Continuum of ground states and aperiodic structures in a lattice gas on a triangular lattice with finite-range interactions

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The problem of structure or pattern formation is among the most important and interesting problems in modern physics. However, in spite of several decades of intensive studies in this field, many fundamental key questions still remain unanswered, in particular, the following ones: Why are quasicrystals—ordered but aperiodic structures with the point spectrum whose indexing requires number of vectors that is finite but greater than dimensionality of the structures—formed and how do they grow?; What is the mechanism of infinite adaptivity in some compounds where, "within certain composition limits, every composition can attain a fully ordered crystal structure"?; Do ordered structures which are neither conventional crystals nor quasicrystals (for example the so-called almost periodic crystals and irregularly ordered structures) exist? Our investigation and subsequent studies will shed some light on all these problems.

We consider a rather simple lattice-gas model with one particle species on a triangular lattice with finite-range interactions and we show that this model possesses a continuum of ground states parameterized with the particle density or even (if the interaction reaches eighth neighbors) with the chemical potential. The continuum contains both periodic (up to phason flips along some channels) and aperiodic structures. It is quite probable that there are quasicrystals as well as non-quasicrystalline aperiodic structures among the latter. The growth mechanism for the structures consists in continuous formation and self-destruction of defects through the propagation of phasonic excitations.