Mechanical Engineering/College of Engineering and Applied Sciences

MECHANICAL ENGINEERING DISTINGUISHED LECTURE

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Title: **Laboratory Earthquakes**

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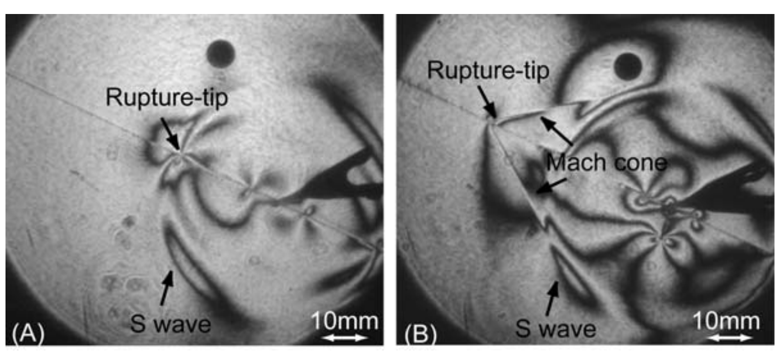
Date: Friday, January 26, 2007, 11:00AM room 301 of the Engineering Building

Abstract

Recently, seismologists have discovered that some earthquakes are very slow with almost no energy radiated, while others excite strong and damaging seismic waves with extremely high rupture speed, sometimes believed to be super-shear (faster than shear-wave speed of the surrounding rock body). This variation reflects the difference in rupture physics dominating different tectonic environments. As a result it has become very important to understand what causes the dramatic variation of rupture speed, and rupture behavior. We have embarked on this problem by constructing laboratory models of earthquakes and by using high-speed imaging of photo-elastic rupture patterns. We have defined a series of experiments to determine the behavior of rupture under spontaneous loading similar to that of crustal earthquakes. With these experiments we have demonstrated that under reasonable loading conditions similar to those for natural earthquakes, super-shear rupture propagation can occur. In such cases we have studied the conditions leading to transition of a sub-Rayleigh rupture to supershear and have related the rupture growth length needed for transition to system parameters. The experiments and analysis has resulted in a better understanding of transition behavior encountered during natural earthquake events such as the 2001 Kunlun earthquake in Tibet. This is probably the first experimental demonstration of super-shear rupture propagation under spontaneous loading. (Xia, Rosakis and Kanamori, *Science,* 2004)



Motivated by such experiments we have also extended the work to observations of spontaneously nucleated events occurring, on frictionally held, bi-material interfaces. Previously, it was generally thought that if there is a velocity contrast the rupture preferentially grows toward the direction of sliding in the lower-speed side of the fault. In contrast to this, we have found that this is not necessarily the case; the rupture can propagate in both directions. In one direction, rupture always propagates at the Generalized Rayleigh wave speed (it is sub-shear) whereas in the opposite direction it may either be sub-shear or may transition to super-shear. This behavior could explain why the rupture in the recent Parkfield earthquake propagated to southeast whereas it propagated northwest in the previous two Parkfield earthquakes. It can also be used to explain field observations during the 1999 Izmit earthquake in Turkey. We hope that these results will help seismologists understand the basic physics of earthquakes and contribute to a better understanding of the vast diversity of earthquake characteristics. (Xia, Rosakis, Kanamori and Rice, *Science*, 2005)

Biography

Ares J. Rosakis, the Theodore von Kármán Professor and Director of the Graduate Aeronautical Laboratories (GALCIT), was the 2005 William M. Murray Medalist and Lecturer for the Society for Experimental Mechanics (SEM), in recognition of his outstanding contributions to the development and application of advanced methods for accurate measurement of transient, dynamic phenomena. The Murray Medal is the highest recognition offered by SEM.Dr. Rosakis received his bachelor's and master's degrees in engineering science from Oxford University. He went on to earn his Sc.M. and Ph.D. degrees in solid mechanics from Brown University. He is the author of more than 260 works on quasi-static and dynamic failure of metals, composites, and interfaces with emphasis on dynamic fracture and dynamic localization. Recent interests include dynamic fragmentation; shear dominated intersonic rupture of inhomogeneous solids, rupture mechanics of crustal earthquakes, shielding of spacecraft from hypervelocity micrometeoroid impact threats, and reliability of thin films. In addition to the Murray Medal, his awards include the IBM Faculty Development Award; NSF Presidential Young Investigator Award; Rudolf Kingslake Medal and Prize from SPIE; Hetenyi, Lazan, and Frocht awards from SEM; Excellence in Teaching Award from the Caltech Graduate Student Council. He is a past Chairman of the Fracture & Failure Mechanics Committee of the Applied Mechanics Division, a Fellow of the ASME and the New York Academy of Sciences. Most recently he has been selected to receive the 2007 Harting award from SEM.

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