Quarks in Nuclei: From Neutron Halo to the Boundary of Nuclear Stability

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In the framework of the semi-empirical quark model of nuclear structure that is based on the quark model of the nucleon, the Strongly Correlated Quark Model (SCQM) [1] we construct nuclei from light to heavy ones, including halo nuclei. Nucleons inside nuclei are bound due to junctions of SU(3) color fields of quarks [1]. According to SCQM, arrangement of nucleons within nuclei reveals the emergence of the face-centered cubic (FCC) symmetry [2]. The model of nuclear structure becomes isomorphic to the shell model and, moreover, composes the features of cluster models. Binding of nucleons in stable nuclei are provided by quark loops which form three and four nucleon correlations. Three nucleon correlations are responsible for the structure of "halo" nuclei. Quark loops leading to four-nucleon correlations are responsible for binding energy enhancement in even-even nuclei. In turn, four-nucleon correlations can be considered as virtual alpha-clusters. In this way all inner closure shells are rearranged into the face-centered cubic lattice with alternating spin-isospin

layers. For medium and heavy nuclei the arrangement of nucleons in alternating spin-isospin layers is modified by Coulomb repulsion of protons. This effect together with quark/nucleon correlations leads to deviation from the shell model expectations. The model describes well quadrupole moments of nuclei, although, deformation of nuclei is much more complicated. Moreover, it shows that neutron and correspondingly matter distributions are deform essentially larger. The model can predict the boundary of the maximal numbers of proton and neutron excess, i.e. proton and neutron drip lines.

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References

[1] G. Musulmanbekov in Frontiers of Fundamental Physics, New York, Kluwer Acad/Plenum Publ., 2001, p. 109 - 120; PEPAN Lett., 18 (2021) 548.

[2] G. Musulmanbekov and N.D. Cook, Phys. Atom. Nucl., 71 (2008) 1226,

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