1. THE PRODUCTION OF AND EXPERIMENTS IN STRONG MAGNETIC FIELDS

In the light of modern knowledge we take it that the structural character of the atom is of an essentially dynamic nature: that is, the atom consists of a system in which moving charged bodies move round a central nucleus, the properties of the atom being wholly dependent on the number and orbits of the electrons. We therefore see that these properties, for instance the magnetic moments, coherence forces, spectra, etc., may be changed if we can find a means of disturbing the motion of the orbital electrons. The most efficient way of doing this is by subjecting the atom to an outside magnetic force.

The internal magnetic field produced in the atom by the motion of the electrons in their orbits is of very great magnitude, but should it be possible to obtain an external field of the same magnitude it is obvious that the motion of the electrons would be altered very considerably as the coupling energy between them will be of the same order as the perturbation produced by the field; we should then expect to get some very significant results. However, when we come to consider the order of the fields inside the atom, we find that even for the most loosely bound electrons it would be in the neighbourhood of 1,000,000 gauss. As such a field would be about 30 times larger than is usually available in laboratory work the object of my research has been to develop a method for obtaining fields of this order.

The usual way of generating a strong magnetic field is by means of an electromagnet, but the field is strictly limited owing to the fact that the iron gets saturated. An increase in strength can only be brought about by an enormous increase in the weight of the magnet and of the current used. The largest electromagnet ever built is that of Professor Cotton; the diameter of the iron cores is about 1 metre, between the pole pieces there is room for a man to stand, and an immense current is required. The magnetic field only increases very slowly with increasing size of the electromagnet, and even Professor Cotton's magnet will not produce a field much stronger than 60,000 gauss in a space sufficiently large for experiments.

Text of a lecture of 27 February, 1931, from Transactions of the Oxford University Junior Scientific Club, 5th series, no. 4 (October 1931), 129-133.

P. L. Kapitza, Experiment, Theory, Practice
A more successful method was found to be with a coil. Very large currents are required as the magnitude of the field in a coil is proportional to the exciting current. The obvious way, then, of creating large fields is to increase the current, but here we meet with difficulties; not only do we have to provide a source of very high current, but the magnitude of the current is strictly limited by the heating which it produces in the coil. One method for reducing this heat effect would be to carry away the heat as it was generated, or alternatively and more directly, by cooling the coil to very low temperatures. The resistance would thereby be reduced very considerably, and even in certain metals to zero when the metal becomes a supraconductor. The difficulty in this case is that the magnetic field produced by the coil will destroy the supraconducting state and also very rapidly increase the resistance to a value very close to that at room temperature. Neither of these methods seem very feasible, and even if carried out most efficiently would not allow a greater field than 50,000–60,000 gauss to be produced. If we assume we can make an efficient coil with an inside diameter of 1 cm, it can be shown that in order to produce a field of 1,000,000 gauss a power of 50,000 kw. is required, and in one second the coil will be heated to 10,000°C., and it is obvious that we could not deal with such a large temperature rise.

The main idea of our method of attacking the problem has been to make the time of duration of the field very short, when the coil has practically no time to overheat. The time actually chosen was 0.01 sec.

This condition, of course, created a new set of difficulties, firstly a very large current was required, and secondly all the measurements had to be made in a very short space of time.

Our first experiments were done using accumulator batteries having a very small capacity and a small internal resistance. In this way we were able to produce fields of 100,000 gauss by charging the accumulators for a few minutes and then discharging them in 0.01 sec., but further increase was impossible as it was found difficult to break currents of several thousand amperes sufficiently suddenly.

In our later experiments when larger powers were required we used a single phase A.C. turbo-generator. It is well-known that such a machine will give very large impulses of current when short circuited, and this is carefully avoided in usual practice as it might cause a serious accident. Our machine was purposely designed on the opposite lines so that large impulses were obtainable on short circuit. Considerable revision in design and careful calculation were necessary as the electro-dynamical forces might easily result in breakdown of the windings. The machine was of the size normally