Growth of Soft Quasicrystals

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By employing a phase field crystal model and Brownian dynamics simulations we explore the growth processes of two-dimensional colloidal quasicrystals. We consider colloidal systems where the quasicrystalline symmetry is either stabilized by two incommensurate length scales in an isotropic pair interaction potential or where the quasicrystalline ordering is due to interactions that possess preferred binding angles. The later can be realized in systems of patchy colloids.

For quasicrystals that grow from a seed out of the melt, we observe two different growth modes. Close to the triple point a perfect, defect-free quasicrystal can grow. However, far away from the triple pint the growth is dominated by phasonic flips which are incorporated as local defects into the grown structure [1]. The later structure corresponds to a dislocation-free random-tiling-like quasicrystal.

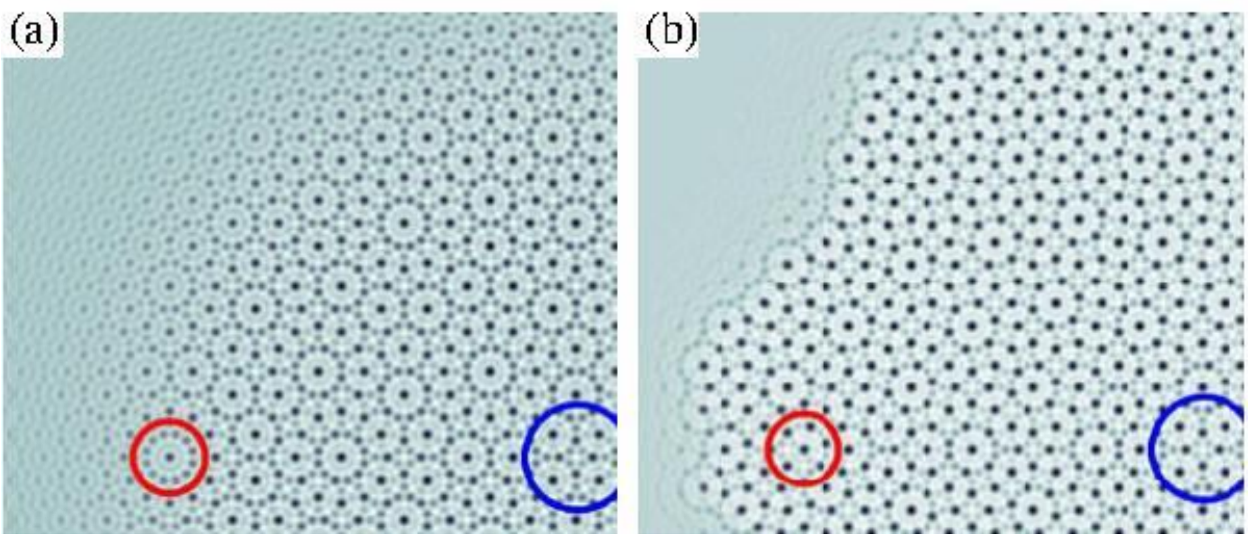

Figure 1. Growth modes of a quasicrystal obtained with phase field crystal calculations. (a) Growth of a perfect quasicrystal. (b) Growth of a quasicrystal without dislocations but a lot of local excitations (phasonic flips). Figures are from [1].

A similar behavior is found for Brownian dynamics simulations of the growth front of a quasicrystal. Depending on the growth rate and the mobility of the particles close to the front, either excitation-free quasicrystals or random-tiling-like structures can be observed.

Interestingly, there is an important difference between the growth in systems with isotropic pair interaction and in systems with particles that possess interactions with preferred binding angles. Preferred binding angles support the creation of chain-like structures that reach out of the surface and lead to the incorporation of dislocations. In contrast, in case of isotropic interactions dislocations are rare because due to the additional degrees of freedom they usually relax as long as they are close to the surface.

Finally, we explore how the growth started by multiple seeds is affected by the possibility of stress relaxation via the phasonic degrees of freedom. While for crystals that are grown from multiple seeds domain borders consisting of dislocations can develop even in case of small mismatches, in quasicrystals there is the possibility to adjust one structure such that it fits to another by employing phasonic rearrangements (see figure 2 and [2]).

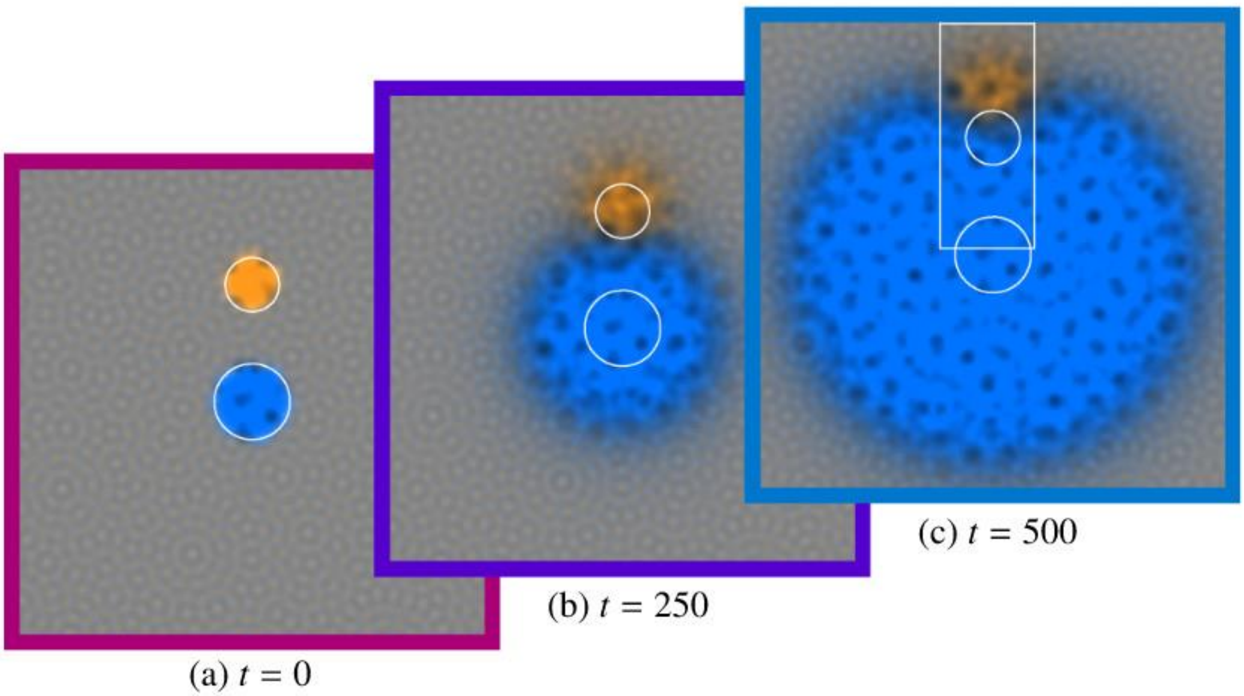

Figure 2. Growth of two quasicrystals (shown in blue and orange) from two seeds. Though there is a mismatch between the two quasicrystalline structures, no domain boundary with dislocations develops. In contrast, the large (blue) quasicrystal can incorporate the small (orange) one by adjusting its structure via phasonic rearrangements. Figures are from [2].

In conclusions, the growth process of quasicrystals might differ from the growth process of periodic crystals because of the additional degrees of freedom that exist in quasicrystals. Specifically, by relaxing stress via phasonic rearrangements the formation of dislocations can be suppressed. Furthermore, particles that form quasicrystals due two preferred binding angles exhibit a different growth behavior than particles that interact according to isotropic interactions.

1. C.V. Achim, M. Schmiedeberg, H. Löwen, Phys. Rev. Lett. **112**, 255501 (2014).

2. M. Schmiedeberg, C.V. Achim, J. Hielscher, S. Kapfer, and H. Löwen, Phy. Rev. E **96**, 012602 (2017).