Ferromagnetism in suspension of magnetic platelets in liquid crystal

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Suspensions of nanoparticles in liquid crystals are interesting particularly because of the coupling of the orientational order of liquid crystal with a positional or/and orientational order of nanoparticles. We showed¹ that in ordered nematic liquid-crystalline phase of the suspension of BaHF nanoplatelets doped with Sc in liquid crystal 5CB ferromagnetic ordering appears. The magnetization is along the nematic director and comes from the ferromagnetic ordering of the nanoplatelets. When the sample is prepared in the absence of external magnetic field, two types of magnetic domains appear with magnetizations in opposite directions. If during the preparation external magnetic field along the director is applied, a monodomain sample is obtained. Magnetization curves show that small magnetic field is needed to switch the domains. In samples with low concentration of magnetic platelets the memory of the initial magnetic state of the sample is preserved and after the removal of the external field, the sample relaxes back to its initial magnetic state, while in samples with high enough concentration a complete reversal of magnetization can be observed.

Figure 1: (a) and (b) Switching of ferromagnetic domains in external magnetic field of 3.2 mT parallel to the director. The magnetic field in the images (a) and (b) was applied in opposite directions. (c) The surface domain walls (white lines) that appear during a complete director reversal in a monodomain sample, B = 20 mT.

Switching of ferromagnetic domains can be observed by polarization microscopy. Sample between cross polarisers with nematic director parallel to one of the polarisers appears dark. When external magnetic field is applied along the director, domains with magnetization along the magnetic field remain dark, while domains with the magnetization opposite to the magnetic field become brighter, which can be clearly seen in two images in Figure 1a and 1b, where magnetic field was applied in opposite directions. In the bright regions the director field is deformed. In the samples with high enough concentrations of magnetic platelets the nematic director can be completely reversed by applying strong enough external field (of the order of 10 mT) in the direction opposite to magnetization. In this case the initial deformation of director field disappears and during this complete reversal travelling of the domain walls at sample surface can be observed (Figure 1c).

References:

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