Oe

The picture of a neutron passing through the sample appears to be as follows. At the sample boundary, neutron spin precession arises around the induction vector in the sample because of a jump in induction direction. Inside the induction vector turns slowly, and the precessing spin follows adiabatically. The $P_s(\lambda)$ oscillation period determines the mean magnetic induction within the sample, which allows the elementary magnetic dipole parameters to be evaluated. To do this, we use the Langevin formula for the magnetization, J, of a paramagnet:

$J = J_s c\,(cth X - 1/X)$, where $X = mH_m/kT$, m is the magnetic moment of the dipole, H_m is the local magnetic field, J_s is the saturation magnetization, and c is the spatial concentration. Assuming $H_m = H + (\gamma - N)\cdot J$, where N is the sample demagnetization factor and γ is the factor taking into account the spatial distribution of the magnetic dipoles, we obtain $4\pi J_s c\,(1 - N) = 1.176\ kOe$, $\gamma - N = 0.95$, and $m = 0.95\times10^{[illegible]}\ Gs\cdot cm^3$. These parameter values are in good agreement with the parameters of colloid elementary particles. Thus, for the colloid with a concentration of $c = 20\%$, no clustering was observed for H [illegible] Oe. For c [illegible] 10% (Fig. 1b), the polarization exceeds 1 as the field increases, which seems to be connected with neutron scattering in the lattice formed by dipole chains [7].

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ТЕМАТИЧЕСКИЕ КАТЕГОРИИ ПУБЛИКАЦИЙ ОБЪЕДИНЕННОГО ИНСТИТУТА ЯДЕРНЫХ ИССЛЕДОВАНИЙ

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Докукин Е.Б. и др. E3-94-291
Исследование поведения в магнитном поле коллоида Fe_3O_4 методом пропускания поляризованных нейтронов

Проведены измерения поляризации нейтронов, пропущенных через коллоид Fe_3O_4, в зависимости от внешнего магнитного поля, концентрации частиц в коллоиде и длины волны нейтронов. В магнитном поле до 500 Э наблюдалась прецессия поляризации нейтронов. Определена намагниченность коллоида в зависимости от величины магнитного поля, и проведено сравнение экспериментальных данных с теорией.

Работа выполнена в Лаборатории нейтронной физики им. И.М.Франка ОИЯИ.

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Dokukin E.B. et al. E3-94-291
Investigation of Fe_3O_4 Colloid Behaviour in a Magnetic Field by Polarized Neutron Transmission

Experiments were conducted to measure the dependence of neutron polarization following their transmission through a magnetic colloid on the concentration of magnetic particles, magnetic field strength and wavelength of neutrons. In a magnetic field up to 500 Oe the precession of the neutron polarization is seen. Comparison of the experimental data and theory is made and colloid magnetization is determined. The measurement was carried out with the SPN-1 polarized neutron spectrometer at the high-flux pulsed reactor IBR-2 in Dubna.

The investigation has been performed at the Frank Laboratory of Neutron Physics, JINR.

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