Geometrically Frustrated Rose Petals

Yafei Zhang*[1], Eran Sharon†[1], Michael Moshe‡[1], and Omri Cohen[1]

[1]Hebrew University – Israel

Abstract

Roses, known worldwide for their beauty and symbolic significance, have long captivated artists and poets alike. Yet, the underlying mechanism shaping the distinctive form of rose petals and its implications for petal development remain elusive. Here, we unveil the mechanical instability that governs the unique evolution of rose petals geometry. We show that it emerges from simple growth that induces uniaxial reference curvature perpendicularly to the petal's edge. Though simple and highly symmetric, this curvature field violates the Mainardi-Codazzi-Peterson (MCP) compatibility equations. As a result, a sequence of cusps gradually appears along the growing petal's edge. Using analytical, numerical and experimental work, we study the problem of a circular disc with radial reference curvature and determine the phase space of the problem, including the formation of the first, as well as subsequent cusps along the initially axisymmetric edge. We go further and study the characteristic shape of a cusp, which partially regularizes the curvature singularity of an idealized cusp. Finally, we find evidences for the effect of the stress focusing generated by the cusps, on the local petal tissue morphology and its further growth. To our best knowledge, this is the first report on MCP geometric frustration, the following stress-focusing and its effect on growth in natural systems. This study not only advances our understanding of fundamental principles governing shape formation and growth regulation in nature, but also opens avenues for developing innovative functionalities in engineered materials and structures.

*Speaker

†Corresponding author: erans@mail.huji.ac.il

‡Corresponding author: michael.moshe@mail.huji.ac.il