Electromagnetic interaction

An overview of the basic types of interactions

In our everyday life we encounter gravitational, electric and magnetic forces.

From the point of view of modern physics, we recognize four types of interaction:

1. **Gravitational interaction** – exists between all material objects, i.e. every body that has mass acts on another body through gravitational interaction (e.g. the Earth and the Sun).
2. **Electromagnetic interaction** – exists between electrically charged particles and bodies through an electromagnetic field. Electromagnetic interaction between atoms and molecules of solids gives solids their rigidity, holding electrons in atoms. The same interaction is also responsible for the behavior of magnets, it is the essence of friction, resistance, pressure and tensile forces, and its manifestation is, for example, light radiation.
3. **Weak interaction** - participates in some transformations of elementary particles. The effect of weak interaction is also applied in some types of watches, where due to the disintegration of the particles of the luminescent layer, the dial glows in the dark.
4. **Strong interaction** - acts, for example, between protons and neutrons in the nuclei of atoms.

Basic information

An electromagnetic field is a physical field that corresponds to the degree of action of electric and magnetic forces in space. It therefore consists of two physically connected fields – electric and magnetic. Although the electromagnetic field is infinite, usually only the part of it that directly affects the movements of bodies in range is considered.

Electromagnetic interaction is mediated by a photon.

Photon

A quantum of an electromagnetic field that has zero rest mass and travels at the speed of light *c.*

A photon is characterized by its corpuscular-wave character, which is reflected in its properties.

The particle nature of a photon is characterized by the energy of the photon:

$$E = hf = hc/\lambda$$

The energy of a photon is equal to the product of Planck's constant and the frequency of electromagnetic radiation, which is equal to the product of Planck's constant and the speed of light divided by the wavelength of the corresponding electromagnetic wave in a vacuum, where E **is the energy of the photon,** h **is Planck's constant,** f **is the frequency of the electromagnetic wave,** c **is the speed of light in vacuum and** λ **is the wavelength of electromagnetic waves in vacuum**

Wave properties are described by the equation for momentum:

$$p = mc = h/\lambda$$

Momentum is equal to the product of the photon's relativistic mass and the speed of light in a vacuum, and this is equal to Planck's constant divided by the wavelength of the relevant electromagnetic wave in a vacuum, where p **is the momentum of the photon,** m **is the relativistic mass of the photon,** c **is again the speed of light in a vacuum,** h **is Planck's constant and** λ **is the wavelength of electromagnetic waves**

Photons are produced in many ways, e.g. by radiation during the transition of electrons between orbital levels of atoms or during particle annihilation (a process in particle physics that occurs when a particle meets its antiparticle). Special instruments such as masers and lasers (biophysics) can create a coherent beam of radiation.

All photons of monofrequency radiation of frequency f have the same mass, energy and momentum. The lifetime of a photon is infinite, in the sense of an infinite half-life. So a photon is a stable particle. Photons can be created and destroyed in interactions. The particle properties of electromagnetic radiation manifest themselves mainly at high frequencies (i.e. at high photon energies), otherwise the wave properties of electromagnetic radiation predominate, i.e. radiation manifests itself as a wave.

Electromagnetic force

Atoms and molecules are held together by the electromagnetic force. Thus, these repulsive and attractive forces are the most prominent interaction of the four forces. Even magnetic effects are usually only visualized at greater zoom.

So this power consists of two components. By the electric forces between charges (Coulomb's law) and the magnetic force described by the Lorentz force. Both electric and magnetic forces are external manifestations of the exchange force, due to the exchange of photons. The electromagnetic force acts over an unlimited distance and is inversely proportional to the square of the distance - similar to the gravitational force.

Electromagnetic field

The non-stationary electromagnetic field is characterized by the electric field intensity vector *E* and the magnetic field intensity vector *H*. Changes in the magnetic field give rise to an electric field and vice versa, with the intensity vectors E and H being perpendicular to each other.

A non-stationary magnetic field is the cause of the induced electric field (we call this phenomenon electromagnetic induction). Between the ends of the conductor in a non-stationary magnetic field there is an induced electromotive voltage U_i and an induced current I_i passes through the closed circuit.

Farraday's Law of Electromagnetic Induction

Electromagnetic induction was discovered by M. Farrday. He conducted an experiment based on the reasoning that electric and magnetic waves are closely related. He thus followed Oersted's experiment, which proved that a magnetic field is created by an electric field. So Farraday wanted to prove that the reverse is also true and that a magnetic field can also create an electric current. The creation of a current in one coil when the current in the other coil changes, while both coils were wound on a common core, became demonstrable evidence. So Farraday's law of electromagnetic induction is a generalization of his experiments:

The induced electromotive voltage is equal to the negative time change of the magnetic induction flux.

$$U_i = -\Delta\Phi / \Delta t$$

This relationship gives the mean value of the induced electromotive voltage over time t, where **U** i is the electromotive voltage, **ΔΦ** is the change in magnetic induction flux, and **Δt** is the change in time.

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https://www.wikiskripta.eu/w/%C3%9A%C4%8Dinky_elektromagnetick%C3%BDch_pol%C3%AD_na_organismus

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