Effect of clustering on the orientational properties of a fluid of hard right isosceles triangles

E. Velasco[1], and Y. Martínez-Ratón[2]
[1]Departamento de Física Teórica de la Materia Condensada, Universidad Autónoma de Madrid, Madrid
[2]Departamento de Matemáticas, Universidad Carlos III de Madrid, Madrid

Recent studies [1, 2] have shown the fluid of hard right triangles to possess fourfold and quasi-eightfold (octatic) orientational symmetries. However, the standard density-functional theory for two-dimensional anisotropic fluids, based on two-body correlations, and an extension to incorporate three-body correlations, fail to describe these symmetries.

To explain the origin of octatic symmetry, we postulate strong particle clustering as a crucial ingredient. We use Scaled Particle Theory to analyze four binary mixtures of hard right triangles and squares, three of them being extreme models for a one-component fluid, where right triangles can exist as monomeric entities together with triangular dimers, square dimers or square tetramers. In some circumstances the orientational distribution function of triangles has equally high peaks at relative particle angles 0, $\pi/2$, and π, signalling fourfold, tetratic order, but also secondary peaks located at $\pi/4$ and $3\pi/4$, a feature of eightfold, octatic order.

Also, we extend the binary mixture model to a quaternary mixture, consisting of four types of clusters: monomers, triangular and square dimers, and square tetramers. This mixture is analyzed using Scaled Particle Theory under the restriction of fixed cluster fractions. Apart from the obvious tetratic phase promoted by tetramers, we found that, for certain cluster compositions, the total orientational distribution function of monomers can exhibit quasi-eightfold (octatic) symmetry [3].

The study gives evidence on the importance of clustering to explain the peculiar orientational properties of liquid-crystal phases in some two dimensional fluids.

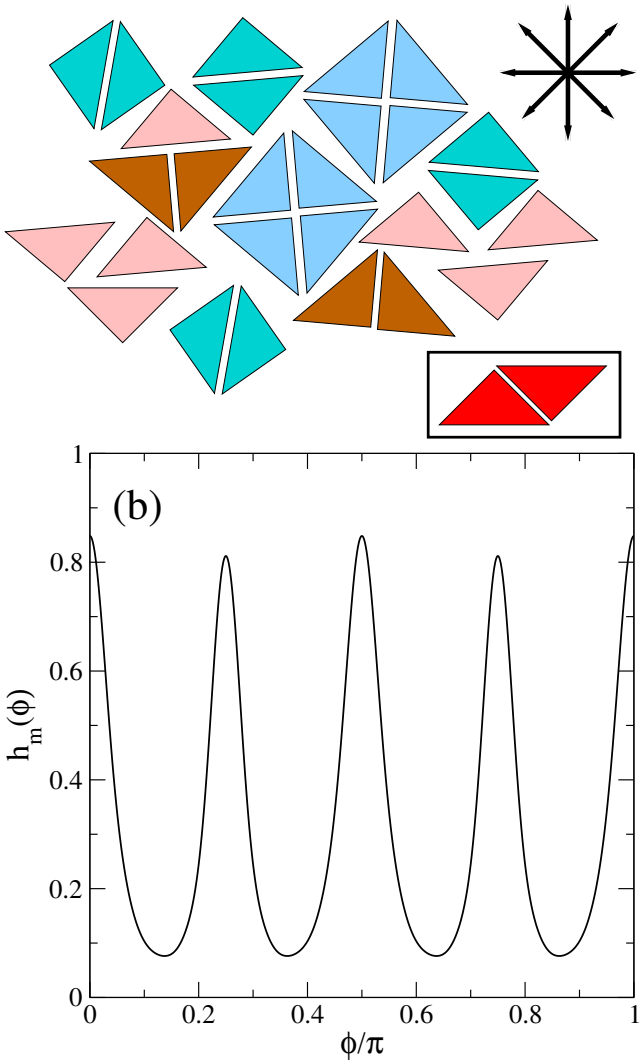

Fig. 1. (a) Sketch of clusters of triangles in the octatic phase. (b) Monomer angular distribution function.

[1] A.P. Gantapara, W. Qi and M. Dijkstra, Soft Matter **11**, 8684 (2015).

[2] Y. Martínez-Ratón and E. Velasco, Phys. Rev. E **104**, 054132 (2021).

[3] Y. Martínez-Ratón and E. Velasco, arXiv:2001.05525v2 (2022).