

It is also important to note another aspect of this model. At the very high temperatures, $T \geq 10^{13}$ °K, at which these reactions occur, pair production of baryons may increase the density substantially. Under these conditions the Fermi temperature $T_f \approx 10^{-13} T^2 (M_n/M_b)$, where M_n is the neutron and M_b the baryon mass. Thus neutrons will not become degenerate until $T \approx 10^{13}$ °K. If quarks are to combine at this or higher temperatures, the quark-baryon mass defect would have to be sufficiently large to release a Fermi energy of about $10^{-26} T^2 (M_n/M_b)$ GeV. Another effect which may become important at high densities is induced if the effective quark radius is much smaller than that of the baryon. In order to create a space Δv for the newly formed baryon, an amount of energy approximately equal to the work $p\Delta v$ must be liberated, where p is the local pressure. Were the mass defect unable to supply the required energy, quark combination would have to be balanced by processes which reduced the local pressure. For quark masses of the order of a few GeV, this also becomes important at temperatures of about 10^{13} °K and such quarks would not be expected to combine at earlier phases of the expansion, except possibly to form a statistical equilibrium with baryons. At these high temperatures there may also be pair production and annihilation of quarks. Such considerations provide relations between quark mass and temperature, and the resultant time-scales for evolution will also be affected by anisotropy and inhomogeneities.

If quark combination from an initially cold universe is responsible for the radiation field, the effects of degeneracy and pair production are less important. In an oscillating universe, the role of quarks may be to exchange energy between the matter and the radiation field during dense phases. Such an exchange, if irreversible, could lead to a damping of the oscillations. The discovery of quarks and their properties may well provide further constraints on theories of the early stages of an expanding universe.

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THE SOLID STATE

Simultaneous Magneto-optic Recording of Hysteresis Loops from Both Surfaces of a Magnetic Film

MAGNETIZATION reversal processes in thin magnetic films have been extensively investigated in recent years. The usual techniques adopted for the display of hysteresis loops have been based on the use of a pick-up coil to detect dM/dt , as described in detail by Crittenden *et al.*^{1,2}

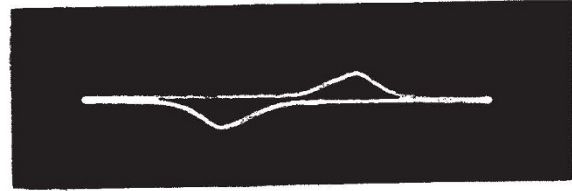


Fig. 1

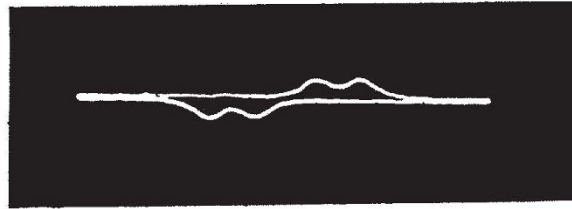


Fig. 2

More recently, use has been made of the magneto-optic effects and, in particular, Green and Thomas³ have developed a simple technique in which hysteresis loops are obtained using the transverse Kerr effect in the infra-red. With a 50 c/s drive field reversing the magnetization, the intensity changes in the reflected beam are detected by a phototransistor and then amplified.

This technique is being used in investigations of cobalt films in the thickness range 500–4000 Å produced by evaporation on to glass substrates (10–20 Å/sec) and some of the results have already been reported elsewhere⁴. The simplicity of the method has now permitted simultaneous investigations of the magnetization changes occurring at both surfaces of a single film.

In the case of the thinner films (< 2000 Å) the signals detected from each side appear identical. For the thicker films, however, differences are apparent in the signals obtained from each side. This effect first becomes noticeable at a thickness of about 2000 Å and is very pronounced at about 4000 Å. Figs. 1 and 2 show the signals of dM/dt versus drive field taken from the free surface and the substrate surface respectively of a 4000 Å film. It is clear that the reversal process is different at each surface and, furthermore, preliminary results indicate that the effect is dependent on the orientation of the film with respect to the drive field.

Simultaneous recording in this fashion should find useful application in investigations of multiple films.

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Synthetic Single Crystals of Graphite

THE formation of Kish graphite in iron/carbon is well known¹, and reports have appeared of the growth of usable single crystals of graphite at 3,200° C in these systems². Such crystals have not had the benefit of formation at a high temperature, so that in order to produce