News Releases

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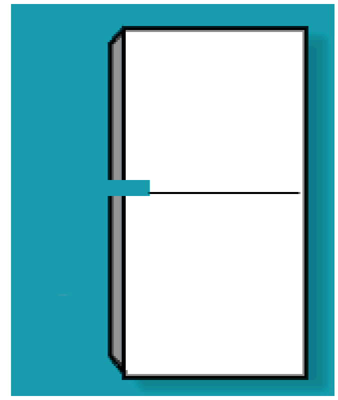
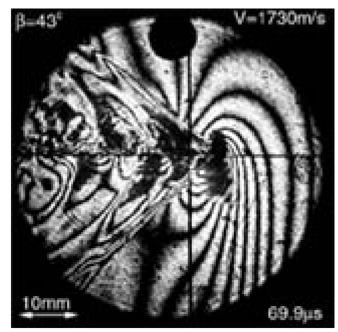


Aeronautics researchers generate cracks that move as fast as the speed of sound, and resemble certain earthquake shear ruptures

PASADENA-When a brittle material breaks, the resulting cracks tend to spread quite rapidly. Anyone who has inadvertently subjected a favorite vase to "floor stress" can attest to this.

But exactly how fast a crack can move has been a subject of debate for some time. To understand how fast is fast, one has to know how quickly stress waves spread. In a solid material, waves spread with two speeds-the slower shear waves move at the shear wave speed, and the faster pressure waves move at the pressure wave speed, also commonly known as the speed of sound in the material.

The researchers who specialize in the topic have thought that cracks move at speeds substantially slower than either of these wave speeds in the material (usually less than 20 percent of the speed of sound).



Click here to view or download the high speed photographs showing the propegation of shear cracks (QuickTime format, 2MB)

But new work from California Institute of Technology researchers shows that a certain type of crack can exceed the shear wave speed through the material, creating a sort of "sonic boom," and can almost reach sound speed.

According to Ares Rosakis, professor of aeronautics and applied mechanics, such a crack (called a shear crack) can be generated under controlled circumstances and photographed with ultrahigh-speed equipment capable of taking two million photographs in a second. The pictures show a crack with angled shock waves (Mach cones) that closely resemble photographs of a supersonic bullet breaking the sound barrier.

This result has practical applications, Rosakis says, because there is reason to believe that certain earthquakes can arise from similar shear breakages. A better understanding of the way in which these cracks get rolling could help seismologists with their models of earthquakes along shear faults, Rosakis believes.

To test the idea, Rosakis and his graduate students Omprakash Samudrala and Demirkan Coker bonded two sheets of a clear polyester material called "Homalite." They introduced a notch along the bond line, and rammed the bottom sheet from the side with a steel projectile moving only at 25 meters per second (56 miles per hour). High-speed photographs of the event showed a shear crack starting from the notch tip and accelerating almost up to the sound speed in the material.

The Rosakis team used this particular setup because a fault zone itself is the weak link between two planes. So if the shearing force along a fault plane indeed sets up shear cracks, then the act of breaking two weakly bonded Homalite plates by sliding them apart would be very similar dynamically.

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Dr. Ares Rosakis

Dr. Ares Rosakis' resarch group

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The high-speed photographs indeed show that shear cracks propagate along the bond line at about 2,200 meters per second (5,000 miles per hour). Further, the Mach cones were clearly visible because the cracks were outrunning material shear wave speed, just as a bullet from a high-powered rifle outruns the speed of sound in air. In fact, these shear cracks are faster than speeding bullets and also faster than the fastest supersonic jet planes!

"I believe processes like that have to do with certain events that may happen in the earth's crust. They may also be very relevant to the way that layered solids or composites, involving bonds, fail when subjected to impact loading," says Rosakis. "This is the first lab demonstration that shows these phenomena are possible."

The work is being published this week in the May 21 issue of the journal Science. Samudrala and Coker, both Caltech graduate students in aeronautics, are the other authors of the paper.

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