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Controlled Self-Assembly of Soft-Matter Quasicrystals

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A large number of soft-matter systems, whose building blocks range in size from several nanometers to almost a micron, have been shown in recent years to form ordered phases with dodecagonal (12-fold) symmetry (for recent reviews see [1]). Contrary to metallurgic quasicrystals, whose source of stability remains a question of great debate to this day, we show that the stability of certain soft-matter quasicrystals—interacting via pair potentials with repulsive cores, which are either bounded or only slowly diverging—can directly be explained. Their stability is attributed to the existence of two natural length scales in their isotropic pair potentials, along with an effective three-body interaction arising from entropy. We establish the validity of this mechanism at the level of a mean-field theory [2], and then use molecular dynamics simulations in two dimensions to confirm it beyond mean field, and to show that it leads to the formation of cluster crystals [3]. We demonstrate that our understanding of the stability mechanism allows us to generate a variety of desired structures, including decagonal and dodecagonal quasicrystals [3], suggesting a practical approach for their controlled self-assembly in laboratory realizations using synthesized soft-matter particles.

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