Pattern Selection in Polyelectrolyte Gels by Nonlinear Elasticity

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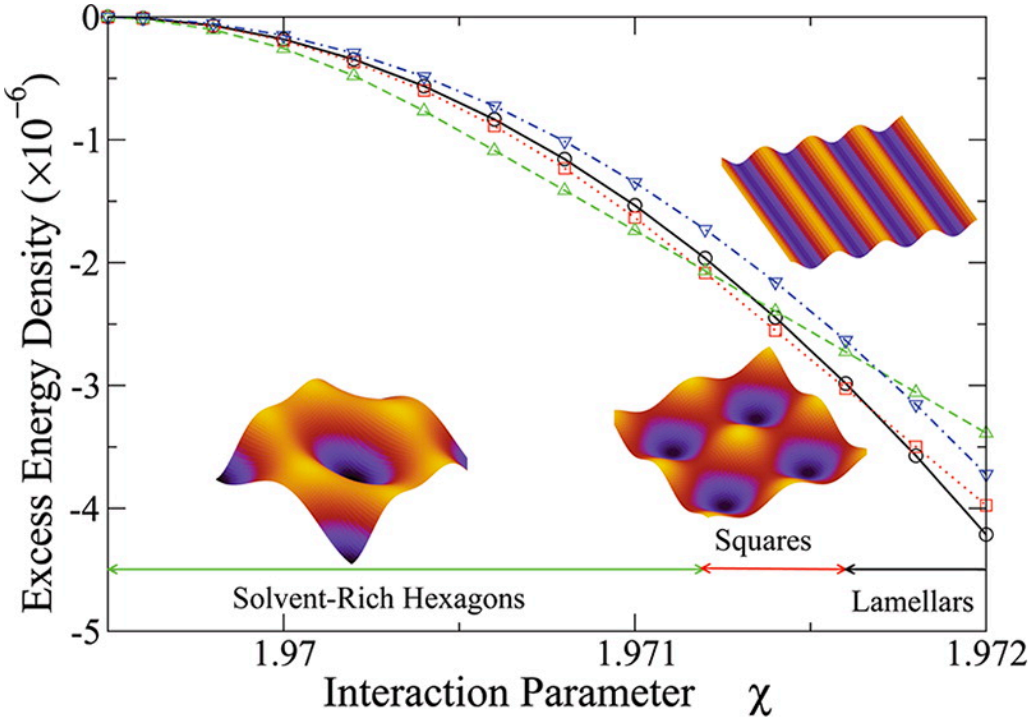
We demonstrate periodic nanostructures emerged in homogeneously cross-linked thin gels made of strongly charged polymers. Free-energy functional of polyelectrolyte gels with density and charge inhomogeneities is developed and numerical energy minimization is performed over candidate nanostructures. The two-dimensional calculations indicate the possibility of realizing lamellar, square, solvent-rich hexagonal, and polymer-rich hexagonal phases, by a fine interplay of polymer and solvent characteristics. Nonlinearities in network elasticity and electrostatic energy are found to be the deciding factor in the thermodynamic selection of nanostructures.



In particular, the nonlinear network elasticity suppresses the stability of solvent-rich hexagonal nanostructures as solvent quality increases, which results in exchange of stabilities between nanostructures and leads to stable nanostructures of square symmetry in two-dimensional gels. The phase transition between nanostructures by changes in environmental stimuli suggests a possible means to control bulk properties of polyelectrolyte gels.

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