Magnetic Domains on Silicon Iron by the Longitudinal Kerr Effect*

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Use of the normal Kerr magneto-optic effect to observe domain patterns in ferromagnetic substances having free surface poles has been described by Williams, Foster, and Wood.[1] Since plane polarized light reflected normally from a polished magnetic surface is not affected by magnetization in the plane of the surface, oblique reflection using the longitudinal Kerr magneto-optic effect[2] has been investigated as a means of observing domains in a single crystal of silicon iron where the magnetization is in the plane of the crystal surface. The plane of polarization of the reflected light suffers a positive or negative rotation depending upon the direction of magnetization. For magnetic saturation this rotation amounts to about 4 minutes at an angle of incidence of 60°. Ambiguity with the transverse Kerr effect is avoided by polarizing the light at right angles to the plane of incidence, for which direction the transverse Kerr effect is zero.[3]

Two methods have been used to observe domain structure on the (100) surface of the silicon iron crystal. Observations of Kerr effects over local portions of the surface have been made by illuminating the surface with a small optical probe, passing the reflected beam through a nicol analyzer set about 2° from extinction, and measuring the intensity of the transmitted light with a sensitive multiplier phototube circuit. A traverse of the crystal in an unmagnetized state with a 0.5-mm probe of light, when compared with a similar traverse after application of a small external field, indicates those regions in which there has been a change in surface magnetization. Figure 1 is the result of such analysis for traverses in the [001] direction across the central portion of the (100) surface.

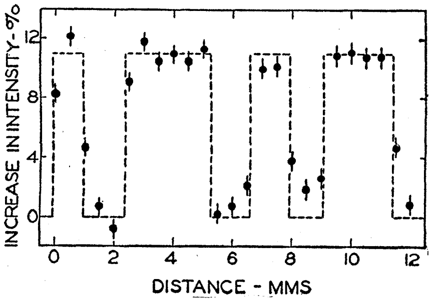

FIG. 1. Percentage increase in transmitted light with magnetization of silicon iron crystal along a line through the center of the crystal in the [001] direction. The broken line indicates the domain configuration suggested and substantiated in (b) of Fig. 2.

Since the contrast between regions magnetized in antiparallel directions is about 10 percent, photographic observations are possible with a suitable optical system. Figure 2 shows oblique photographs of the crystal with the same domain arrangement as that scanned photoelectrically. (a) and (b) differ 180° in the position of the crystal, resulting in the reversal of the relative intensities of adjacent domains. (c) is the result of magnetizing the crystal along the direction of the original domains, namely the [010] direction. This is the long dimension of the crystal although it appears otherwise because of the angle at which the picture was taken. While the crystal was electro-polished to a mirror surface, oblique photography and the need for increasing the contrast in development and printing have magnified surface imperfections and resulted in its rough appearance.

It is interesting to note that a particular domain pattern is generally quite stable and persists indefinitely under normal conditions of handling. Magnetization and subsequent demagnetization generally result in different domain bands, always parallel to the long side of the crystal surface. There is some evidence, however, that patterns may eventually reoccur.

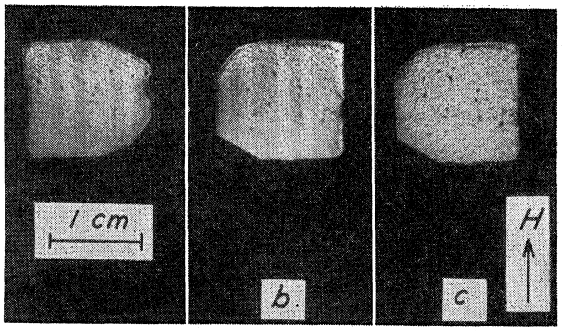

FIG. 2. Oblique photographs of the (100) surface of the crystal. In (a) and (b) the crystal is unmagnetized. An external field in the direction shown was applied in (c).

Results seem comparable with the magnetic powder patterns obtained by Williams, Bozorth, and Shockley[4] although we have not yet employed their method on this particular crystal.

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[3] L. R. Ingersoll, Phys. Rev. **35**, 312 (1912).

[4] Williams, Bozorth, and Shockley, Phys. Rev. **75**, 155 (1949).

[5] H. J. Williams, Phys. Rev. **52**, 747 (1937).

The Occurrence of Heavy Mesons in Penetrating Showers*

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In the course of a cloud chamber study of penetrating showers, two events have been observed which probably represent the decay in flight of τ-mesons,[1] and one event which probably represents the decay in flight of a κ-meson.[2]

One of the τ-meson decays is shown in Fig. 1. The particle enters the chamber at the top, traverses the 2.5-cm lead plate with no detectable deflection, and decays in the lower section of the chamber into three charged particles. All of the tracks except that of the left-hand secondary are at, or very near, minimum ionization; the ionization of the latter secondary is estimated to be 1.4–2.2 times minimum. The momentum of the τ-meson, based upon its curvature in the 5000-gauss magnetic field, is 600 ± 100 Mev/c, and the momenta of the three secondary particles are, from the left to right, 155 ± 30, 350 ± 75, and 210 ± 50 Mev/c. The masses of the secondaries are therefore $350\pm75\ m_e$, less than $600\ m_e$, and less than $300\ m_e$, respectively, and are thus all consistent with π-mesons, but none can be a proton. Charge is conserved, and the measured momenta are consistent with conservation of momentum in the decay. The mass of the τ-meson, calculated from the above momenta, is about $975\ m_e$, which corresponds to an energy release of about 75 Mev.[1] It would be extremely difficult to interpret this event as a collision phenomenon.

The second τ-meson decay is similar in appearance to the above one, but the momenta are higher, making the mass limits on all of the particles less sharp. Both of these τ-mesons, which are the only ones we have so far observed to decay, travel much farther inside the chamber before decaying than do V-particles; this suggests that their mean life is considerably longer than that of V-particles—perhaps 10^{-9} sec or even longer.

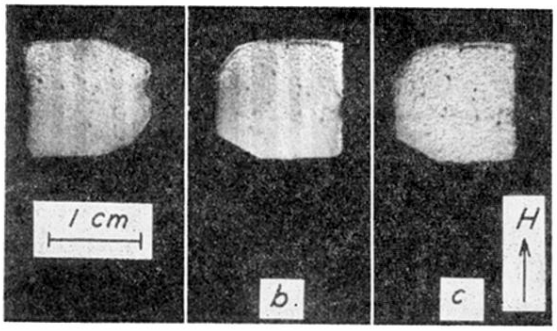

FIG. 2. Oblique photographs of the (100) surface of the crystal. In (a) and (b) the crystal is unmagnetized. An external field in the direction shown was applied in (c).