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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 $^8\mathrm{Be} = \alpha + \alpha$, $^{20}\mathrm{Ne} = {}^{16}\mathrm{O} + \alpha$, $^{44,52}\mathrm{Ti} = {}^{40,48}\mathrm{Ca} + \alpha$, $^{104}\mathrm{Te} = {}^{100}\mathrm{Sn} + \alpha$, $^{212}\mathrm{Po} = {}^{208}\mathrm{Pb} + \alpha$, 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 (χEFT) [1]. Compared with phenomenological models for nuclear interactions, χEFT 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}Be, ^{20}Ne, ^{44,52}Ti, and ^{212}Po are studied by our new model. The theoretical results agree well with experimental data and theoretical expectations. We also study ^{104}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

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