4.11.6 Coulomb-Force

An electric field with the field strength $E = U/d$ is generated between two electrodes at different potentials. Here U is the potential difference, also depicted as a voltage (or voltage difference, voltage drop) and d is the distance of the electrodes. 100 V at a distance of 10 mm yields E = 10 kV/m. If one inserts an electrical charge q into this electrical field, an electrostatic force F is generated which is called Coulomb-force, after its discoverer (Charles Augustin de Coulomb, 1736 – 1806).

$$\vec{F} = q \cdot \vec{E} \qquad \text{Coulomb-force}$$

The coulomb-force does not play any role for guitar pickups; it may lead, however, to misinterpretations: other than for magnetic forces the coulomb-force also "acts" within the homogenous field. While a positively charged Styrofoam ball between two parallel electrodes is drawn to the cathode (negative electrode) an iron ball between two parallel poles of a permanent magnet will rest (more precise: 4.11.1). Indeed, within the magnetic field there are also attractive forces but they are balanced in this idealized example. The Coulomb-force is only mentioned here to point out its differentness. Analogy-considerations between electric and magnetic fields have model limits that have to be observed.

4.11.7 Lorentz-Force

With the Lorentz-force (Hendrik Antoon Lorentz, 1853 – 1928) we will explain another force that has no direct importance for the magnetic pickup (but indeed for the dynamic loudspeaker). Again, we want to eliminate misinterpretations. A force F acts on a conductor of length l carrying a current I when the conductor is carried into a magnetic field with flux density B. F is oriented normal to the plane defined by I and B. If I is directed parallel to B then F = 0. In vector notation one will get the vector product $(\times)$:

$$\vec{F} = l \cdot \vec{I} \times \vec{B} \qquad \text{Lorentz-force}$$

If one points with the thumb of the right hand into the direction of the technical current flow (from plus to minus) and with the forefinger into the direction of the magnetic flux, the middle finger will point into the direction of the force (right-hand rule). The value of the force is given by the product $l \cdot I \cdot B \cdot \sin\alpha$, where α is the angle between the current and field directions. For the magnetic pickup the Lorentz-force, as given in the above form, does not play any role. A small alternating current does in fact flow through the coil which, however, with a value of 10 µA, will not exert any substantial force on it. A retroactive effect on the vibrating string is described by the Maxwell and not by the Lorentz-force, because the string is not carrying a current. If the string would be conductively suspended one could hypothesize an induced current in the neighboring string – however, the effect of its force would be negligible.