Magnetic order in the strongly correlated electron systems on the Penrose lattice

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Electron correlations in quasicrystals have attracted much interest since the report of quantum critical behavior in the rare-earth alloy Au-Al-Yb [1]. Investigation of the interplay of the two effects, strong correlation and lattice quasiperiodicity, is a big challenge, since each of the two is already a big issue. Therefore, to understand generic important characteristics in their interplay, it is useful to employ simpler quasiperiodic lattices. One of the simplest ones with geometrical quasiperiodicity is the Penrose lattice in two dimensions. On this lattice, a few strongly correlated models have been studied: Ising model for classical spins [2], Heisenberg model for quantum spins [3], and the Hubbard model for correlated electrons [4]. On the other hand, it is still unclear how itinerant electrons in the strongly correlated systems affect the magnetic order at low temperatures. One important feature of the Penrose lattice is the presence of thermodynamically degenerate one-particle states, and they are called confined states, since their wave functions are strictly confined in a finite region in space [5]. One of the main issues in this work is how these states respond to electron interactions.

In this study, we consider the Hubbard model on the Penrose lattice to discuss the stability of the magnetically ordered state [6]. We demonstrate that the magnetizations exhibit an exotic spatial pattern and have the same sign in each of cluster region in the weak coupling limit. We then analyze the crossover in the ordered state by the singular value decomposition method for the fractal-like magnetization pattern projected into the perpendicular space. The possibility of the ferromagnetically ordered state is also discussed in the double exchange model on the Penrose lattice.

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