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Study of hyperon’s electromagnetic structure

Popular science description

What are the components of the matter? Components of everything that surrounds us? May all the abundance of the universe be reduced into few basic particles? These questions accompany modern science since it creation. From Boyle’s and Newton’s theories until quantum fields theories. From chemists’ researches in 19th century, until Large Hadron Collider in 21st century, humanity is trying to find fundamental structure, that could be called indivisible. This desire led us from atomic theories to the world of elementary particles, things smaller than anything, that man was able to measure.

At the turn of 19th century scientists found that atom, despite its name, isn’t indivisible. During radiation researches were found negative charged electrons orbiting around positive charged nucleus, then nucleus was divided into single protons and neutrons. Because of this discovery, number of elementary particles was reduced from 92 elements into only 3 particles. But reality turned out to be much more interesting. While carrying out research on cosmic radiation, scientists noticed particles not existing in standard matter. This discovery led to predict even more basic elements of matter, called quarks. Until now, there were found 6 different types of quarks: up, down, strange, charm, beauty and top. To make everything more confusing, to explain universe’s structure, we need only two lightest quarks – up and down. What for are used all the others? We don’t know, yet.

The lightest and because of that the easiest to create in lab “exotic” quark is the strange one. Therefore, particles containing this quark (called “strange” particles) are interesting systems, which help examining unknown phenomenons. One of those systems are called hyperons – particles containing three quarks, at least one of which is the strange. What makes them so interesting is the fact, that we can understand them as proton or neutron with one of quarks substituted into the strange. Comparing attributes of well-known nucleons with hyperons we are able to find some new facts concerning influence of “strangeness” over particle’s properties.

One of basic methods of examining particle’s properties is measuring their excided states. If the particle has excess of the energy, tries to radiate it. Measuring radiated energy (in particle physics radiation means both photons and particles with mass), we may determine a difference of the energy between excited and the ground state. That difference should take some predicted by theory values. This way it is possible to verify theoretical expectations concerning particle’s structure. What’s more, from different features of radiation we may conclude facts about electromagnetic form factor – quantity that defines charge density distribution inside the hyperon. It is something like the “map” of quarks’ distribution. Following program concerns investigation of the spectrum emmited by hyperons.

Another issue that this project concerns is way of interaction between hyperon and electromagnetic field. In theory, for middle range of energy vector mesons play the key role in interaction between field and particle. Those mesons are particles with the same quantum numbers as photon, but having mass. If this statement is true, then the emitted particles spectra should show that.

The answer for those questions may be found in data from two experiments performed by the HADES collaboration: proton-proton and proton-niobium collisions, with beam energy 3.5 GeV. The beam energy was set to maximize mentioned effect of vector mesons creation. The subject of this project will be analysis of this data and preparation of future experiment concerning more detailed examination of hyperons.