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A Geometric Theory of Plant Growth

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In many cases the leaves and petals of plants form curved two-dimensional surfaces. The development of the curvature of those surfaces (ripples, warps, deformations, etc.) can be described by a time dependent Riemannian geometry. Since many biological and chemical systems evolve according to reaction-diffusion equations, the the geometrical description of growth naturally leads to curvature flow equations where the metric describing the geometry of the surface obeys reaction-diffusion type behaviour.

This presentation will introduce a model of plant growth that incorporates Ricci flow together with material transport in a set of tensor, vector and scalar equations that lead to growth patterns that can be compared with observations. The first application is found in the growth of roots for which the theory is able to explain an observation that could not be explained by other growth models. In another case the theory was shown to be applicable to the growth of the algae Acetabularia whose cap begins as a positively curved surface and during its growth passes through a flat (zero curvature) state to eventually become negatively curved.

Both the theory and the observational measurements demonstrate that there is an analogy between plant growth and an expanding universe when one takes into account the Riemannian curvature of the underlying manifold.

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