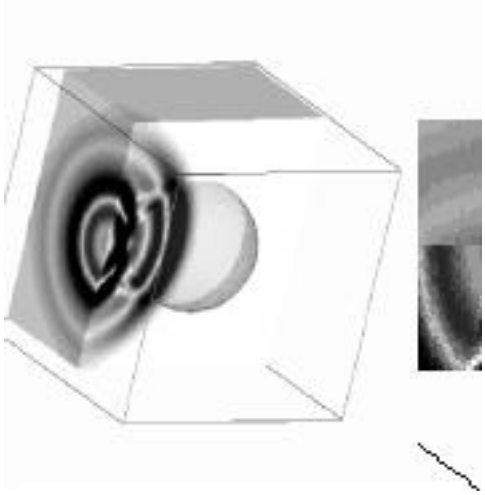
Science and Technology Success Stories

Wave Propagation Modeling

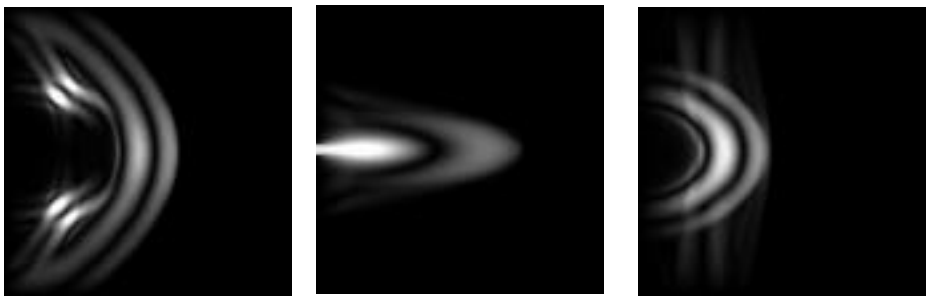
The Naval Research Laboratory (NRL) has a vigorous program in developing large scale simulations of wave propagation in complex materials. This program relies heavily on the use of large Massively Parallel Processor (MPP) computers like the Cray T3E. Time on these large machines is provided by the DOD's High Performance Computing Modernization Plan (HPCMP).

Currently these computational simulations are performed on large grids (up to 512 × 512 × 512) and run for several thousand time steps. On a Cray T3E, using 256 processors, an aggregate performance of about 16 Gflops can be achieved. Programming tools include High Performance Fortran (HPF) - a data parallel Fortran 90 language - and MPI (Message Passing Interface) which permits domain decomposition along with explicit passing of data between processors.

Examples of problems solved to date include scattering of ultrasonic pulses from voids, cracks, and inclusions in 2D and 3D. Another example is wave propagation through composite materials such as graphite/epoxy. These codes may be also used to compute accurate radiated continuous wave (cw) fields from transducers that may be as simple as a single piston source or as complex as a composite ceramic transducer with many active rods embedded in epoxy.



3D rendering of an ultrasonic pulse in steel scattering from an aluminum sphere



2D images of an ultrasonic pulse propagation in graphite/epoxy with fibers oriented:
(1) normal to propagation direction and out of plane
(2) parallel to propagation direction and in plane
(3) perpendicular to propagation direction and in plane

Wave Propagation Modeling

Military Impact

- Improve detection techniques for cracks and other defects in critical components by simulating the expected results
- Design and predict acoustic performance of piezocomposite transducers
- Determine homogenized material properties of composite type materials

Potential Civilian Spin-offs

- Simulation techniques for aerospace industry for inspection of components for manufacturing defects
- Design and tailoring of transducer fields
- Academic training use of these simulations provides understanding of wave propagation and scattering phenomena

Point of Contact

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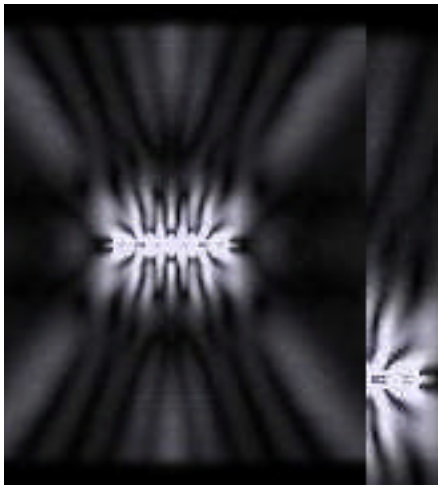
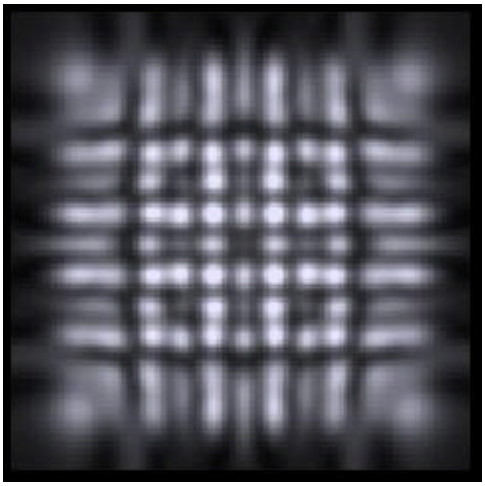


Computed pressure field slice through 3D volume radiated from a piezoceramic composite transducer at 100 kHz



Pressure field slice perpendicular to previous one at 6 mm from transducer face (extreme near field)

Computed pressure field slice through 3D volume at 50kHz