Theory and simulation of two-dimensional nematic and tetratic phases

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Recent experiments and simulations have shown that two-dimensional system can form tetratic phase with four-fold rotational symmetry even if they are composed of particles with only two-fold symmetry. To understand this effect, we propose a model for the statistical mechanics of particles with almost four-fold tetratical symmetry, which is weakly broken down to two-fold. We introduce a coefficient κ to characterize the symmetry breaking, and find that the tetratic phase can still exist even if to a substantial value of κ. By using Landau's expansion of the free energy, we calculate the phase diagram analytically, which is similar to the result of a previous hard particle excluded volume model. To verify our model, we develop a Monte Carlo simulation of spins on a triangular lattice. The results of the simulation agree with our model very well.

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