A Brief History of Electromagnetism

Static Electricity

Static electricity was described by the early Greeks who produced it by rubbing two different materials together. They named the $\eta\lambda\epsilon\kappa\tau\rho o\nu$ meaning “amber”. Early in the 18th century Charles du Fay, who was Superintendent of the French Royal Botanical Gardens, recognised that there were two forms of electricity – either *resinous* or *vitreous*. He found that like forms repelled and unlike forms attracted. Benjamin Franklin explained the experiments in terms of an excess, or deficit, of *vitreous fluid*. The modern ideas of positive and negative charge appeared at about this time.

Franklin also found that a cork ball inside a charged metal cup was not attracted to the inside surface. Joseph Priestly proposed that there was an analogy between the inverse square law of gravity and electricity, to explain the experiment. John Robinson confirmed the hypothesis almost immediately but his results weren’t published until his death almost fifty years later. Cavendish showed that if the interaction was a power law of the form $F \propto r^{-n}$ then $n = 2 \pm 0.02$. He also failed to publish his results!

Charles de Coulomb measured the attractive and repulsive forces with a delicate torsion balance and discovered the eponymous law in 1785. Maxwell established that $n = 2 \pm 5\times10^{-5}$ and the modern value for distances of about one metre is $n = 2 \pm 2\times10^{-16}$. Present day theories suggest that deviations from the inverse square law can arise only if the photon has mass. If the photon has a mass *m* then the attractive potential between two charges separated by distance *r* takes the form

$$U(r) \propto \frac{1}{r}\exp\left(\frac{-mc}{\hbar r}\right)$$

where c is the velocity of light. Measurements of Jupiter’s magnetic field give $m < 4\times10^{-51}$ kg [Williams, Fuller and Hill, Phys. Rev. Lett. (1971) **26**, 721].

Static Magnetism

Historians agree that the magnetic compass was invented in China in at some time between BC 2636 and AD 1100. Other historians agree that it was an Italian, or perhaps Arabic, invention. Greek texts *circa* BC 800 describe Lodestone ($FeO–Fe_2O_3$) which was mined in Magnesia, hence the name *magnetism*. An alternative origin for the name comes from a story by Pliny about a shepherd called Magnes who got stuck to a rock (lodestone) because he wore shoes with iron nails and had a staff with an iron tip.

Early Greek science was entirely theoretical so the explanation, proposed circa BC 460, by Diogenes of Appollonia that there was: “...humidity in iron which the dryness of the magnet feeds upon” survived unchallenged for nearly 2000 years. It was finally tested in the sixteenth century by John Baptista Porta who carefully weighed a lodestone before and after it has been left in a jar of iron filings. In what I believe to be the first reported scientific experiment, published in AD 1269, Petrus Peregrinus showed that a lodestone had two poles.

William Gilbert (1544-1603) summarised the subject and its history in a book but although some of his theories were good (‘Unlike poles attract, like poles repel’), others were less soundly based (‘Loadstone hath a soul’). René Descartes was a philosopher who ignored facts but he did manage to exorcise the lodestone of its soul and replace it with his own theory based on the motion of *parties cannelées* (threaded parts). Apparently these flew through pores in the Earth that were lined with cilia and disliked air-travel.

Although he didn’t understand magnetism, Descartes re-established confidence in the power of reason. He also postulated a dichotomy of the soul and the body thus separating physics and metaphysics and showing it is possible for nature to be understood by systematic study.

In 1778, following the ideas in electricity, a two-fluid model for magnetism (*boreal* and *austral*) was developed independently by two people (whose names I have forgotten). Coulomb concluded from his experiments that magnetic fluids were bound to molecules and could not flow and the same experiments were used as the basis for a mathematical theory by Poisson who developed the idea of a potential after starting work 1824. George Green, a miller whose windmill still stands just outside Nottingham, extended and interpreted Poisson’s and showed that macroscopic studies could never reveal the microscopic mechanism underlying magnetic effects, and real progress had to await the invention of, *inter alia,* quantum mechanics.