Ultrasonic Field Intensity Distribution in Random Inhomogeneous Media

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How Might Ames Laboratory Contribute to Thermal Therapy?

- Mathematical analysis of Ultrasonic Measurement
  - Explain observed phenomena (data interpretation)
  - Measurement design optimization
  - Physical foundation for signal processing
- Analysis issues in thermal therapy
  - Engineering of ultrasound field
    - Transducer design
    - Array phasing
  - Study of ultrasound/tissue interaction
    - Random spatial fluctuation in ultrasound intensity due to spatial inhomogeneity in ultrasonic velocity
      - Impact on tissue heat distribution

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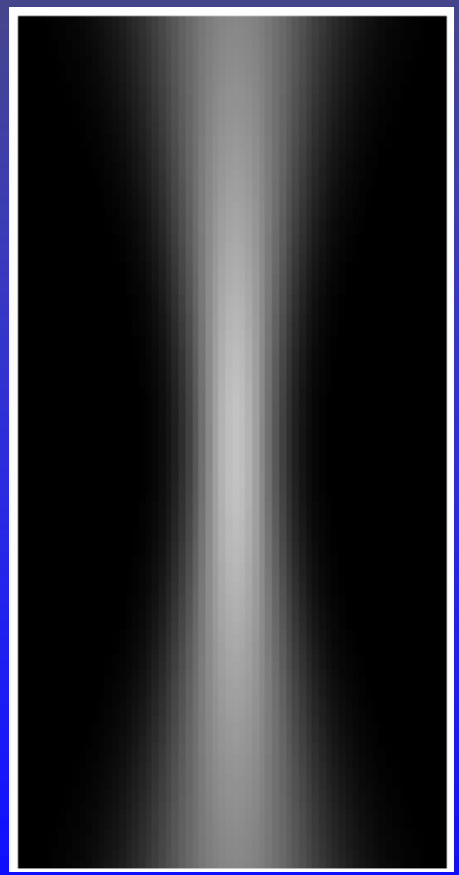
Ideal ultrasound field distribution



Heat is proportional to
field intensity in some fashion

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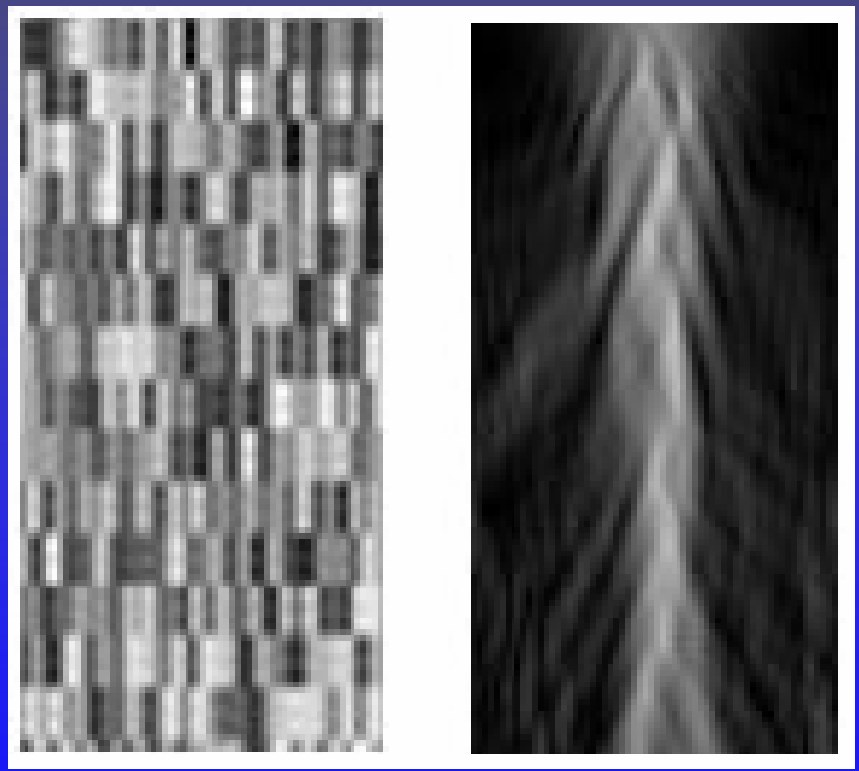
Medium with inhomogeneous microstructure



+ 4% velocity variation

Ultrasonic field

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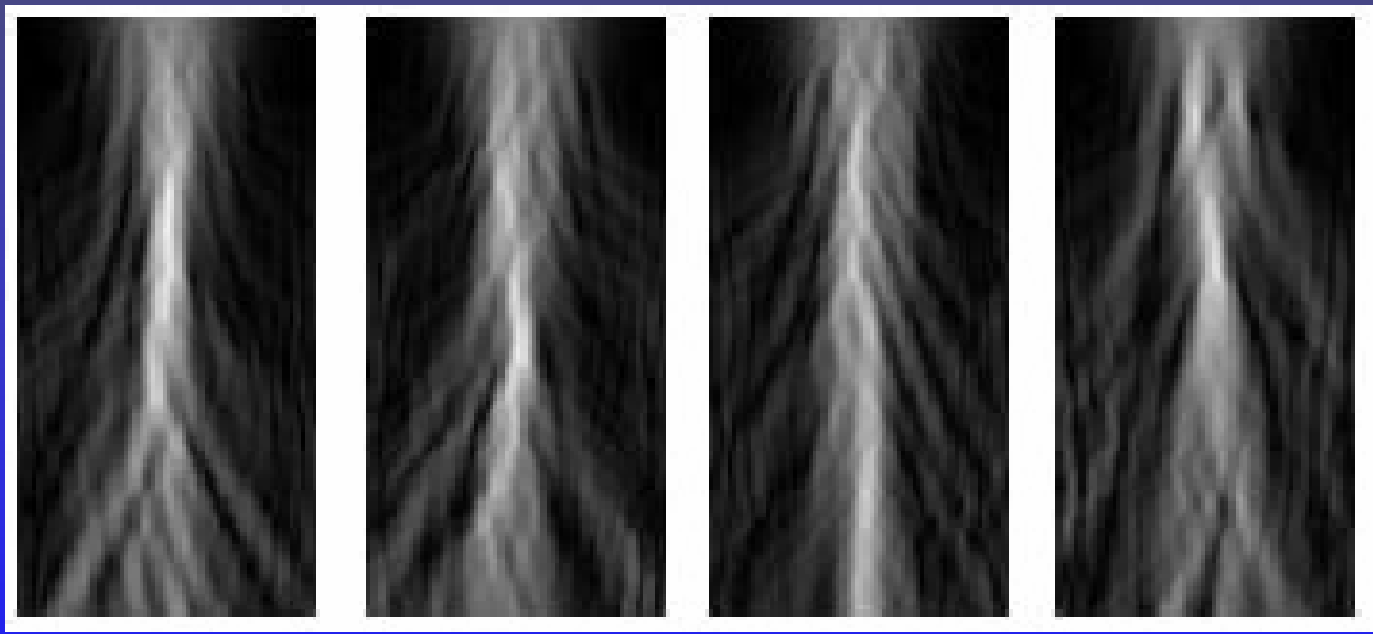
Ultrasonic fields in random microstructure (4 different realizations)



- Energy is localized in “hot spots”
  - **For flaw detection, this introduces a signal variance**
  - **What is implication for thermal therapy?**
    - **Localized excessive tissue damage?**

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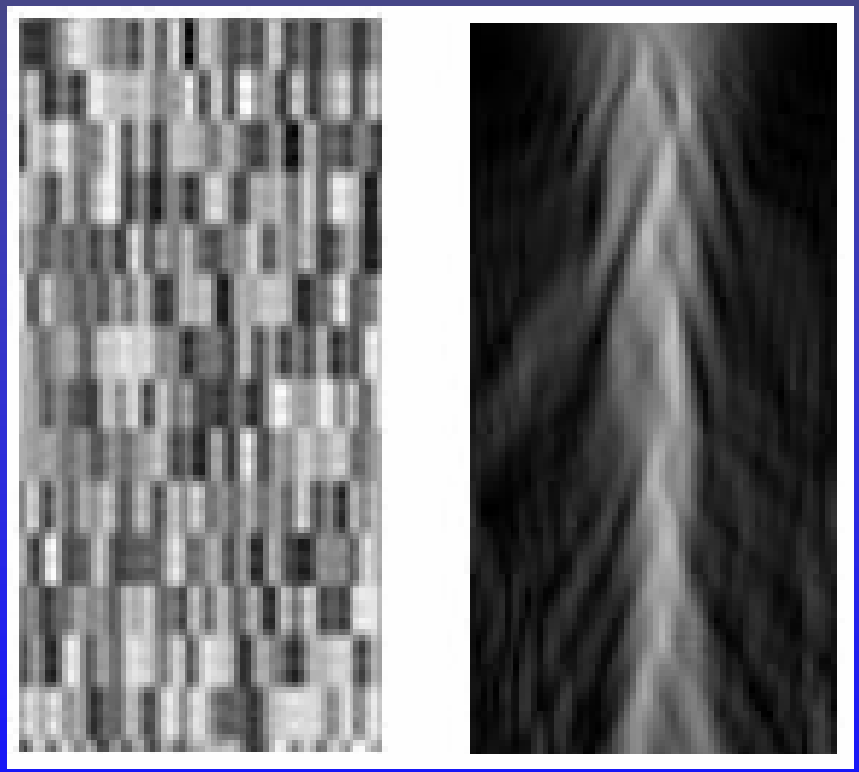
Potential Research Topics

- Study significance of problem
  - Quantify connection between spatial distribution of tissue velocity and heat
- Engineer solution
  - Design ultrasound source for uniform heat distribution
    - Dynamically swept angle of incidence
    - Modulated center frequency

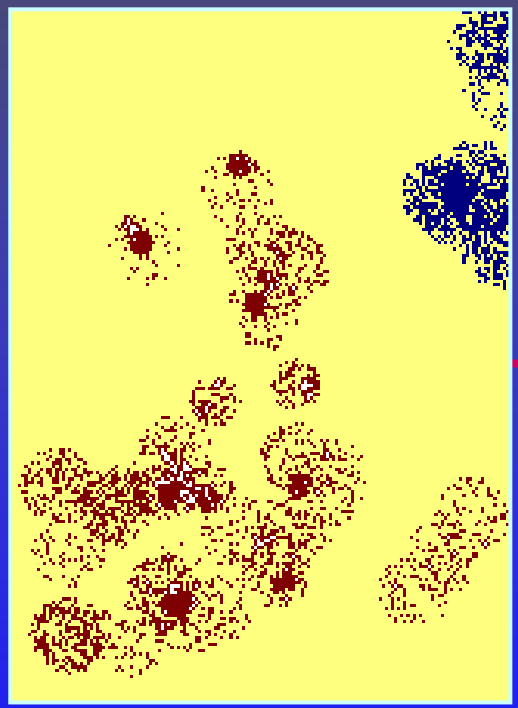
Available Resources for Research

Computational model for ultrasound propagation in random media



Available Resources for Research

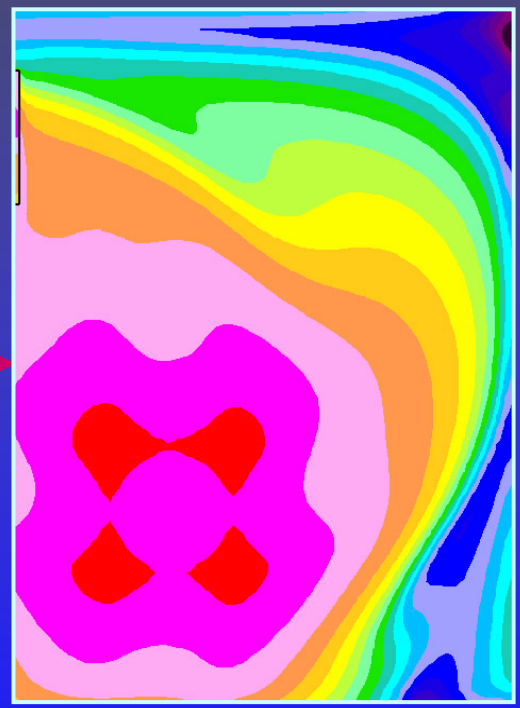
Real-time adaptive modeling of heat transfer



Complex geometry & inhomogeneous material with speckled energy deposition

AMoEBA

Adaptive Modeling by Evolving Blocks Algorithm



Transient temperature distribution analysis completed in real-time

Available Resources for Research

Experimental facilities for laboratory corroboration of model predictions