Rational Mechanics of Viral Shells: Is Elasticity Theory a Stretch?

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The capacity of the self-assembling viral shells (capsids) to respond structurally and mechanically to physical and chemical stimuli makes them of a target of interest for the design of advanced materials. Many viruses undergo "maturation" transitions, exhibiting gross morphological changes, sometimes in coordination with local symmetry-breaking motions of the protein building blocks, or even formation of crystalline defects. These observations form a puzzle: *What are the driving forces for viral maturation? What are the origins of broken symmetry and structural defects, and what biological advantages do they confer?* I will address these questions with continuum theory and discrete particle methods, and show that we can understand conformational changes as being driven by elastic interactions among defects in the crystalline protein lattice. We find that the presence of soft conformational modes in the protein building blocks can promote assembly. Furthermore, the tendency of biological molecules to generate *symmetric* structures competes with the tendency to *break symmetry* in order to achieve specific functional goals. Continuum Landau theory also forms a framework for extending continuum theory to cross length scales of macromolecular discreteness.