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MAGNETIZATION CURVES OF BUBBLE LATTICES IN GARNETS[1])

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The paper presents experimental results of the magnetization as a function of the external field applied normal to the surface of garnet samples of composition $(YSmLuCa)_3(FeGe)_5O_{12}$. A discontinuity in the magnetization was observed at a certain negative value of the applied field, pointing to an anomaly in the existing honeycomb domain structure. The theoretical explanation presented is based on the interaction of double Bloch walls and/or on the aproach to saturation of a stripe domain structure.

КРИВЫЕ НАМАГНИЧИВАНИЯ РЕШЕТОК ЦМД В ГРАНАТАХ

В работе представлены экспериментальные результаты измерений намагниченности как функции внешнего магнитного поля, перпендукулярного к поверхности пленок гранатов с химическим составом $(YSmLLuCa)_3(FeGe)_5O_{12}$. Обнаружен скачок намагниченности при определенной величине отрицательного поля, свидетельствующий об аномалии существующей сотовой доменной структуры. Теоретическое объяснение результатов основано как на взаимодействии конечных Блоховских стенок (двойные стенки), так и на модели коллапса страйп-структуры вблизи насыщения.

I. INTRODUCTION

The magnetization curve measurements (i.e. $m = M/M_s$ versus $h = H/M_s$) were performed on garnet layers of composition $(YSmLuCa)_3(FeGe)_5O_{12}$ by magnetooptical equipment. The bubble lattice was created and the magnetic field perpendicular to the sample surface was increased in $(h<0)$ or opposite to $(h>0)$ the magnetization inside the bubbles. At a certain negative value of the field we observed a jump in the magnetization, which indicates an anomalous behaviour. The measurements were performed on many samples, but we present only curves and theoretical results for a typical sample.

The theoretical explanation of this jump is based on the interaction of finite Bloch walls and/or on an approximation of the magnetic structure by stripe domains near saturation.

II. EXPERIMENT

The magnetooptical equipment consists of a light source, condensing lens, monochromatic filter, polarizer, magnetizing coil with the sample, analyser and photomultiplier. The voltage from the photomultiplier is led to the y-axis, that proportional to the magnetic field to the x-axis of an x-y recorder.

The magnetization curves of a closed packed hexagonal array of bubbles were measured for *virginal* bubbles and for bubbles at *equilibrium*. The *virginal* bubble lattice was created by demagnetizing from saturation in a field oriented a few degrees with respect to the sample surface. The characteristics of this lattice are: irregularity of structure, non-uniform diameters of the bubbles and a larger bubble density as compared with the density at minimum energy. The *equilibrium* lattice was obtained from the virginal one by exposing it to a magnetic field in opposition to the magnetization of the bubbles, having an intensity of about 90 % of the collapse field. Part of the bubbles collapsed, thus lowering the density. The regularity of the structure is improved by adding an a-c field component.

The starting point of each measurement is the remanent state and the field is increased in or opposite to the magnetization in the bubbles. At the end of the measurement the magnetization curve of stripes is recorded to determine the zero of magnetization.

III. THEORY

The theories of magnetization processes in periodic domain structures were developed for stripe domains in [1, 2], for lattices in [3, 4, 5]. Increasing the field opposite to the magnetization inside the bubbles decreases their diameter, the bubbles collapse and the sample saturates. Increasing the field in the other direction their diameter increases, the bubbles change their shape to honeycombs and their size goes on increasing. On reaching a certain value of $h = h_j$ for originally equilibrium bubbles (in our sample $h_j = -0.258$) the structure loses its periodicity — some domains grow, some disappear and the structure looks like a partly torn fishing-net.

None of the existing theories of bubble and honeycomb structures predict such a behaviour. The need for their extention by terms describing the actual situation is evident. Since the domains magnetized opposite to the field are narrow near h_j the interaction between neighbouring Bloch walls was taken into account [6, 7]. The well known total energy density (sum of the wall energy, demagnetizing energy and

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the energy in the applied field) must be supplemented by the interaction energy of two Bloch walls which to first approximation can be written [6]

$$E_{w,int} = -2\sigma_w \exp\left(-(a-d)/\delta\right) .$$

Solving the minimalization energy problem (with respect to d — since according to the experiment a is constant for equilibrium bubbles for $h > h_i$) by means of a computer, we obtain a qualitative agreement with the experiment — the existence of a jump in magnetization for the field $h_i = -0.354$.

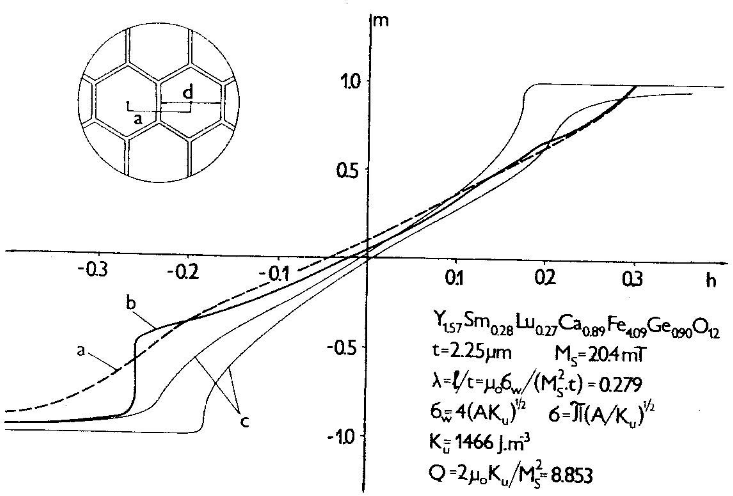

Fig. 1. Measured magnetization curves for virginal lattice (a), equilibrium buble-honeycomb lattice (b), stripe domains (c).

In the other approach we approximate the actual situation by a stripe structure near saturation (domains magnetized opposite to the field are narrow) and use expressions for the energy of stripes [2] in the limits $M \to M_s$ and $Q \to \infty$ [8, 9]. We obtain a system of two simultaneous equations and solving them a curve of stripe collapse field h_{scol} versus characteristic length λ. For the given value of $\lambda = 0.279$ we get $h_{scol} = -0.230$, which is in better agreement with $h_i = -0.258$ than the previous approach.

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