

Dark matter is a mysterious substance and we cannot see it directly. We know about its existence only because we can observe its gravitational impact. In 1933, Fritz Zwicky noticed that the galaxies in the Coma Cluster are moving so fast that if we take into account only the gravitational interaction of the visible matter, then some of galaxies should be thrown away from the cluster. Based on these observations, he concluded that most of the mass in the cluster must be in a form of invisible dark matter. At the beginning, his conclusions were not approved by the scientific community. However, more observational evidence for dark matter existence were found later on. Today it is estimated that dark matter represents more 1/4 of the Universe. The rest consists of ordinary matter (so called baryonic) and dark energy, which is also a great puzzle for scientists.

At the beginning, people thought that dark matter is just the ordinary matter, which simply does not emit or reflect light and that is why we cannot see it. These could be brown dwarfs (stars with very small masses, in which the nuclear reactions does not start), neutron stars or black holes, located in halo of galaxies. After many observations, astronomers found that there is not enough of these objects, to be responsible for dark matter contribution. This means that there is an entirely new form of matter in the Universe with properties unknown to science.

At the moment, non-relativistic (moving much slower than light) and long-lived neutral Weakly Interacting Massive Particles, so called WIMPs, are the most likely scenario. It is believed that dark matter is present in the whole Universe so it is possible to study it, even from the Earth. On the one hand, it is assumed that the WIMPs can elastically scatter off nuclei and be detected directly. Many experiments attempt to measure the kinetic energy of the nuclear recoil after such a collision, but so far the existing results are inconclusive and controversial. Alternatively, there are indirect detection methods, which are based on search for products of dark matter annihilation or decay.

As a result of such annihilation various particles such as leptons, quarks and bosons can be produced. Additionally a lot of new particles can be produced as a result of subsequent decay of primary products. Indirect detection methods focus on the search for antimatter, photons and neutrinos. Neutrinos can provide very good information on their source position while traversing unaffected through galactic scales. Moreover, their energy remains unchanged during propagation providing valuable information about energy spectra generated in dark matter annihilation and decay processes. However, due to the very weak interactions with matter, neutrino detection is a huge challenge. It takes place in the huge ground-based detectors, where a problem of atmospheric neutrino background occurs.

Super-Kamiokande is a water Cherenkov detector with a mass of 50,000 tonnes, which is located in the Japanese laboratory Kamioka. The detector is placed 1,000 meters below Earth surface and it is made up of a cylindrical container, 40 m high and 40 m in diameter, filled with ultra-pure water and surrounded by more than 12,000 photodetectors. The Super-Kamiokande detector record the products of neutrino interactions with the water particles. As a result of such interactions, charged particles are produced (mainly electrons and muons) which propagate in water with velocities greater than the speed of light, emitting the Cherenkov radiation. This light is recorded by the photodetectors located on the detector walls and provides information about the direction, flavour and energy of neutrinos. In the performed analysis an excess of neutrinos that may come from the annihilation of dark matter particles inside the Earth core or the Galactic Center is searched for, relative to the atmospheric neutrino background.

Dark matter searches are very difficult, but also extremely interesting. In spite of overwhelming observational evidence for its existence, and many detection attempts, its nature remains unknown. Different approaches to dark matter detection complements each other. This shows that to fully understand the nature of dark matter it is necessary to look at a broader picture. Further research in this area are extremely important because dark matter is still a huge gap in our knowledge about the Universe.