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Microscopic theory of topological entanglement constraints in fluids of rigid macromolecules DANIEL SUSSMAN, KEN SCHWEIZER, University of Illinois at Urbana-Champaign — A theoretical description of the slow dynamics of an ideal gas of infinitely thin, non-rotating rods or three-dimensional crosses is presented. As objects with no excluded volume their equilibrium structure is trivial, and thus slow dynamics are determined solely by bond uncrossability and macromolecular connectivity. Our work builds on the dynamic mean-field theory of Szamel, which successfully predicted tube localization and reptation for non-rotating uncrossable rods. We derive an effective diffusion constant by exactly enforcing uncrossability at the two-molecule level in conjunction with a self-consistent renormalization to account for many-particle effects. For crosses and isotropically translating rods a topological localization transition is predicted at a critical density above which macromolecules are localized by a confinement potential with very strong anharmonicities. The spatial nature of the latter, including the density-dependent localization length, is analyzed and contrasted with recent experiments on entangled F-actin filaments. The stability of the localization transition to both an external force (yielding) and macromolecular collective density fluctuations is examined, and comparison with simulations on entangled crosses is performed.

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