MAR09-2008-001433

Abstract for an Invited Paper
for the MAR09 Meeting of
the American Physical Society

The Packing of Flexible Screws and the Self-Limited Assembly of Biopolymer Bundles

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Living cells rely heavily on assemblies of filamentous proteins, such as F-actin and microtubules, to perform a variety of tasks, ranging from adhesion and locomotion to cell division and intracellular transport. In the dynamic cellular environment, the efficiency of these tasks is crucially dependent on the robust assembly and disassembly of rope-like bundles of filamentous molecules. Recent *in vitro* studies of F-actin assembly [Lai *et al.*, Phys. Rev. Lett. (2007)] suggest that bundle formation may take place as an equilibrium process, with a thermodynamically-preferred bundle diameter. Within the context of a generalized elastic model of filament packings, we explore the possibility that limited-bundle growth is directly linked with the intrinsic chiral structure of biological filaments themselves. The hexagonal packing of biopolymers leads to the build up of chiral stress, or torque, that generically induces the formation of twisting filament bundles of finite size. We demonstrate that the underlying elasticity of the bundle–i.e. whether hexagonal-solid or hexagonal-columnar–plays a key role in dictating both the thermodynamics (i.e. disperse, bundled or bulk aggregation) and structure (i.e. size and twist) of "self-braiding" aggregates of helical filaments.