Ferronematics - liquid crystalline sensors of magnetic fields

Peter Kopcansky

Institute of Experimental Physics SAS, Kosice, Slovakia
Email:kopcan@saske.sk

Liquid crystals (LCs) respond very sensitively to application of an external electric field due to the large dielectric anisotropy, whereas they are only weakly sensitive to the magnetic field. A possible way to improving that sensitivity is doping LCs with magnetic nanoparticles (MNPs). As a result, stable colloidal suspensions of LCs with relatively low concentrations of MNPs, called ferronematics (FNs), can be produced. These suspensions are considered to be extremely promising materials, in which the properties of LCs are modified by doping [1]. Therefore, these materials may serve as sensor of small magnetic fields.

In the presentation will be illustrated basic theory with description of these materials, especially many experimental data regarding structural changes so called Freedericksz transitions, effect of shape and size of used MNPs in LCs on structural transitions [2], response of these system to magnetic field especially to linear response in low magnetic field region [3], nematic- isotropic transition (T_{I-N}) in presence of magnetic field as well as the idea how to prepare liquid ferromagnets based on FNs. Behavior of these systems near T_{I-N} in the presence of very small magnetic field opens the doors towards application possibilities such as low magnetic field sensors [4] or basic logical elements for information storage technologies. A new method of detecting low magnetic fields by Whispering gallery mode (WGM) will be also presented. Under the influence of an applied magnetic field the WGM resonances experience spectral shift towards shorter wavelengths. The experimental results demonstrated that the proposed sensor was almost of 3 pm/mT more sensitive for samples infiltrated with rod like and spherical like ferromagnetic suspensions than for undoped liquid crystal sample [5]. This is the way to obtain magnetovision camera with the possibility of mapping the magnetic field in space.

FNs can be also realized on the base of lyotropic LCs (biological e.g.) and MNPs. The possible formation of nematic LC phase in solutions containing lysozyme amyloid fibrils (LAF) and MNPs will be presented. The adsorption has been studied with the aim to order the fibrils in liquid crystal phase by applying external magnetic field [6].

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Structure and Hyperthermia effect in magnetosome solution

Milan Timko
Institute of Experimental Physics SAS, Watsonova 47, 040 01 Košice, Slovak Republic

Magnetosome are "new" biological magnetic nanoparticles which were found as a product of the biomineralization process from magnetotactic bacteria. At present magnetosome are under investigation especially for hyperthermia effect for biomedical applications. This ability depends on the presence of intracellular magnetosome which are composed of two parts: first, nanometer-sized magnetite (Fe_3O_4) or greigite (Fe_3S_4) crystals and second one, the bilayer membrane surrounding the crystal. Interesting is that particles are arranged in the form of chains, which gives unique characteristics. By the changing of conditions during biomineralization process [1] we can observe the increasing of the mean diameter and length of magnetosome chains. On the other hand the sonication and ultracentrifugation processes [2] after isolation of magnetosome we can observe the breaking of the chains and existence the individual magnetosome. The both methods call out the changes in their magnetic and hyperthermic properties. Further research is devoted to study detailed chain structure of magnetosome by using of neutron scattering techniques (SANS and SAXS, respectively) [3]. Experimental results from SANS and SAXS experiments after sonication and ultracentrifugation after isolation indicate the presence of polydispersity of particles in the investigated samples.

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Composite systems based on thermotropic liquid crystals

Natália Tomašovičová

Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovakia

Experimental studies are reported focusing on the dynamic ac magnetic susceptibility of a ferronematic (i.e., a nematic liquid crystal doped with magnetic nanoparticles). It was found that a weak dc bias magnetic field (a few Oe) applied to the ferronematic in its isotropic phase increases the ac magnetic susceptibility considerably. Passage of the isotropic-to-nematic phase transition resets this enhancement irreversibly (Figure 1), but can be reinduced by applying the dc bias field again in the isotropic phase [1]. The effect has no analogue in the neat host liquid crystal. A model based on aggregation and disaggregation of the nanoparticles is proposed as an interpretation. It is demonstrated that tuning the concentration of the magnetic nanoparticles, the range of the dc bias magnetic field to which the ferronematic is sensitive without saturation can be increased by about two orders of magnitude [2]. This finding paves a way to application possibilities, such as low magnetic field sensors, or basic logical elements for information storage.

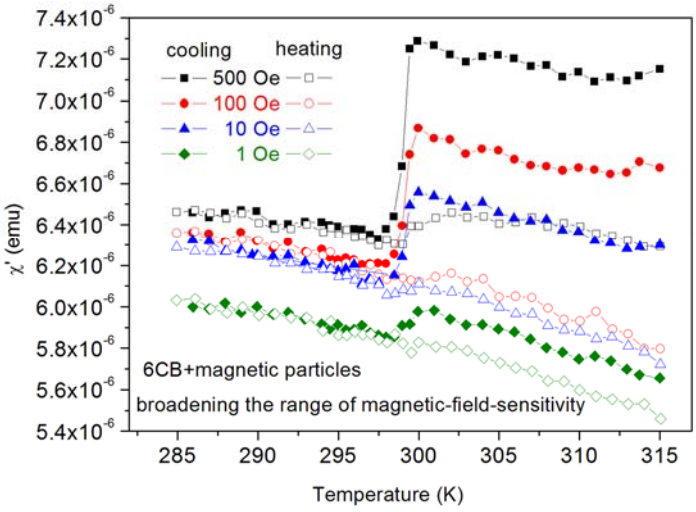


Figure 1. The temperature dependence of the ac magnetic susceptibility of the ferronematic.

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The interplay between mitochondria, oxidative stress and protein amyloid formation
Functional and structural insights into the phospholipid-protein interaction

Andrey Musatov and Katarina Siposova

Department of Biophysics, Institute of Experimental Physics, Slovak Academy of Sciences
Košice, Slovakia

musatov@saske.sk, siposova@saske.sk

Reactive oxygen species (ROS) -induced damage to cellular components is associated with a number of age-related disorders. In fact, one of the most well-known theories of aging is the free radical theory which was proposed by Harman [i,ii]. According to this theory ROS-induced oxidative damage to the mitochondrial components leads to accumulation of dysfunctional or defective mitochondria with age. Because mitochondrial respiration is essential for the energy generation, damage to the mitochondria could result in reduced ATP production and compromised physiological function. In the first part of our presentation we will review a selected research data of the authors regarding the ROS-induced structural and functional alterations within mitochondrial electron-transport proteins: cytochrome *c* oxidase (Complex IV), cytochrome bc_1 (Complex III), NADH dehydrogenase (Complex I), and cytochrome *c*. We will also demonstrate the important role of cardiolipin, a highly unsaturated phospholipid that is susceptible to oxidative damage and may participate in ROS-induced damage. Our current research is focused on understanding the mechanism by which the cell‘s oxidative stress is involved in age-related neurodegenerative diseases. Knowledge of the mechanism of fibrillogenesis is crucial for understanding of pathology, prevention and therapy of age-related disorders, such as Alzheimer’s, Parkinson’s, and others. Particularly important appears to be the interaction of proteins/peptides with membranes and interaction of already formed amyloid aggregates with the membrane components, which can be modified as a result of oxidative stress. In the second part of our talk we will focus your attention on the importance of hydrophobic interaction in the process of protein amyloid formation.

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