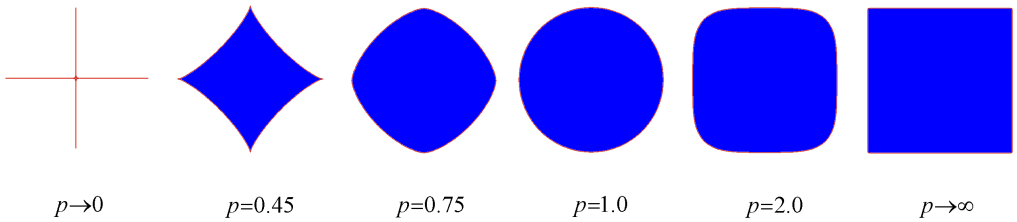

FIG. 1: (color online). Superdisks with different values of the deformation parameter p.

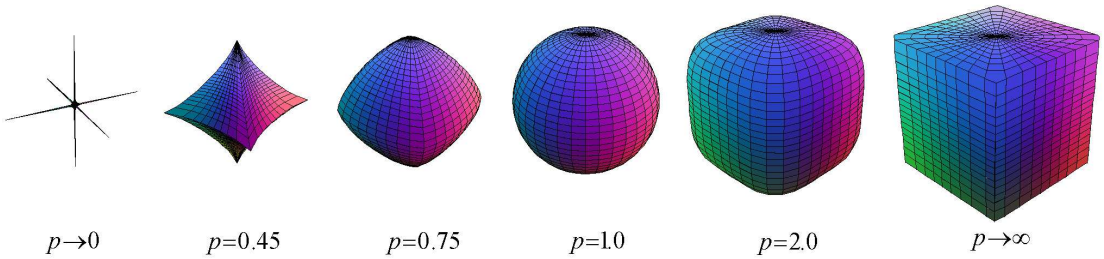

FIG. 2: (color online). Superballs with different values of the deformation parameter p.

the two-dimensional ($d = 2$) and three-dimensional ($d = 3$) cases, respectively. A superdisk possesses square symmetry, as p moves away from unity, two families of superdisks can be obtained, with the symmetry axes rotated 45 degrees with respect to each other; when $p < 0.5$, the superdisk is concave (see Fig. 1). A superball can possess two types of shape anisotropy: cube-like shapes (for $p > 1$) and octahedron-like shapes (for $0 < p < 1$) with a shape change from convexity to concavity as p passes downward through 0.5 (see Fig. 2).

Optimal packings of congruent superdisks and superballs apparently are realized by certain Bravais lattices possessing symmetries consistent with those of the particles [25, 26, 28]. Even these crystalline packings exhibit rich characteristics that are distinctly different from other known packings of nonspherical particles. For example, we found that the maximal density ϕ_{max} as a function of p at $p = 1$ (the sphere or circular-disk point) is nonanalytic and increases dramatically as p moves away from unity. In addition, we have discovered two-fold degenerate maximal density states for square-like superdisks, and both cube-like and octahedron-like superballs.

In this paper, we generate both packings of binary superdisks in $\mathbb{R}^2$ and monodisperse superballs in $\mathbb{R}^3$ that represent the maximally random jammed (MRJ) state of these particles, using a novel event-driven molecular dynamics algorithm [34, 35] and investigate their