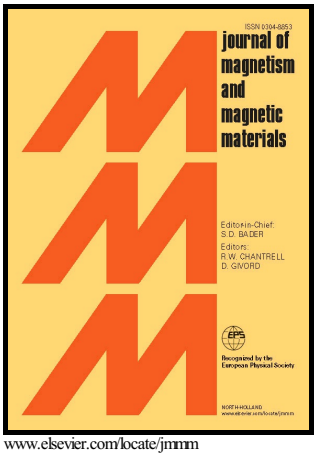

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Mechanics of Magnetic Fluid Column in Strong Magnetic Fields

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Abstract: Elastic-and magnetic properties of magnetic fluid confined by ponderomotive force in a tube fixed in horizontal position are considered. The system is placed in a strong magnetic field under the influence of external static and dynamic perturbations. An experimental setup has been developed. A theoretical basis of the processes of magnetic colloid elastic deformation has been proposed. The values of the static ponderomotive elasticity coefficient and the elasticity coefficient under dynamic action are experimentally determined. The calculations of the saturation magnetization for two magnetic fluid samples, carried out according to the equation containing the dynamic elasticity coefficient, are in good agreement with the experimental magnetization curve. The described method is of interest when studying magnetophoresis and aggregation of nanoparticles in magnetic colloids.

Keywords: magnetic fluid, viscosity, static ponderomotive elasticity coefficient, hydrostatic pressure, saturation magnetization.

INTRODUCTION

STATICS

A magnetic fluid (MF) is a unique artificially synthesized technological material, which has flowable and magnetic-field controlled properties. They have broad application prospects in engineering, medicine, biology, and ecology. In many respects, they got their widespread use due to the possibility of controlling their physical parameters. One of the most important fact is that magnetic fluid position remains fixed when viscosity is almost unchanged under the influence of external magnetic fields. The most common method of measuring MF's viscosity is the use of Brookfield viscometer [1, 2]. In some works U-shaped systems applications are found [3, 4]. Many common engineering systems using MFs such as sensors, dampers, seals, etc. are based on linear oscillations of MF-column in a magnetic field. The design of many devices using MFs involves the impact of non-uniform magnetic field on the magnetic colloid drop, i.e. the influence of ponderomotive force, which becomes evident when a drop is displaced from its equilibrium position. Such devices are oscillatory systems, wherein the MF acts as an inert-viscous element. For both theoretical and practical applications, it seems appropriate to study the role of magnetic insertions in oscillations damping and to find out how to control this process using magnetic field.

In this regard, it is of great importance to study elastic and magnetic parameters of MFs confined by ponderomotive forces in a tube placed in horizontal and vertical positions in a strong magnetic field. These parameters include oscillation frequency, magnetization curve, as well as magnetic field intensity and its gradient. It should also be noted that the parameters, which can influence the physical mechanisms of static elasticity such as compressibility, density, and thermal conductivity, of magnetic colloids, are essentially independent of the magnetic field intensity and the degree of its non-uniformity [5].

EXPERIMENTAL BASE

An experimental setup to determine dynamic action was developed to carry out the experiment. It was designed to measure the frequency of free damped MF-column oscillations. It is shown in Fig. 1a. We used a laboratory electromagnet FL-1. The transparent tube 1 is fixed between the pole tips by means of the holding device 6. The tube axis passes through the center of the pole gap and is parallel to the surface of the pole tips; the tube axis crosses the axis of the pole tips at right angle.