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Dynamics of Domain Walls in Iron Borate and Yttrium Orthoferrite in Alternating and Constant Magnetic Fields

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The velocity of domain wall in iron borate and yttrium orthoferrite as a function of a driving alternating magnetic field with a constant magnetic field present is experimentally investigated.

Keywords: Weak ferromagnets, Yttrium orthoferrite, Iron Borate, Domain walls, Helmholtz coils.

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1. INTRODUCTION

Nonlinear dynamics of magnetic domains is not only of a scientific interest but also of important practical application; therefore, interest in them has persisted for many years.

Dynamics of domain walls (DWs) in ferromagnets is significantly affected by anisotropy – both crystal and artificially created [1, 2].

Anisotropy due to surfaces limiting the size of the crystal (films, wire) not only influences on mobility [2] but also can stabilize DW, which results in great speeds at application of a driving magnetic field parallel to magnetic momentum [3]. Anisotropy caused by application of an additional constant magnetic field perpendicular to the driving magnetic field also provides such results [4].

Theoretical consideration of influence of an additional magnetic field involves a lot of difficulties that stem from the absence of data about magnetic momentum dissipation. At the same time in many experiments with weak ferromagnets there is a gradient magnetic field that makes DW to restore to the equilibrium state [5-13]. The influence of a gradient magnetic field on dynamics of DW in rare-earth orthoferrites is considered in [14].

2. EXPERIMENTAL

We measured the amplitude of the DW shift using the magneto-optical Faraday effect in single crystal plates (thickness 0.1 mm) under a sinusoidal magnetic field without gradient magnets. Visualization of domain structure and investigation of its dynamics was conducted according to methods given in [5, 6, 15, 16] with the use of visible band radiation. In $YFeO_3$ dynamics of two-domain structure with a single straight DW in plates cut perpendicular to the optic axis was investigated. In $FeBO_3$ dynamics of multiple domain structure was studied in plates grown in basal plane. Magnetic fields of a sinusoidal form with a frequency of up to 200 kHz and an amplitude of up to 100 Oe causing shift of the DW with respect to the equilibrium state were produced by Helmholtz coils. The shift amplitude of DW was measured at the intensity of the penetrated radiation using the signal from a photodiode or recorded with computer processing of an averaged image. The velocity amplitude was computed assuming its sinusoidal dependence similar to [15].

3. RESULTS AND DISCUSSION

Figure 1 shows the velocity amplitude of DW as a function of the amplitude of a sinusoidal magnetic field $\tilde{H}_m$ in iron borate (without gradient magnets) applied in the sample basal plane with a constant magnetic field H that was also applied in the same plane perpendicular to the driving field.

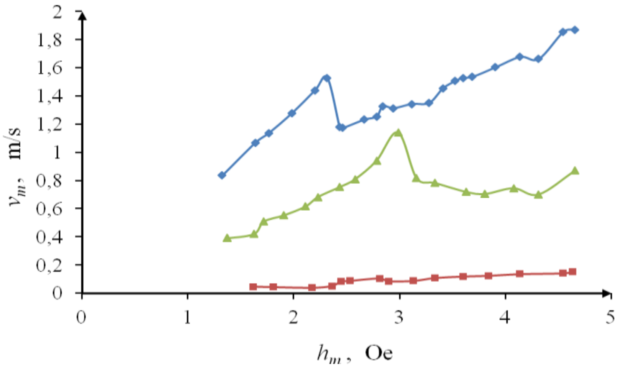

Fig. 1 – Dependence $v(h_m)$ at a frequency f = 10 kHz in $FeBO_3$ sample at a constant magnetic field H = 0(♦), H = 1.9 Oe (▲), H = 6.8 Oe (■)

It follows from Fig. 1 that with increasing constant magnetic field H the DW velocity is reduced. Also, it is seen from Fig. 1 that (without constant field) there is a jump in velocity at h_m = 2.3 Oe. Application of a constant magnetic field H causes this jump to shift to grater amplitudes h_m = 3 Oe. At H = 6.8 Oe the jump virtually vanishes. The jump may be relevant to the arrangement of domain structure. In this case one can say about stabilization of domain structure by constant magnetic field.

In Fig. 2 shown are amplitude-frequency dependencies of DW velocity for yttrium orthoferrite in a driving sinusoidal field with an amplitude H = 38 Oe at a constant magnetic field H directed along the DW motion in the sample plane.

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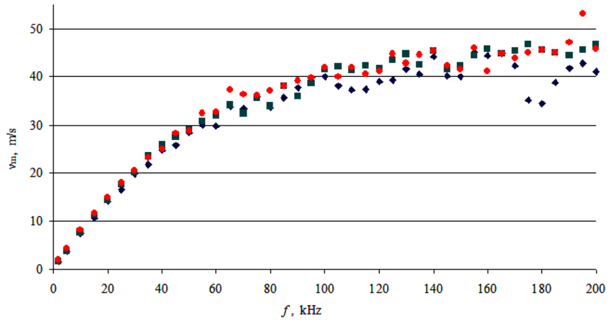

Fig. 2 – Velocity amplitude of DW as a function of the driving magnetic field amplitude at a frequency $f = 20$ kHz without (◆) and with transversal magnetic fields of 3.3 Oe (■) and 27 Oe (●)

An increase of the DW velocity with frequency occurs in accord with theory [17]. Figure 2 also shows that the effect of a constant magnetic field in yttrium orthoferrite is much weaker than in iron borate.

Thus the effect of constant magnetic fields on dynamics was studied for iron borate and yttrium orthoferrite in weak magnetic fields, which do not require the application of gradient magnets.

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