8

The Law of Force

In this modern age of science we really should be able to say that we know how to work out the force which one electric particle exerts on another. But can we? We know that like charges repel and that unlike charges attract according to the law named after Coulomb. The force of interaction between charges at rest varies inversely as the square of their distance apart. Do we know the law of interaction for discrete charges which are both in motion? We can hardly explain the physics of diverse phenomena in terms of a common relation with a particle system of electric charge unless we can answer this question with a firm 'yes'. Explaining Nature in terms of electric charge behaviour is physics. The mathematician knows how his symbols interact so he has no problem creating his theories of the universe. The physicist has problems finding the facts and even finding how to express the facts, because we are not quite sure any more what we mean when we talk of a particle in motion. Motion is a relative quantity and requires a reference frame. Do we have to specify a reference frame to develop physics? The answer to this is affirmative for the problem with our two electric charges, unless we expect to find that the interaction force is the same whichever frame we choose. In Nature it might be that the force does not depend upon our choice of reference frame and then we need not confuse our basic question by digressing in this way. Experiment should provide the answer.

Early in the twentieth century Trouton and Noble (1903) relied upon accepted electrodynamic theory in performing a relevant experiment. They found that the interaction forces between opposite charges on the plates of a moving capacitor did not depend, as was expected, upon the orientation of the capacitor in space. The capacitor was carried through space with the earth at a speed which could have resulted in electromagnetic interaction permitting detection but it was evident that the earth's speed did not figure in the electrodynamic interaction. It was as if the reference frame was not important. However, this is like proving experimentally that two plus two is not four. There must have been error in the logic of our deduction. If the reference frame does not matter we can examine a law of electrodynamic interaction between two charges moving at different velocities and choose one which is at rest relative to one of the interacting charges. Then we would have concluded that the force between a charge at rest and one in motion is the same as that between the two charges if an equal velocity component is added to both. Since the interaction force can be divided into components by pairing off the interactions between the original and additional velocity quantities, we see that three interactions have been added to the basic one and that these three must together sum to zero. Since this has to apply for any possible basic system so that there are numerous parameter combinations in the various sets of three interactions, it must be that each of these interaction components is zero. In short, we can argue that only the basic Coulomb interaction force can exist from the findings of the Trouton–Noble experiment. On this argument we deny the existence of electromagnetic interaction between discrete charge and have experimental evidence on which to rely. However, we now have it that two zeros plus two zeros sum to more than four zeros, in effect, and the experiment thus interpreted proves nothing.

On this basis we assert that there is electromagnetic interaction between charges in motion and that this action varies with the velocities of the charges relative to a common reference frame. Did Trouton and Noble check the effect of moving the capacitor at different velocities relative to this common frame? They did not. In fact, taking the earth itself as a frame they did not move the capacitor at all. They merely assumed that the earth must be moving in space due to its motion with and about the sun. Their experiment showed that two discrete electric charges moving together with the same velocity must have an interaction force acting directly along the line joining the charges, as does the Coulomb force. Trouton and Noble must have used an incorrect law of electrodynamics. Alternatively, we admit but one reference frame to the experiment, the earth frame, and contend that we have proved nothing about electromagnetic interaction save that it adapts to a local reference frame.

Yet, although this is the logical outcome of a study of a famous and accepted experiment in physics, we find that neither of these alternatives is admitted by orthodox teaching. How, then, has history disposed of Trouton and Noble's findings? Perhaps the best answer to this question is to be found in Sir Edmund Whittaker's *History of the Theories of Aether and Electricity*. He notes that shortly before his death in February 1901, Fitzgerald commenced to examine the phenomena exhibited by a charged electrical condenser, as it is carried through space by terrestrial motion. Magnetic theory prevailing at that time indicated the prospect of detecting the earth's motion through space from changes in torque on the condenser resulting from variations of its state of charge. Fitzgerald's pupil Trouton followed through with the experimental work but no effect of any kind could be detected. Whittaker then dismisses the subject by saying that the explanation of the result 'was rightly surmised by P. Langevin to belong to the same order of ideas as Fitzgerald's hypothesis of contraction'. The impossibility of determining the motion of the earth relative to the so-called aether then emerges as a principle of physics. Whittaker reports that Poincaré, lecturing in St. Louis, USA in September 1904 named this principle 'The Principle of Relativity'. Applying this principle, one has to override one's expectations of results from the Trouton and Noble experiment. No torque can occur, as a matter of 'principle'. We need not, it seems, worry about our conclusions concerning the interaction of electric charges in motion.

Thus history shows us that this important experiment was swept aside with daring abandon as the theory of physics succumbed to invasion by Relativity. Sterile physical principles became the foundation stones for a new kind of physics, which, being Man's own fabrication rather than a replica discovered from Nature's own structure, is subject to erosion with the passage of time.

The Trouton–Noble experiment reappears from time to time in the scientific literature. Writing in 1970, Strnad* demonstrates how there are difficulties in applying the Special Theory of Relativity to explain the null result of the experiment, and how it may be necessary to accept the added complication of a principle of virtual work suggested recently by Fremlin (1969).† It seems that there are doubts in applying the Principle of Relativity to a system at rest in our earth frame. Nothing happens by which we can detect our motion, so why should there be a problem to answer? Yet, those versed in Relativity do not seem ready to accept the basic principle. They go into all kinds of mathematics to explain their difficulties in working with Relativity. Page and Adams (1945)‡ dealt with the paradox of the Trouton–Noble experiment rather differently. They merely asserted that according to Relativity there should be no torque, consistent with the experimental result. Hence, without analysis, they were led to assert that the dielectric structure holding the charged capacitor plates apart must transmit some balancing torque.

The writer here submits the proposal that we really do not know what force exists between two electric charges due to their magnetic interaction. Physicists are lost. They need to take a fresh look at the problems and work out a new law of electrodynamics.

Where do we stand in our effort to unify physics in terms of interaction between electric charge? We still have not reached an answer to our question: do we know the law of interaction force for discrete charges which are both in motion? The Trouton–Noble experiment should have at least suggested action along the line of separation for charges in parallel motion, but this prospect went adrift since the purpose of the experiment was not to pronounce on electrodynamic law but to

---

* J. Strnad, *Contemporary Physics*, p. 59, 1970.

† J. H. Fremlin, *Contemporary Physics*, p. 179, 1969.

‡ L. Page and N. I. Adams, *Electrodynamics*, Dover, p. 278, in 1965 version of 1945 edition.

detect motion in the aether. What is curious is that the theory leading to the experiment was never questioned to its classical foundations as a result of the null findings. The theory should have been rechecked. Even more curious is the fact that the accepted versions of electrodynamic interaction laws between discrete charges in motion all give answers contrary to the findings of the Trouton–Noble experiment. Rather than modifications in the basic equations we have seen attempts to distort the experimental apparatus by the mystic action of the all-important principle.

Let us look back at the origins of electrodynamic theory. We see that discrete charges are not isolated in experimental work to facilitate measurement between two and only two such charges. In fact, we are not even interested in this ourselves since all we need to know is the effective interaction force between pairs of charges in a populated system of charge. This is the additive component of the interaction. But, what we need to know is the interaction where charge in one part of the system is all moving with one velocity and charge in the other part of the system moves with another velocity. Our problem is that the classical law is deduced from experiments in which charge in one of the interacting systems moves in closed circuits and therefore does not possess a unique velocity common to the system. Classical theorists, therefore, made assumptions about the direction of the force interaction between two isolated charges. They formulated many alternative laws of electrodynamics any one of which can explain the observed electrodynamic interaction between electric charge in motion, provided one of the interacting charge systems is effectively a closed circuital current. The most famous of these laws was that of Ampère, but it is seldom used. Today we have turned to the intermediary use of the notion of a magnetic field, and usually combine two electromagnetic rules, the left-hand rule and the right-hand rule, to work out the electrodynamic interaction between separate charges. However, even here we rely on one of the charges being effectively a closed loop of current. Had Ampère, or the others who had to make assumptions to formulate their laws, used the empirical fact later to emerge from the Trouton–

Noble experiment, then they would have obtained a different law of electrodynamics. Necessarily, this law would give electromagnetic interaction along the line joining the interacting charges when both have the same velocity, that is, move parallel relative to the appropriate frame of electro-magnetic reference. The author has presented this law in several publications* but popular attention has not yet been turned to the problem, even though unified physical theory is so much dependent upon knowledge of the interaction between electric charge.

It is startlingly easy to show where the opinions of the past went adrift. What we have to do is to take note of the fact that our two electrons can never exist in isolation. Whittaker seems very briefly to come close to this when he explains how Eddington used Mach's principle to approach the problem of gravitation:†

> Eddington applied Mach's general principle to the interaction between two electric charges. If they are of opposite sign, all their lines of force run from one to the other, and the two together may be regarded as a self-contained system which is independent of the rest of the universe: but if the two charges are of the same sign, then the lines of force from each of them must terminate on other bodies in the universe, and it is natural to expect that these other bodies will have some influence on the nature of the interaction between the charges.

As we shall see in Chapter 11, where Mach's principle is discussed, it is really wrong to try to explain gravitation without first explaining the nature of mass. Our prime concern has to be electric interaction effects. Then, when we understand these we can hope to discover an understanding of the force of gravitation. It is permissible, nevertheless, to use the mathematical techniques developed for gravitational theory in our study of the effects of inverse square law actions between electric charge.

---

* *The Theory of Gravitation*, H. Aspden, Sabberton Publications, Southampton, 1960; 'The Law of Electrodynamics', H. Aspden, *Journal of the Franklin Institute*, 287, p. 179, 1969; *Physics without Einstein*, H. Aspden, Sabberton Publications, Southampton, 1969.

† *History of the Theories of Aether and Electricity, 1900–1926*, E. Whittaker, Nelson, London, 1953, p. 151.

It is a well known and easily-proved fact of particle dynamics that external forces will act on a system of two particles as a single force through the common centre of gravity and that any motion of the particles relative to this centre of gravity is completely independent of these external forces. Therefore, we have to be open to the possibility that, in analysing a two electron system in isolation, we can have a force communicated by the environment so as not to exert any turning moment on the system.

This is the simple, logical and straightforward starting point to an analysis of the problem. It has apparently eluded recognition in the past. Indeed, some theorists have gone out of their way to make it an absolute condition that no external out-of-balance force should act on the system as a whole. They have lived with Newton's maxim that action should balance reaction but forgotten the rider that this only applies to a complete system. They have assessed an incomplete system and found that their results do not have utility in explaining the behaviour of Nature, which evidently will not let itself be fragmented to suit the theoretical whims of the physicist.

The force communicated by the field environment will divide into two equal components X acting separately on each electron, as depicted in Fig. 1. The centre of gravity of the system is midway between the two electrons because of their equal charges and masses and so the force components need to be equal to provide no turning action and need to sum to the total force exerted from outside.

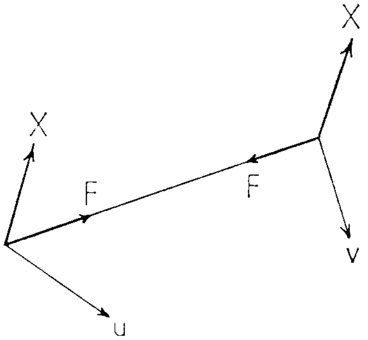

Fig. 1

Next, note that electrodynamic theory concerns actions additional to the Coulomb effects between charges. Usually we are dealing with current elements, that is charge moving in association with other local charge which provides an electrostatic field cancellation. The result is that there can be Coulomb forces on the electrons in these circumstances, as when they are flowing in a conductor, but they must be embraced exclusively by the two vector forces X depicted in Fig. 1.

We are then left to consider the mutual magnetic effects of the two electrons. By working out the interaction of their magnetic fields and analysing how the interaction energy component changes with separation distance between the charges, we find that a direct force acts between them. This is denoted F in Fig. 1. The history books show that some workers, notably Helmholtz, worked along these lines and proposed F as the complete law of electrodynamics.* It was inadequate, of course, because it took no account of the forces X. To find X is quite simple. We merely consider energy deployment at each particle. The force components, the energy supplied and the energy absorbed by the electrons must be compatible. The result presented in the Appendix at page 161 is a new general law of electrodynamics which differs from those derived historically and based on other assumptions. But it is a law which not only gives all the right answers when adapted for use for studying interaction involving a closed circuital current; it additionally reduces to a form for which the forces X are zero when the current elements represented by the electrons move in parallel directions. The two velocities u and v in Fig. 1 then are parallel. The result of the Trouton–Noble experiment clearly conforms. Hence, in electrodynamic terms we arrive at a law of attraction conforming exactly with the form of Newton's law of gravitation for a common condition of all interacting elements. This condition is satisfied if all mass is associated with a related electric charge moving harmoniously in synchronous circular orbit. Charge in such motion was the key to Véronnet's aether, as presented in Chapter 4 to explain the earth's magnetism. Hence, we have

---

* F alone is inadequate to explain the circuital laws but Helmholtz's formulation would have explained the null result of the Trouton–Noble experiment.

our clue to understanding gravitation. It is beyond the scope of this work, but it is possible to derive the Constant of Gravitation in terms of the charge/mass ratio of the electron and thus provide convincing evidence in support of such a theory of gravitation. This is presented in detail in the author's recent book *Physics without Einstein*.

A concluding remark, perhaps needed to dispel some doubts, is that the above views are not refuted because an electrical current will turn a coil in a magnetic field. To develop the turning moment here there are at least three current interactions, two current elements in the coil and one developing the field. No two alone will develop a torque between them. The coil will never turn itself. Nor will the whole system including the source of the field ever turn itself due to its own interactions.