Geometric frustration in twisted filament assemblies: Non-euclidean packing and morphology of self-limiting bundles

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From extracellular tissues and synthetic organogels at the nanoscale to fabrics and cables of macroscopic materials, filament assemblies represent a basic prototype of materials organization. In this seminar, I describe recent models that probe anomalous assembly properties of filaments that derive from a largely unknown formal equivalence between the geometry of inter-filament spacing and the metric properties of non-Euclidean surfaces. Motivated by a common structural motif formed by chiral filaments (e.g. biofilaments), I will discuss the consequences of the metric equivalence between packing in twisted bundles and on positively curved surfaces (e.g. the Thomson problem), which include self-limiting lateral assembly of cohesive bundles and the optimal patterns of defects needed in the ground state bundles. In this talk, I focus on a new "assembly mode" of twisted filament bundles which shares an analogue with recent experiments on colloidal crystallization at a spherical interface, whereby lateral shape of bundle cross section is determined by competition between geometrically-induced inter-filament stresses, intra-filament bending mechanics and surface energy of the assembled bundle. A universal phase diagram which delineates stable formation of isotropic bundles (both with and without defects) from anisotropic "helical tape" morphologies is proposed and compared to numerical simulations of cohesive filament assemblies as well as experiment data for polymorphic assemblies of amyloid peptide mixtures.