POSTINGS FROM PRIESTLEY HOUSE

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Joseph Priestley and the Inverse Square Law of Electrostatics

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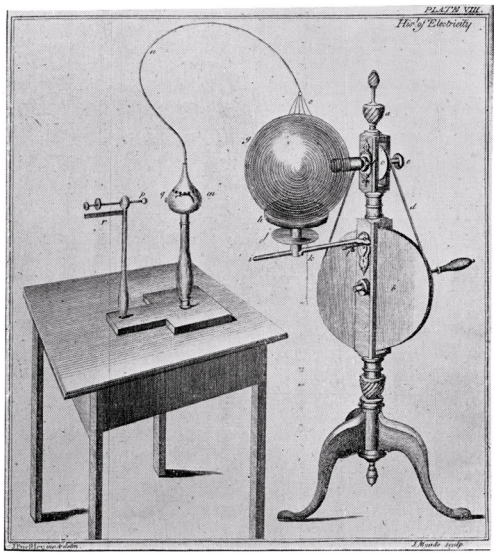
Straddling the French-Swiss border near Geneva is the largest scientific instrument ever built, the Large Hadron Collider (LHC) at CERN, the European Centre for Particle Physics. There, physicists from all over the world are trying to learn more about the fundamental building blocks of nature and the laws which govern the forces they exert on each other. They do so by repeatedly colliding protons into each other at huge energies, thereby recreating, on a small scale, the hot dense conditions that we believe existed in the earliest fractions of a second after the birth of the universe. The expansions of these `mini Big Bangs' are then studied.



One of the basic laws of physics is known as the Inverse Square Law of Electrostatics and it describes in detail how positive and negative charges exert forces on each other. It was first published by Joseph Priestley way back in 1767. Priestley, like the CERN physicists, used the most powerful machine available: he built (and drew) this `electrical machine' himself. One can only imagine what Mrs. Priestley thought about the beautiful table that ended up without its tripod base, but, to a physicist, a machine that can be used to discover one of Nature's hidden secrets is itself a thing of great beauty, albeit rather abstract.

The task of this machine was to deliver electric charge. It did so by making use of the fact that when you rub glass and silk together, the glass becomes negatively charged and the silk positively charged.

By turning the handle on the right, the glass flask can be made to turn on a pad of silk. The negative charge that is produced on the glass can be delivered by connecting the flask to the destination by means of a wire. To get a better feel for this you can find a video on http://tinyurl.com/Priestley2011.

> *I SHALL close the account of my experiments with a small set, in which, as well as in the last, I have little to boast besides the honour of following the instructions of Dr. Franklin. He informed me, that he had found cork balls to be wholly unaffected by the electricity of a metal cup, within which they were held; and he desired me to repeat and ascertain the fact, giving me leave to make it public.*
>
> *(Priestley: The History and Present State of Electricity with Original Experiments*)

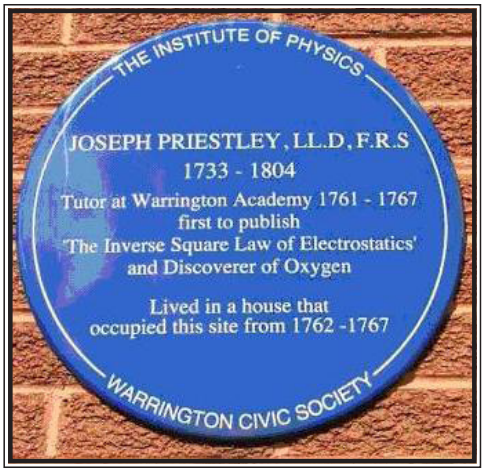
Priestley's great discovery came as a result of a suggestion made to him by Benjamin Franklin who had discovered something that he found surprising: when he, Franklin, delivered electricity to a metal cup sitting on an insulator (to prevent the cup discharging), he found that he could not find evidence of the charge by placing a detecting instrument in the cup. Priestley verified the result and then did something a little out of character. He once said, "I can only repeat, that it is not my opinions, on which I would be understood to lay any stress. Let the new facts, from which I deduce them, be considered as my discoveries, and let other persons draw better inferences from them if they can".

In this case, however, Priestley stuck his neck out and offered a far-seeing inference of his own to account for the surprising result. Although he was just embarking on his scientific career, Priestley was aware of a problem that had worried Newton. Imagine an object, the Earth say, hollowed out, so that there was no matter inside the remaining spherical shell. If one were able to place a test mass at some random point inside the shell, what would happen to it? Would it be attracted to the centre, or to the side near to it, or would something else happen? Newton had showed that there would be no gravitational field inside the shell and that, therefore, the test mass would not move from its original position.

Priestley conjectured that the inability to detect an electric field inside the charged cup was evidence that the law describing electrical forces was mathematically similar to gravity, that it was an `inverse square law'. (This means that the force between two charges weakens by, say, 25, or 5^2, if the distance between them increases by 5.)

> *MAY we not infer from this experiment, that the attraction of electricity is subject to the same laws with that of gravitation, and is therefore according to the squares of the distances; since it is easily demonstrated, that were the earth in the form of a shell, a body in the inside of it would not be attracted to one side more than the other?*
>
> *(Priestley: The History and Present State of Electricity with Original Experiments)*

Recently, the Institute of Physics in the United Kingdom erected a Blue Plaque to celebrate Priestley's discovery at the Salvation Army Citadel, 8 Academy Street, Warrington, England. Priestley was a tutor at the Warrington Academy when he made this discovery. Unfortunately the building no longer exists.



The great American physicist, Richard Feynman, points out that Priestley's statement of the Inverse Square Law came 18 years before the Frenchman Coulomb measured the inverse square dependence directly. It seems an injustice that the law is known as Coulomb's law.