A growth model for arboreal termite nests

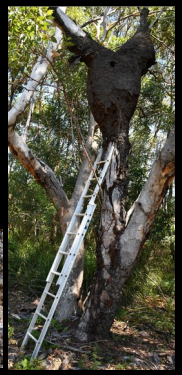
Giulio Facchini, Alexandre Lazarescu, Andrea Perna and Stéphane Douady

Motivations

Termites nest are impressive structure:

- *Nest size ~ termite size * 1000*
- *A colony count 10^5-10^6 individuals*

→ Construction must be self-organized,but difficult to observe!

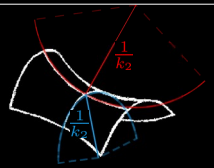


Nest Analysis

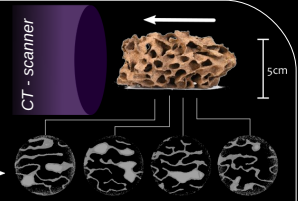
- *Nest walls form a structure which is disordered but coherent.*
- *Surface is saddle-shaped, and is reconstructed with tomography.*

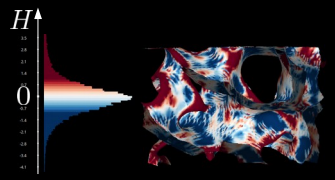
mean curvature:
$H = (k_1 + k_2)/2$

Gauss curvature
$\Gamma = k_1 * k_2$



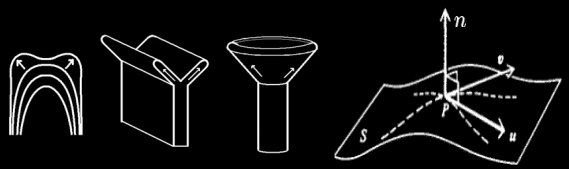
$H = 0, \Gamma < 0$





Our Minimal Growth model

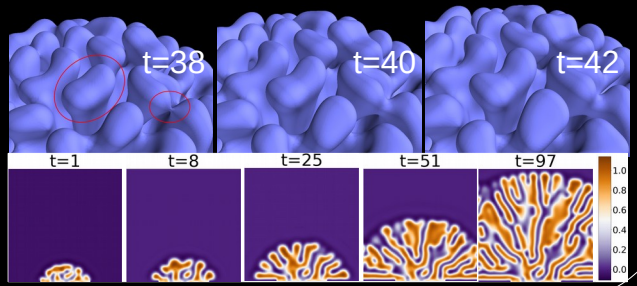
- *Phase field approach* $f(\boldsymbol{x}), \boldsymbol{x} \in \mathbb{R}^3 : \boldsymbol{x} \to [0,1]$
  1 is a wall, 0 is empty space, surface is f=0.5
- *Our hypothesis is that surface shape contains building "instructions"* $\to \partial_t f = \mathcal{A}(f)$
- *Walls must branch a lot,* $\to \mathcal{A}(f) \propto -\nabla \cdot \boldsymbol{n} \approx -\Delta f$



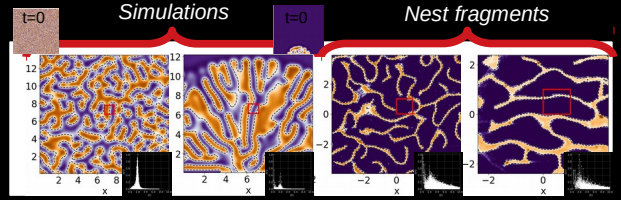
$$\frac{\partial f}{\partial t} = -df(1-f)\Delta f - \Delta^2 f$$

- *Curvature focuses material deposition*
- *Growth happens at the wall surface*
- *Pellets finite size, and smoothing action of termites*

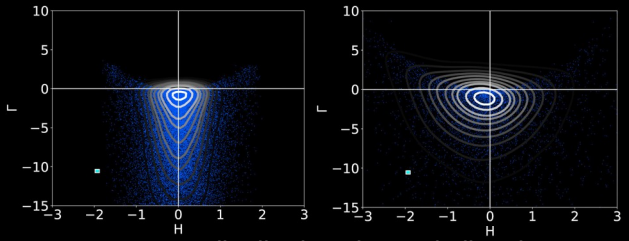
*We reproduce both **branching** and **reconnections**!*



Comparison



- *We find a typical length scale*



- *Curvature distributions have similar shapes*

G. Facchini et al., J. R. Soc. Interface 2020, **17,** 168**,** 20200093.