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Methods of Neutron Optics fof Studying Physical Properties of Liquids

Tuesday, 24 September 2024 14:30 (40 minutes)

This presentation is aimed at using neutron optics methods to study the physical properties of bulk and confined liquids. To achieve this goal, the defining idea of M.M. Bogolyubov regarding the hierarchy of relaxation times and the sequential description of the dynamic evolution of condensed systems was used [1]. The following results were obtained by the methods of neutron optics [2-6], which apply the Schrödinger equation for the neutron wave function and the Fermi potential depending on the local numerical value of the density of nuclei [2]:

1. For bulk liquids, the singular behavior of the temperature derivative for the diameter of the neutron refractive index (NRI) is theoretically predicted, the main reason for which is a violation of the Polyakov conformal invariance hypothesis on the coexistence curve of a real liquid-vapor system.
2. Due to the spatial inhomogeneity of the bulk fluid near the critical state in the external gravitational field (see, for example, [7,8]), the appearance of a uniaxial ellipsoid of the NRI has been proven (by analogy with the ellipsoid of wave normals in crystal optics). The parameters of such an ellipsoid were determined for a cylindrical volume of liquid with a radius significantly larger than the correlation length of density fluctuations. On the axis of such a cylindrical sample, the uniaxial NRI ellipsoid becomes the NRI sphere.
3. Different signs of the coherent scattering length of the components of the solution of liquids predict the phenomenon of zero refraction of the neutron beam, which resembles the zero optical activity of a racemic mixture. Theoretical calculations established that for a binary solution of ethane and carbon dioxide, the phenomenon of zero refraction of the neutron beam should take place in the solution of [6].
4. It was theoretically established that the temperature dependence of the peak width of quasi-elastic scattering of slow neutrons is quantitatively confirmed by experimental results for confined supercooled water with spatial dimension d = 2 near its lower critical temperature T = 2280C [9].
5. Using Mandelbrot's formula [10] for the fractal dimension, it was proved that the dependence of the cross section of the elastic neutron scattering, being proportional to the random mean-square fluctuation of the number density of nuclei, on linear sizes of a confined liquid volume is determined by a new critical index, which is equal to the fractal dimension. For systems that belong to the universality class of the Ising model in a magnetic field, the fractal dimension values are 1.875 and 2.482, respectively, for spatial dimensions d = 2 and d = 3 [11].
6. It has been proven that the method of quasi-elastic neutron scattering [4,6] makes it possible to create a reliable basis for new diagnostic tests of the carcinogenesis process based on the established correlation between the self-diffusion coefficient of water molecules in aqueous suspensions of plasma membranes and the sensitivity of different groups of tissues to anticancer drugs [12]. Another biomedical application of neutron optics methods is the calculation of NRI and refraction of a neutron beam in an aqueous suspension of proteins and lipids.

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