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THE ROLE OF QUARKS IN NUCLEAR STRUCTURE: ALPHA-CLUSTERING AND NUCLEOSYNTHESIS IN STARS

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We propose a quark model of nuclear structure where quark correlations lead to nucleon-nucleon correlations and arrangement of them into lattice–like structure. The model is based on the quark model of nucleon structure in which valence quarks are strongly correlated within a nucleon (SCQM) [1]. Nuclei are built by junctions of SU(3) color fields of two quarks of neighboring nucleons. Application of the model to larger collections of nucleons reveals the emergence of the face-centered cubic (FCC) symmetry at a nuclear level where nucleons are arranged in alternating spin–isospin layers [2, 3]. The model of nuclear structure becomes isomorphic to the shell model and, moreover, composes the features of the liquid drop and cluster models. In difference with the shell model, protons and neutrons in our model are strongly correlated. It turns out that building blocks of the nuclear structure are three-nucleon (triton and 3He) and four-nucleon (α-cluster) like configurations. These configurations form inside nuclei virtual triton/3He and α- clusters. We apply the model to analyze nucleosynthesis in stars in the framework of α-clustering. It turns out that the gateway for synthesis of elements heavier than 12C is provided by composition of 5 α- clusters, that corresponds to the excited state 20Ne. Excited 20Ne, than decays to lighter nuclei C, N, O. Our approach is an alternative to the 3-α Hoyle state that provides the nucleosynthesis of heavier elements occurring naturally in stars.

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Primary author(s) : MUSULMANBEKOV, Genis (JINR)

Presenter(s) : MUSULMANBEKOV, Genis (JINR)

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