Abstract for GR-TR Conference on Statistical Mechanics and Dynamical Systems

Plenary Invited | Invited Talk

Packing of wires in cavities and growing surfaces

Hans Herrmann*

ETH Zrich, Switzerland
* Electronic Address: hans@ifb.baug.ethz.ch

We investigate the morphologies and maximum packing density of thin wires packed into spherical cavities. Using simulations and experiments with nylon lines, we find that ordered as well as disordered structures emerge, depending on the amount of internal torsion. We find that the highest packing densities are achieved in a low torsion packing for large systems, but in a high torsion packing for small systems. An analysis of both situations is given in terms of energetics and comparison is made to analytical models of DNA packing in viral capsids. In two dimensions we also find that wires can crumple into different morphologies and present the associated morphological phase diagram. Our results are based on experiments with different metallic wires and confirmed by numerical simulations using a discrete element model. We show that during crumpling, the number of loops increases according to a power-law with different exponents in each morphology. Furthermore, we observe a power-law divergence of the structures bulk stiffness similar to what is observed in forced crumpling of a membrane. We also investigate the morphology of thin discs and rings growing in circumferential direction. Recent analytical results suggest that this growth produces symmetric excess cones (e-cones). We study the stability of such solutions considering self-contact and bending stress. We show that, contrary to what was assumed in previous analytical solutions, beyond a critical growth factor, no symmetric e-cone solution is energetically minimal any more. Instead, we obtain skewed e-cone solutions having lower energy, characterized by a skewness angle and repetitive spiral winding with increasing growth. These results are generalized to discs with varying thickness and rings with holes of different radii. Simple experiments with cardboard confirm the simulations.