Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Magnetostriction of Diamagnetic Substances in Strong Magnetic Fields.

THE change in shape of a body, when magnetised, may be accounted for by two causes. First the stresses produced by the magnetic forces act on the magnetic poles of the magnetised body. This effect, which we shall call the *classical magnetostriction*, is in a given magnetic field completely determined by the magnetic susceptibility and the elastic constants of the body. In general it will result in a contraction for diamagnetic substances and an expansion for paramagnetic ones. The classical magnetostriction is very small even for a strongly diamagnetic substance like bismuth, where $\delta l/l$ in a field of 300 kilogauss is only $1\cdot3\times10^{-6}$. It is evident that the discovery of an effect of this order would amount to a verification of the classical theory of magnetisation and would afford no new information on the property of the substance.

On the other hand, in a sufficiently strong magnetic field we must expect another phenomenon to happen, namely, an observable change of the shape of the body which is due to the distortion produced by the field on the binding forces between the atoms. This we shall call the *atomic magnetostriction*. After the modern picture (Heitler and London) of the homopolar binding forces which are essentially of an electrodynamical origin, such an atomic magnetostriction must occur in metals and other homopolar substances. The question is only of the magnitude of the phenomena, which probably must be small as it has not yet been observed in dia- or para-magnetic substances in weak magnetic fields.

To find whether such magnetostriction occurs in strong magnetic fields, such as are available in our laboratory (*Proc. Roy. Soc.*, **115**, p. 568; 1927), a special method has to be developed, since the field can be produced only for a very short time, during which the experiment has to be performed. We were successful in devising a method which enabled us to observe changes of length of the order of 10^{-7} occurring in a rod, placed in the coil parallel to the lines of magnetic force, the duration of the field being about a hundredth of a second and its magnitude up to 300 kilogauss. This method proved to be very accurate, since, when the experiment is performed in one-hundredth of a second, the disturbances produced by accidental thermal variation in length of the rod are negligible.

The first substance which was investigated was an extruded bismuth rod, and it showed a small contraction which was only slightly larger than that expected on the classical magnetostriction. But when the bismuth rod was grown in a crystal a larger effect was easily observed, which could be due only to the atomic magnetostriction. A more detailed investigation showed that, when the trigonal axis was parallel to the field the rod expanded; when the axis was perpendicular to the field the rod contracted. The contraction and expansion in the same magnetic field are practically equal, so that in an extruded polycrystalline rod they compensate each other, and this accounts for the absence of the effect as observed with this rod. We were also able to trace an atomic magnetostriction in other diamagnetic substances besides bismuth, but the effect was about ten times smaller and more difficult to study. We have therefore chosen bismuth as the first to be studied more carefully. The experiments are still in progress, but it seems clear that at room temperature the contraction and elongation vary according to a square law with the field, and in a field of 300 kilogauss the length changes by 5×10^{-5} (larger than is observed in ferromagnetic substances). The temperature has a strong effect, and at the temperature of liquid nitrogen the atomic magnetostriction increases several times.

These results explain why the previous attempts to find magnetostriction in bismuth failed (E. Van Aubel, *Phys. Rev.*, **16**, 60; 1903). In this experiment the largest field used was only 3 kilogauss, so that even with a crystal of bismuth the magnetostriction will be only 5×10^{-9}, but as actually polycrystalline rods were used, the effect will be only of the order of 10^{-10}, and this is too small to be measured.

The general picture of the phenomenon appears to be as follows. The cell of a bismuth lattice is very similar to a cube slightly pulled out along one of its long diagonals, which coincides in direction with the trigonal axis. In a magnetic field apparently the cube becomes still more stretched in the same direction.

From the general theory of magnetostriction (Helmholtz, *Ann. de Phys.*, **13**, 385; 1881) we must necessarily expect that such a deformation of the lattice if produced by pressure will result in an increase of the diamagnetic susceptibility perpendicular to the crystal axis and in a decrease along the axis.

The main physical interest of the phenomenon is that it may conceivably throw more light on the nature of the homopolar bonds. At present, from the general aspects of the phenomenon in bismuth, it is probable that under the influence of the magnetic field the bonds between the atoms which lie farther apart weaken, whilst those of the closer atoms are strengthened. If this view is correct, we must expect to observe larger atomic magnetostriction in the substances where the atoms are not symmetrically bound, such as tin, tellurium, graphite, and others.

P. KAPITZA.

Magnetic Laboratory,
Cavendish Laboratory,
Cambridge, June 21.

A New X-ray Effect.

IT is a remarkable but as yet imperfectly understood fact that crystalline graphite has a diamagnetic susceptibility many times greater than that of carbon in other forms, either by itself or in combination. In the hope of elucidating this phenomenon, we were led to make a careful study of the X-ray diffraction patterns of purified graphite, using a narrow pencil of the *K* radiation of copper, and taking special pains to avoid fogging of the plate in the vicinity of the primary beam, either by stray radiation or by photographic halation. The diffraction photographs obtained with powdered graphite in this way show a new and hitherto overlooked phenomenon (Fig. 1). We find a notable amount of scattered radiation in the area surrounding the primary beam, terminating sharply at the first diffraction ring, and reappearing with a much smaller though quite sensible intensity in the area between the first and second diffraction rings.

These observations contradict the general belief that crystals or coarsely crystalline powders do not show any appreciable X-ray scattering at small angles with the primary beam (Hewlett, *Physical Review*, **20**, 688; 1922). Our experiments show the effect to become distinctly more noticeable when graphites of