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Self-consistent field theory of wormlike chains and its applications in polymer physics

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In recent years, a whole body of knowledge has been built on the structural and conformational properties of polymers, based on the Gaussian description of polymer statistics. Whether we are dealing with a single polymer or spatially inhomogeneous polymer systems, the solution of the self-consistent field theory has been one of the central focuses of theoretical studies. A wormlike-chain model, which differs from a Gaussian-chain model by using a bond-bending energy rather than monomer-monomer stretching energy, is more suitable for dealing with semiflexible polymers; a self-consistent field theory can be built for systems where both spatial inhomogeneity and orientational ordering need simultaneously considered. The wormlike chain model captures a number of physical features of a polymer system that go beyond those described by a Gaussian-chain model. A wormlike-chain based self-consistent field theory can be used to study the structural properties within the length scale smaller than the persistence length and the length scale where the polymer is strongly extended to an almost fully stretched conformation. As well, such a theory can be used to study a system where the orientational properties of polymer segments are important such as a liquid-crystal system. In this talk, we review the progress in solving the self-consistent field theory of wormlike chains for various physical problems and specifically discuss two recent examples of the applications of the theory: (a) the influence of chain rigidity on the phase diagram of AB diblock copolymers [Y. Jiang and J. Z. Y. Chen, Phys. Rev. Lett. **110**, 138305 (2013); Phys. Rev. E **88**, 042603 (2013)]; and (b) liquid-crystal defect structures in confined geometry [J. Z. Y. Chen, Soft Matter **9**, 10921 (2013)]. As well, we address the question that under what physical conditions, the self-consistent field theory of wormlike chains recovers the theory of Gaussian chains.