

Alpha-Cluster Structures above Double Shell Closures from Chiral Effective Field Theory

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α -cluster states above double shell closures are important examples of nuclear α clustering. They include ${}^8\text{Be} = \alpha + \alpha$, ${}^{20}\text{Ne} = {}^{16}\text{O} + \alpha$, ${}^{44,52}\text{Ti} = {}^{40,48}\text{Ca} + \alpha$, ${}^{104}\text{Te} = {}^{100}\text{Sn} + \alpha$, ${}^{212}\text{Po} = {}^{208}\text{Pb} + \alpha$, etc. Many theoretical and experimental efforts have been made to understand their physical properties.

We develop new cluster models with local potentials to study these α -cluster states in the light of chiral effective field theory (χ EFT) [1]. Compared with phenomenological models for nuclear interactions, χ EFT is characterized by its intimate connections to quantum chromodynamics through chiral symmetry breaking [2,3]. Also, its EFT framework provides a systematic way to make improvements and estimate theoretical errors. We obtain the local potentials between α clusters and doubly magic core nuclei by doubly folding their realistic density distributions with soft local chiral nucleon-nucleon potentials at next-to-next-to-leading order proposed in Ref. [4]. To simulate the Pauli blocking between alpha clusters and core nuclei, we adopt a modified version of the Wildermuth condition.

Various physical properties of α -cluster states in ${}^8\text{Be}$, ${}^{20}\text{Ne}$, ${}^{44,52}\text{Ti}$, and ${}^{212}\text{Po}$ are studied by our new model. The theoretical results agree well with experimental data and theoretical expectations. We also study ${}^{104}\text{Te}$, which has become a hot topic recently [5,6]. We analyze the available experimental data systematically within our model. The results could be helpful references for future experiments.

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Field of your work

Theoretical nuclear physics

Primary author: Dr BAI, Dong (School of Physics Science and Engineering, Tongji University, Shanghai 200092, China)

Co-author: Prof. REN, Zhongzhou (School of Physics Science and Engineering, Tongji University, Shanghai 200092, China)

Presenter: Dr BAI, Dong (School of Physics Science and Engineering, Tongji University, Shanghai 200092, China)

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