Printing Non-Euclidean Solids

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Abstract

Geometrically frustrated solids with non-Euclidean reference metric are ubiquitous in biology and are becoming increasingly relevant in technological applications. Often they acquire a targeted configuration of incompatibility through surface accretion of mass as in tree growth or dam construction. We use the mechanics of incompatible surface growth to show that geometrical frustration developing during deposition can be fine-tuned to ensure a particular behavior of the system in physiological (or working) conditions. As an illustration, we obtain an explicit 3D printing protocol for arteries, which guarantees stress uniformity under inhomogeneous loading, and for explosive plants, allowing a complete release of residual elastic energy with a single cut. Interestingly, in both cases reaching the physiological target requires the incompatibility to have a topological (global) component. This work is in collaboration with Lev Truskinovsky - ESPCI - Paris.