Watching paint dry

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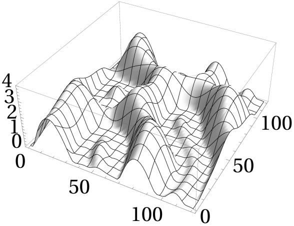
01/24/2013

“Wrinkling paint” vs simulation results

Wrinkling paint



Simulation results with dichloromethane

Paint: Viscosity changes can affect paint stability

1. Paint is a highly viscous medium
2. Paint has molecules of different shapes and sizes and invariably components of different **concentrations**
3. The viscosity of the paint matters a lot because:
    - Highly viscous paint would stay put on a vertical surface (falling films)
    - Highly viscous paint is used to create "impasto" art [4]
    - In high viscosity paint, the pigment components don't move about too fast as they are impeded
    - Low viscosity paint behaves in the opposite manner
    - The viscosity of the paint, determines the span of time required for the coat of paint to harden (*to polymerize*)
    - So if the viscous time scale is **larger** than the Thermo/solutocapillarity time scales, there is greater chance of severe wrinkling

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Impasto Art

Impasto Art: Art that sticks out

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Addition of a solvent to paint

1. Turpentine is added to paint to make it's viscosity "manageable".
2. There is such a thing as too much turpentine. It causes "wrinkling".
3. Wrinkling [6] can be caused because: non-uniform evaporative mass flux (of the turp.), + non-uniform vapor recoil = thermocapillary stresses on the surface = migration of paint polymer particles.
4. The non-uniform distribution of polymeric paint molecules innately sets up solutocapillarity.

Smudged paint

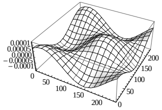
Oil paint "wrinkling" as a result of dilution with solvent

Controlling thermocapillary (TC) wrinkling

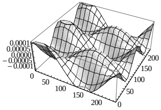
1. Based on our numerical observation, TC wrinkling can be controlled to produce desired patterns with the proper application of perturbations to drying paint ⋇
2. Our observations suggest:
   2.1 The initial condition has an effect on the final structure.
   2.2 Given the physical characteristics of the paint (thickness of coat, strength of thermocapillarity, strength of gravity), desired patterns (wavelengths) can be produced.
   2.3 This should be valid for polymeric substances like paint.

⋇ Our numerical evidence is based on the assumption that a layer of paint is susceptible to long wave instabilities.

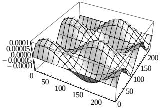
Numerical evidence:
Smooth sine-like initial conditions



$L = \lambda_{\max}$, cos

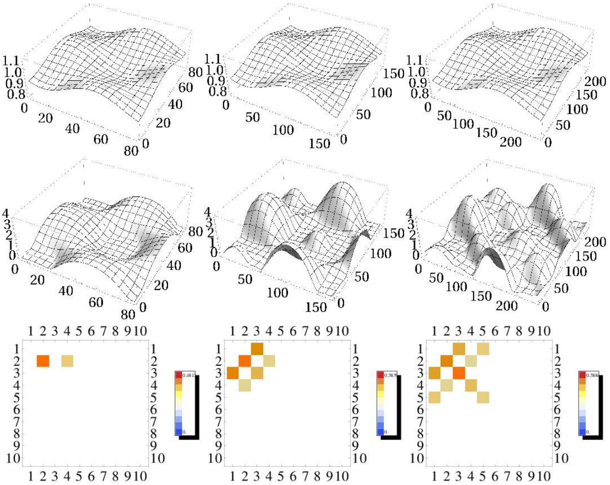


$L = \lambda_{\max}$, $\cos^2$



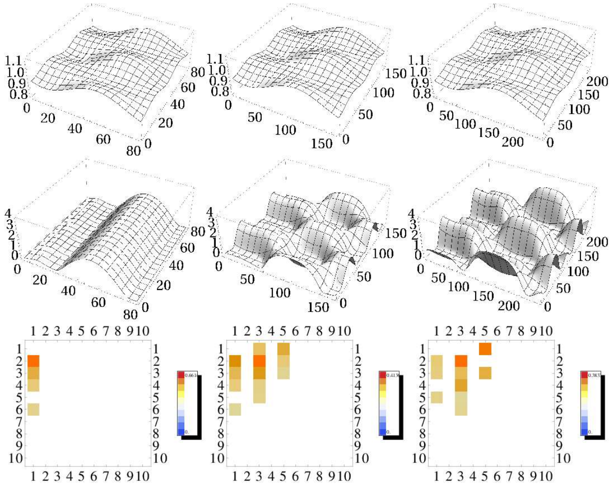
$L = \lambda_{\max}$, cos sin

Effect of initial conditions with $L = n\lambda_{\max}$, where $n = 1, 2, 3$ E=0.0001, G=0.0



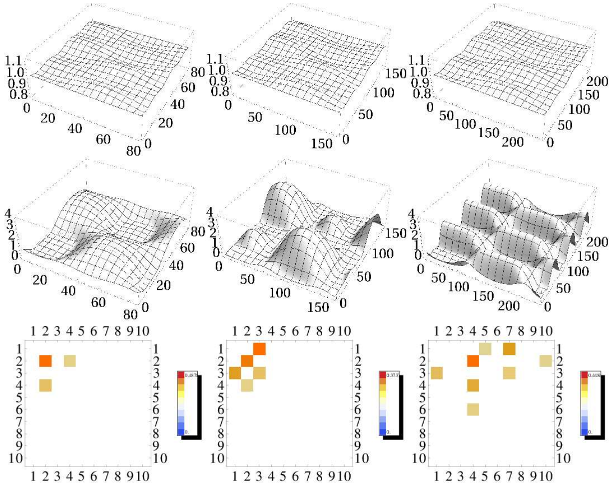
$$1 - 0.05(\cos[2\pi x/L] + \sin[2\pi x/L])(\cos[2\pi y/L])$$

Effect of initial conditions with $L = n\lambda_{\max}$, where $n = 1, 2, 3$ E=0.0001, G=0.0



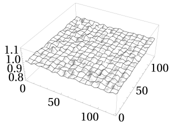
$$1 - 0.05(\cos[2\pi x/L] + \sin[2\pi x/L])(\cos[2\pi y/L])^2$$

Effect of initial conditions with $L = n\lambda_{\max}$, where $n = 1, 2, 3$ E=0.0001, G=0.0

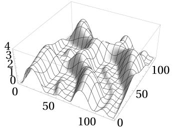


$1 - 0.05(\cos[2\pi x/L] + \sin[2\pi x/L])\cos[2\pi y/L]\sin[2\pi y/L]$

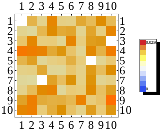
Numerical evidence: Jagged white noise (Using Dichloromethane(DCM) in zero gravity as an example*)



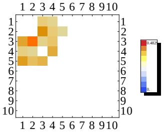
Initial condition



Rupture



DFT, Initial condition

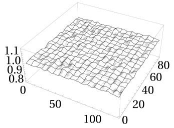


DFT, rupture

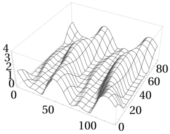
Random perturbations, 2.35 mm DCM, g=0.0 m/s^2 in a domain size where $L = n\lambda_{\text{max}}$, n =non whole number

* "Thick" DCM in zero gravity would behave like "thin" DCM in regular gravity

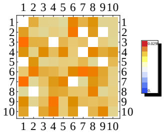
Numerical evidence: noisy initial condition (Using DCM in zero gravity as an example)



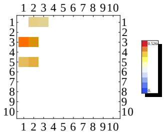
Initial condition



Rupture



DFT, Initial condition



DFT, rupture

Random perturbations, 2.35 mm DCM, g=0.0 m/s^2 in a domain size with rectangular domain

Conclusions

- Thermocapillarity and solutocapillarity cause wrinkling in paint.
- If paint were subject to long wave instabilities, we can “create” art by controlling the perturbation that a coat of paint is subject to.
- The nature of the perturbation changes mean curvature which in turn has an effect on strength of various terms.

Acknowledgements

The presenter would like to thank,

- **Michigan Technological University**, and the **Microfluidics and Interfacial Transport Laboratory**, where this research was performed.
- **National Science Foundation** and **NASA**, who supported the work.
- Dr. James C. Hermanson, Juan Carlos Gonzales (PhD Candidate) from the University of Washington.
- Dr. Robert W. Kolkka, Dr. Allan Struthers and Dr. Jeffrey S. Allen from Michigan Technological University.