Discontinuous bundling transition in semiflexible polymer networks induced by Casimir interactions

Abstract:
Fluctuation-induced interactions are an important organizing principle in a variety of soft matter systems. We investigate the role of fluctuation-based or thermal Casimir interactions between cross linkers in a semiflexible network. One finds that, by integrating out the polymer degrees of freedom, there is an attractive logarithmic potential between nearest-neighbor cross linkers in a bundle, with a significantly weaker next-nearest-neighbor interaction. Here we show that a one-dimensional gas of these strongly interacting linkers in equilibrium with a source of unbound ones admits a discontinuous phase transition between a sparsely and a densely bound bundle. This discontinuous transition induced by the long-ranged nature of the Casimir interaction allows for a similarly abrupt structural transition in semiflexible filament networks between a low cross linker density isotropic phase and a higher cross link density bundle network. We support these calculations with the results of finite element Brownian dynamics simulations of semiflexible filaments and transient cross linkers.

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