Quadtree Grids & Dendritic Growth

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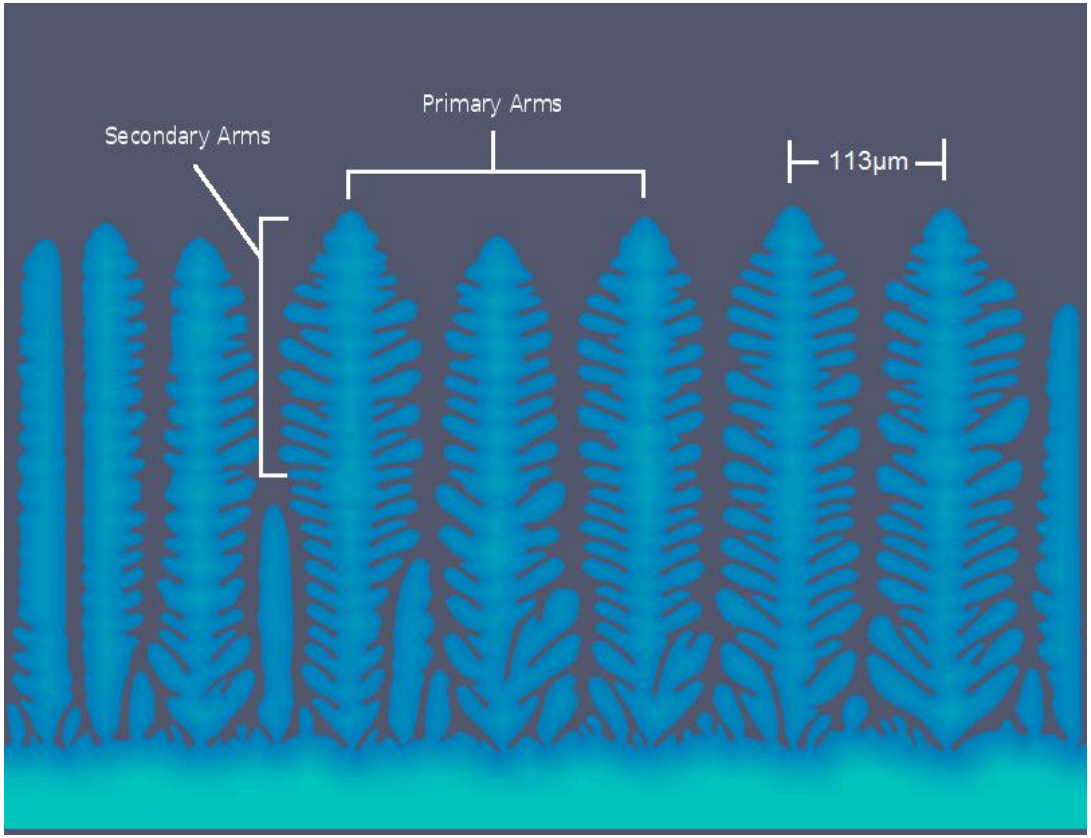

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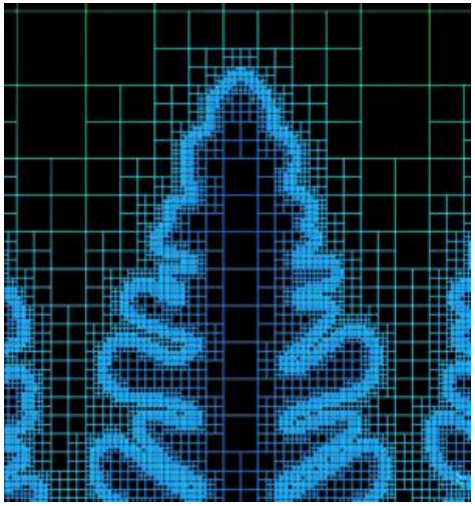
Funding Source

Applications of our Simulation

Big Picture

- Metals are often made of dendritic crystals
  - Properties come from the crystal's characteristics
  - We want to grow crystals with desired characteristics
  - Metal can be customized for specific applications
    - Such as jet engine turbine blades
- Many problems cannot be solved analytically
  - Our numerical method approximates the answers
  - We model the result using a Quadtree Grid

Courtesy of iagblog.blogspot.com



Quadtree Grid

Research Goals and Challenges

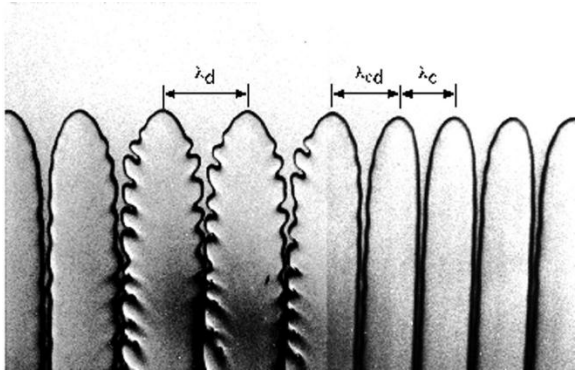
Primary Goal

- Prove our numerical method
  - Enable extensive research
  - Save time and money

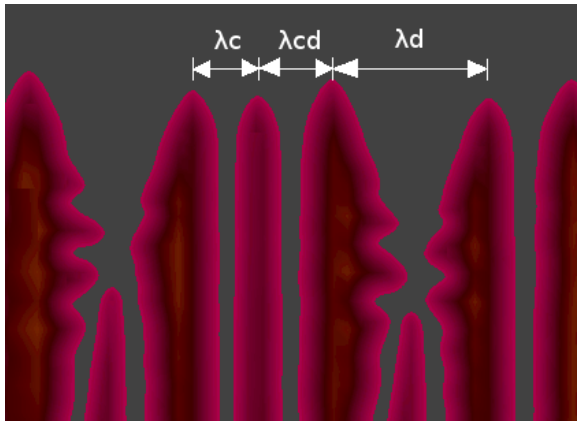
Challenges

- Determine if collected experimental data is reliable

- Match simulation to existing experimental data



(a) courtesy of R. TRIVEDI, YUNXUE SHEN, and SHAN LIU



(b)

(a) & (b) demonstrate characteristic phase changes

Simulating the Crystals

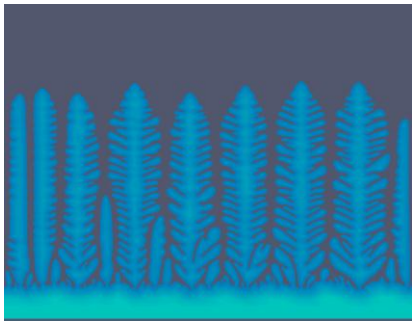
Numerical method developed by:

Partial differential equations approximated using a Level Set Method.

Simulation coded in

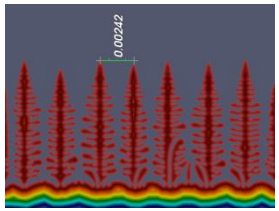
C++

Output data in .vtk format

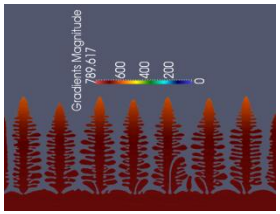


Measurements and Predictions

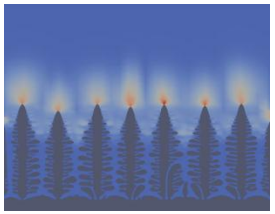
ParaView
Parallel Visualization Application



Primary Arm Spacing



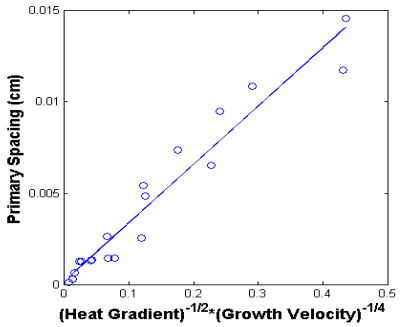
Heat Gradient



Growth Rate

$$Primary\ Spacing = k \frac{1}{Heat\ Gradient^{1/2} \times Growth\ Rate^{1/4}}$$

Theoretical equation used to predict spacing.

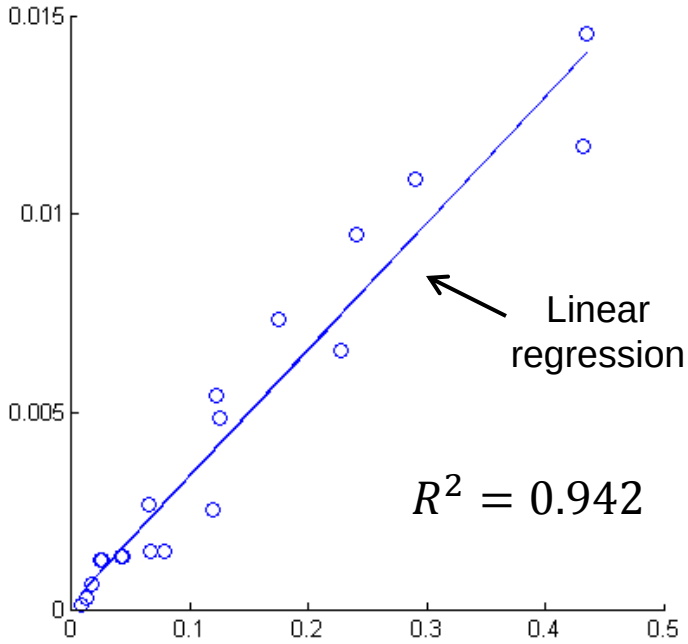


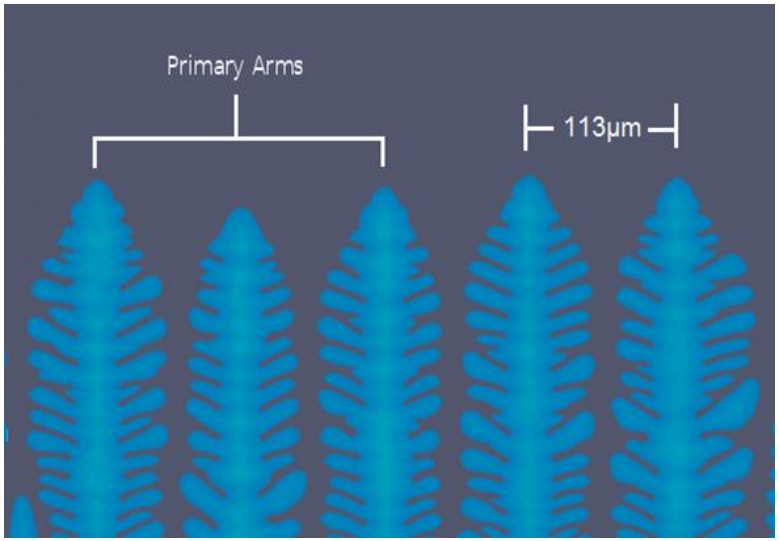
MATLAB

Primary Spacing Results

$$Primary\ Spacing = k\ \frac{1}{Heat\ Gradient^{1/2} \times\ Growth\ Rate^{1/4}}$$

Primary Spacing (cm)



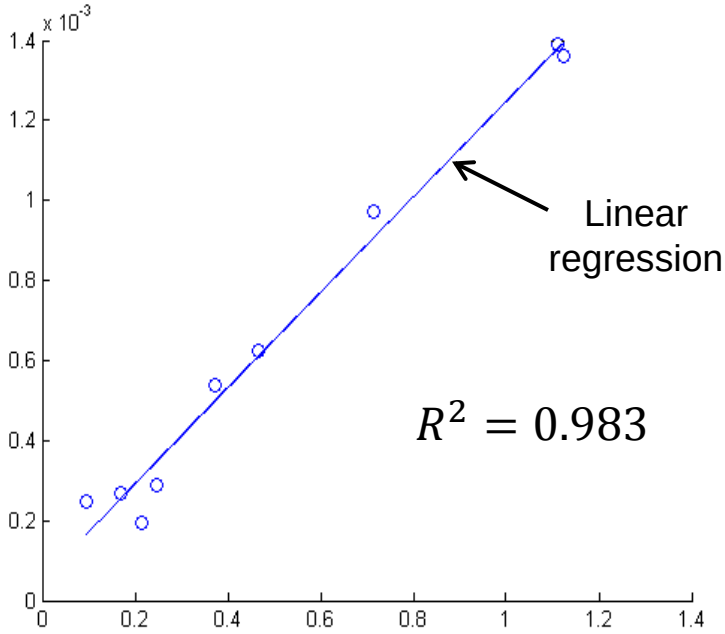


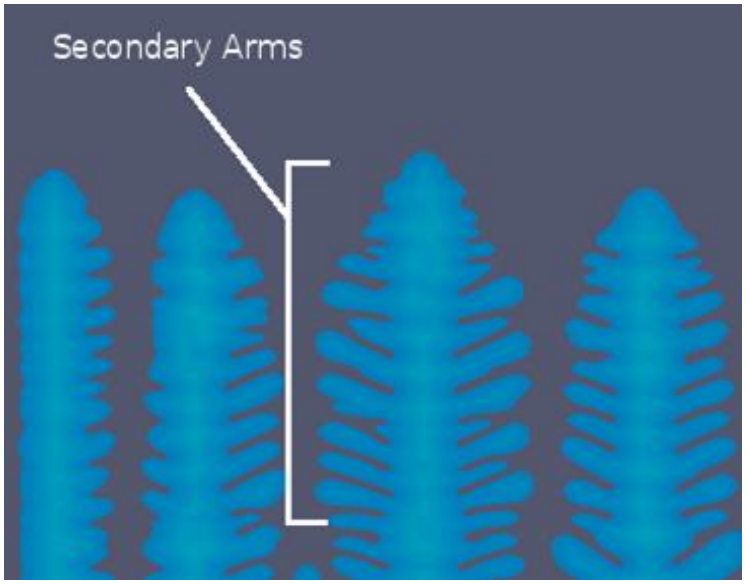
$$Heat\ Gradient^{-1/2} \times\ Growth\ Rate^{-1/4}$$

Secondary Spacing Results

$$Secondary\ Spacing = k\frac{1}{(Heat\ Gradient \times Growth\ Rate)^{1/3}}$$

Secondary Spacing (cm)





$(Heat\ Gradient\ \times Growth\ Rate)^{-1/3}$

Future Plans

- Continue to develop our method
  - Simulations in 3D
  - Factor in more natural phenomena
    - Convection effect

- Explore
  - Work with Materials Scientists
  - Solve unanswered questions

Acknowledgements

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