Multiscale and Multiphysics Modeling in Beamed Energy Harnessing Applications

- **Research group** involving graduate programs in the Departments of Mathematical Sciences and Mechanical Engineering
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Objective: Develop a fundamental modeling paradigm for electromagnetic energy absorbers that allows for efficient exploration of design space

Idea: Energy collection by an electromagnetically lossy porous ceramic material; fluid run through the material to delivery the energy or to produce work.

Process: Use mathematical and computational modeling techniques to find simpler representations of the same physics within a prescribed tolerance.

Idea: Develop simpler mathematical descriptions of multiple physical processes, valid in a limited operation space, to understand the nonlinear interactions between thermal and electromagnetic energy transport. Validate these models through full computational simulations of the system under consideration.

Goal: Find porous-media designs that instigate thermal runaway in the lossy component of the material but efficiently transfer energy to coolant.

Thermal Runaway: When using a microwave to cook food, some parts of the food heat up much more quickly than others. Food absorbs the microwave energy *better* as the food gets hotter, so if a spot gets hotter than its neighbor, then it can absorb energy better, which makes it get hotter, and so on. For *food science*, this phenomenon is a ***flaw*** in using microwaves to cook reliably. However, for *harnessing electromagnetic energy*, this phenomenon is a ***feature***.

Porous Media: Materials with a porous network are helpful to transfer heat from a solid, since the surface area is much larger in the porous network than simpler surfaces like cylinders or planes. For example, the surface area of the airway network in a human lung is about one-half the area of a tennis court. The rate of heat transfer is proportional to surface area, so porous media is the best way to have a large surface area for a given volume.

- **The research programs** are sponsored by the Air Force Office of Scientific Research (AFOSR) and the Air Force Research Laboratory (AFRL)

- **Research assistantships** are available for both PhD and MS students

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