Propagating Instabilities in Structures and Materials

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Abstract: This Grand Challenge award will be used to work on two problems outlined below. (a) The numerical simulation of dynamic buckle propagation of onshore pipelines in water. Recent experiments have quantified the velocity of buckle propagation in water as a function of pressure. The energy dissipated by the fluid in this problem is by radiation, which requires the fluid to be compressible. A fluid/structure interaction numerical model with a compressible water model was developed, in cooperation with Charbel Farhat of Stanford in a MURI on dynamic implosion of underwater structures. A significant part of the semester will be devoted to evaluating this code and one used by the Navy (DYSMAS) for their ability to simulate the physical experiments of dynamic buckle propagation. An issue that will require further development is the treatment of large deformations and contact between the walls of the collapsing structure in these codes. (b) Thermomechanics of Phase Transformation Fronts in Shape Memory Alloys. Shape memory alloys like NiTi undergo phase transformation at room temperature from either small changes in temperature or from the application of stress. The transformation involves change in the lattice and an associated elongation or contraction. During stress-induced phase transformation, the two phases can coexist, which implies coexistence of two deformation regimes. The new phase propagates until the whole domain is transformed, while the stress remains essentially unchanged. In cooperation with Chad Landis, we are investigating the interaction of this propagating material instability with NiTi structural nonlinearities. Since phase transformation can take place with either temperature or stress, it is essential that the model be extended to include thermal effects. This is a non-trivial task that requires first careful experiments, thermodynamic additions to an isothermal model, and non-trivial numerical implementation in finite element structural models that includes heat transfer. The release from teaching will enable concentration of efforts on these two tasks.