Confotronic of biofilaments

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Many biofilaments like those of the cytoskeleton show anomalous behaviors in various experiments. As we will show, this can be explain by the existence of internal degrees of freedom, usually inaccessible by direct observation, but crucial for the understanding of the collective dynamics of the biofilaments. This is the case for coiled helices squeezed flat onto two-dimensional surfaces. Under such 2-d confinement helices form "squeelices", peculiar squeezed conformations often resembling looped waves, spirals or circles. The shapes as well as the unusual statistical mechanics of squeelices can be understood in terms of moving and interacting localized conformational quasi-particles called the twist kinks. These theoretical results will be interpreted in the light of recent experiments realized on actin and intermediate filaments. As a second example we will consider tubular lattices like microtubules. Despite significant effort, understanding the unusual mechanics of microtubules remains elusive. Based on recent experimental evidences for a conformational switch of the tubulin dimer we will introduce prestress in tubular structures and see that localized conformational quasi-particles called confloplexes emerge naturally. When we switch on additional mechanical coupling terms in the lattice, these quasi-particles will exhibit cooperative interactions. The cooperativity will lead to the formation of larger scale quasi-polymer superstructures called confostacks which will govern the collective shape dynamics of the lattice via elastically mediated interactions. The notion of quasi-particles/-polymers is the most natural language to quantitatively describe many new phenomena that we named confotronic dynamics. In particular, these internal degrees of freedom lead to a microtubule lattice that coexists in discrete super helical polymorphic states that have very unique characteristics in the world of macromolecules: microtubules are helices that are permanently but coherently reshaping due to thermal fluctuations. This particular zero energy motion could be the clue to explain the observed anomalous elastic and dynamic behavior of microtubules. Another persistent mystery is the formation of long lived arcs and rings in kinesin driven gliding assays. Our theory predicts that metastable curved states can be induced via a mechanical hysteresis involving torques and forces typical of a few molecular acting in unison in agreement with experiments.

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