Kink on the domain wall in orthoferrite

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It is shown that a kink propagates along the domain wall in yttrium orthoferrite, moving at the velocity of sound, under conditions of high mobility. The velocity of the kink can attain the limiting value of 20 km/sec. The kink appears due to the strong instability of supersonic motion and the absence of hysteresis in the magnetic field dependence of the velocity.

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In recent years, interest in investigations of nonlinear magnetization waves in ferromagnets has increased. In this paper we show that a kink, whose velocity attains 20 km/s, can propagate along a domain wall in yttrium orthoferrite moving with the velocity of transverse sound. It was shown in Refs. 1 and 2 that in passing through the velocity of transverse sound, a rectilinear domain wall in yttrium orthoferrite is distorted and semicircular leading sections appear on it. As the mobility of the domain wall is increased, this process becomes more distinct and the motion of the domain wall at a velocity exceeding 4 km/s is nonstationary. A theoretical analysis shows that the transient nature is due to the negative differential mobility.[3,4] The formation and motion of a kink on the domain wall is illustrated in Figs. 1a-1d. Each figure shows two sequential positions of the domain wall in a $YFeO_3$ plate with a thickness of 100 μm, perpendicular to the optic axis, at 110 K. The photographs were obtained using the Faraday effect and two 1-ns pulses of light spaced 5-ns apart. The region traversed

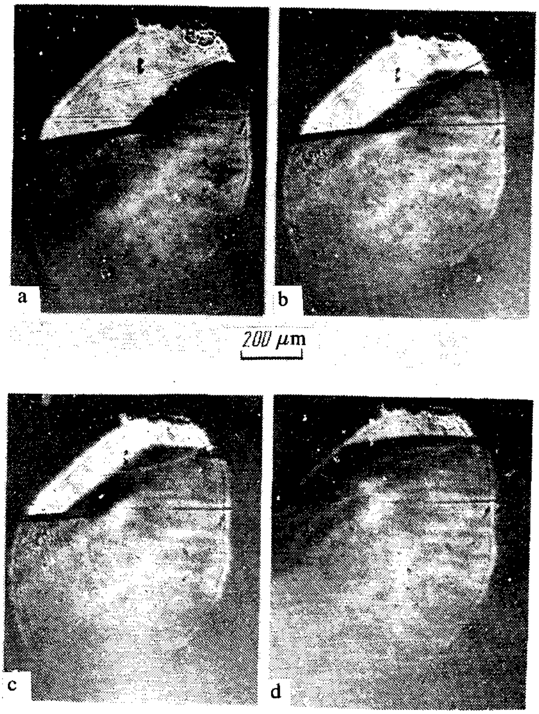

FIG. 1. Photograph of two sequential positions of a kink on a moving domain wall in yttrium orthoferrite, taken every 5 ns in a 140-Oe pulsed magnetic field at 110 K. The time interval between successive photographs is ~3 ns.

by the domain wall in 5 ns is represented in the figure by the dark band. For this purpose, a separate polarizer is used in each of the two light beams.[5] The left part of the domain wall always remains rectilinear and moves at the velocity of transverse sound 4 km/s. A semicircular formation forms on the right side of the domain wall; the velocity of the top of the formation greatly exceeds the velocity of transverse sound in Fig. 1a. However, after 5–10 ns, the velocity of this section again decreases to 5 km/s, which is indicated by the width of the dark bands, delineated by the domain wall on the right side of the figure within 5 ns (Figs. 1b-1d). A kink moving from right to left appears on the domain wall moving at the velocity of transverse sound. The 20-km/s velocity of the kink can easily be measured from two successive positions of the dynamic domain structures in the figure. The sharpening of the kink as it moves from right to left is also clearly visible in the figure. The kink forms in magnetic fields ranging from 100 to 140 Oe. The appearance of the semicircular formation on the domain wall as it passes through the velocity of sound is a random process, which can appear at any point on the domain wall. If it arises at the center, then two kinks moving in opposite directions form simultaneously. The kink forms according to the following mechanism. A single-domain wall is created in the specimen with the help of a gradient of a magnetic field perpendicular to the surface of the specimen, grad $H = 300$ Oe/cm. A moving pulsed magnetic field is superimposed on this field and, as the domain wall moves, the field acting on it gradually decreases in a linear manner. This process causes the domain wall to be gradually immersed into the total magnetic field corresponding to the field of its nonstationary motion at a supersonic velocity. Under the action of the gradient of the magnetic field the domain wall again moves at a velocity of 4 km/s. The kink forms with magnetic fields of about 30 Oe. The amplitude of the kink decreases with increasing gradient of the field. In this case, the transient nature of the formation of the leader sections along the domain wall increases. The velocity of the kink along the domain wall in orthoferrite moving at the velocity of transverse sound must not exceed the velocity of the flexural wave along it. Bar'yakhtar *et al.*[3] and later Zvezdin *et al.*[7] showed that the velocity of the flexural wave on the domain wall is equal to the limiting velocity of the domain wall V_s, which coincides with the phase velocity of volume spin waves on the linear section of their dispersion curve. On the whole, the domain wall with the kink moving along it is a complicated dynamic object whose mass varies along its length. We have here essentially a kink on a kink. Our experiment shows that with the transition through the velocity of transverse sound, the motion of the domain wall is very unstable, especially with maximum mobilities, attaining 2×10^4 cm·s^{-1}·Oe^{-1}. The transition from motion at a velocity of 4 km/s to motion at a velocity of 14 km/s and back again indicates that the motion at these velocities is transient in nature and that there is no hysteresis in the dependence $V(H)$. In magnetic fields 140–200 Oe, the domain wall moves in a stationary manner at a velocity of 14 km/s. As the field is increased further, it reaches the limiting velocity V_s of 20 km/s. Superlimiting velocities are not observed up to magnetic fields of 5 kOe. The report of such a velocity in Ref. 6 is apparently attributed to the appearance of new domains in front of the moving domain wall in high pulsed magnetic fields. Thus a method is proposed for obtaining a kink on a moving domain wall, which is also effective in the region of other nonstationary formations. The absence of hysteresis on the $V(H)$ curve observed in the experiment at 110 K requires additional theoretical analysis. It would be worthwhile to trace the motion of the kink after the magnetic field is abruptly removed.

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