Electrostatics

Human beings have long been aware of, and captivated by, the mysterious presence of electricity. As early as 600 BC, the ancient Greeks were already carrying out rudimentary experiments on static electricity, rubbing amber with fur and observing the strange effects that followed. Initially, however, the true significance of electricity escaped us. Apart from the spectacle of lightning in the sky, it did not appear to be a fundamental feature of the natural world. The truth is quite the opposite: electricity lies at the heart of the physics of the universe, shaping the physical and chemical properties of matter itself. Without electricity, not only would this chapter never have been written, but matter as we know it would not exist at all. In the pages that follow, we will delve into the realm of electrostatics, electric charge, and electric fields, guided by the laws of great minds of the nineteenth century, such as Ampère, Faraday, Maxwell, and many others.

Electric Charge

By empirical evidence, we know that there exist two types of electrical charge, a positive charge, and a negative charge. The reason behind this label has only to do by an historical accident. Indeed, there is nothing negative about negative charges. The quality of the charge of a particle is only determined by symmetries and the relation of a sequence of events in the particle itself.
Electric charges satisfy the following natural laws:

Properties of Charges

- Charges of opposite signs **attract** each other, and charges with the same sign **repel**.
- The total electric charge in an isolated system, that is, a system where no matter is allowed to cross the boundary of the system, is always **conserved**. In other words, the algebraic sum of positive and negative charges present at any time never changes.[1]
- The electric charge is **quantized**: in nature we find only particles with a charge equal to a multiple of the charge of one electron ($e = 1.602 \cdot 10^{-19} C$). Protons have been proven experimentally to have the same charge as electrons up to a precision of 10^{-20}. We shall mention that protons are made up of Quarks, particles that have only a fraction of the electron charge ($\pm\frac{e}{3}$, $\pm\frac{2e}{3}$). However, these particles cannot be found isolated, so we can consider the charge of the electron as the **elementary charge**.

[1] Notice that the conservation law of electric charges meets the test of Lorentz invariance. In fact, observers in different reference frames, measure always the same charge.