Liquid crystalline patterns of exotic symmetries in monolayers of vertically vibrated granular particles

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Monolayers of millimetre-sized metallic particles confined into thin cavities and subject to periodic vertical agitation form a variety of fluid patterns with orientational order that resemble those found in molecular and colloidal liquid crystals. This is remarkable given that these systems are driven by dissipative forces. Within some reasonable windows of experimental parameters one can identify different patterns, including nematic and smectic, which could be understood in terms of classical statistical mechanics of hard bodies. In particular, low aspect ratio cylinders project as rectangles and may form uniaxial and tetratic nematic phases [1]. The latter exhibits four-fold symmetry, possesses two equivalent directors and corresponds to the two-dimensional analogue of the three- dimensional cubatic phase.

We have experimented with more general metallic particles, consisting of prisms with different transverse shapes: equilateral triangles (see Fig. 1), right-angle triangles, etc. In the first case the exotic triatic phase, with six-fold symmetry and three equivalent directors, is excited. Even more remarkable, geometric frustration caused by confinement in cavities that are not compatible with the intrinsic symmetry of the fluid causes topological defects to arise [2]. These defects seem to abide by the same topological rules as standard liquid crystals. Our findings can be understood with the help of simulations of hard particles subject to thermal equilibrium.

Overall, we believe that these experimental systems may be used with advantage to explore many features of two-dimensional liquid crystals, including formation of phases with exotic symmetries, effect of confinement in cavities of different geometries, and formation of topological defects and their nature and interactions.

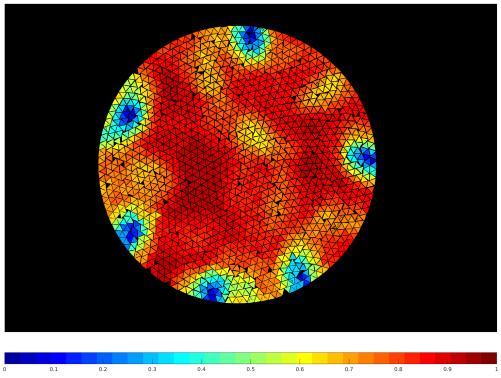

Fig. 1. False colour field of triatic order parameter, showing the formation of a triatic phase and six topological defects that restore the global symmetry of the system, broken by confinement of the six-fold symmetric fluid in a cicular cavity.

[1] M. González-Pinto, F. Borondo, Y. Martínez-Ratón and E. Velasco , Soft Matter, **13**, 2571 (2017).

[2] M. González-Pinto, J. Renner, D. de las Heras, Y. Martínez-Ratón and E. Velasco, New J. Phys. **21**, 033002 (2019). (2019).