College of Natural Sciences & Mathematics
UNIVERSITY OF DENVER

Physics & Astronomy Colloquium

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Emergent topics in thin-structure elasticity

In this talk I will discuss three recent projects in theoretical thin-structure elasticity, and highlight their applications to engineering, biology, and fundamental physics. First, I will introduce an exciting new area of nonequilibrium continuum mechanics called “odd elasticity,” and show how its mathematical hallmark – major anti-symmetry in an elastic response tensor – can in fact be realized in purely conservative, equilibrium systems by tuning anisotropic prestresses. The tuning recipe that does this can be used to derive lattice spring models that function as unique elastic waveguides, and I will discuss several such models along with their novel acoustic and transport properties. Next, I will introduce 2D vertex models as a means of studying epithelial tissue mechanics, and show how the closely related cellular Potts model can be harnessed to model an understudied process known as “epithelial docking.” This process – essentially two epithelial sheets meeting at their apical or basal surfaces and their constituent cells rearranging to mirror each other across the bilayer – is a precursor to the topology-altering tissue fusion that occurs in neural tube closure, optic fissure closure, and foregut compartmentalization, among others. The last part of the talk concerns inextensible rods that can flex and sustain axial forces and torques within an Euler-Bernoulli description. Surprisingly, the dynamics of such a rod are isomorphic to the dynamics of a minimally coupled quantum particle in 1D, including de Broglie and uncertainty relations. When formed into a ring, the rod supports quantized orbital angular momentum and a “twist quantum” that is analogous to the magnetic flux quantum. A similar analogy between a 1D bipartite quantum system and an inextensible elastic sheet demonstrates the existence of entangled states in the latter.