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The Seismological Wind Tunnel: From Lab-Scale Experiments to Global-Scale Seismic Events

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ABSTRACT:

Understanding the destructive power of earthquakes and estimating their seismic hazard for engineering structures is a major challenge across disciplines. At the core of every earthquake lies a dynamic rupture event propagating at high speeds on a fault (frictional interface) in the earth's crust, whose vast range of length and time scales involved poses a tremendous challenge to modelers and experimentalists alike. Friction plays a central role in determining how such ruptures propagate along faults and how they release waves that cause the destructive shaking threatening our infrastructure and endangering our lives. The detailed nature of the underlying dynamic friction is one of the biggest uncertainties in earthquake mechanics, a fact which limits our ability to model earthquakes accurately and to mitigate their effect to the built environment.

To better understand the dynamic frictional laws at play, we have developed a unique experimental method combining high-speed full-field imaging with digital, ultra-high-speed photography. Together with a laboratory-scale replication of seismic events, this technique allows us to follow individual ruptures at high resolution and in real time in vitro – i.e., on the laboratory scale under conditions mimicking real earthquakes. With this method, we can measure the evolving on-fault friction as well as the associated ground shaking, and we demonstrate that friction does in fact not follow the classical assumptions routinely used in earthquake physics. Our findings provide guidance to theoretical seismology by furnishing the necessary on-fault physics needed for the numerical simulation of the rupture process. Such simulations, in turn, are crucial to estimate the seismic hazard for engineering structures situated at various distances away from known active faults as well as the associated tsunami Hazards – in Southern California and across the world.

BIOGRAPHY:

Ares J. Rosakis is the Theodore von Kármán Professor of Aeronautics and Mechanical Engineering at Caltech. He has served as the fifth Director of Graduate Aerospace Laboratories, GALCIT (2004-2009) and as the Chair (Dean) of Division of Engineering and Applied Science EAS (2009-2015). He is a fellow of U.S. National Academy of Sciences, U.S. National Academy of Engineering, the American Academy of Arts and Sciences, Academia Europaea, the European Academy of Sciences and Arts, The European Academy of Sciences, the Academy of Athens and the Indian National Academy of Engineering and the American Association for the Advancement of Science He is also fellow of various professional societies; he was honored with numerous awards such as the von Kármán (ASCE), Timoshenko (ASME), the Zdeněk P. Bažant (ASCE), the Sia Nemat-Nasser (SEM), the Eringen (SES) and the Horace Mann (Brown University) medals and has also been named Commandeur dans l'Ordre des Palmes Académiques by the Republic of France. He received his B.A. and M.A. from Oxford University and his M.S. and Ph.D. from Brown University.

Rosakis has contributed widely to the field of Materials Reliability and Failure in both Engineering and Geophysics and is credited with the experimental discovery of "Intersonic" or "Supershear" rupture processes in both coherent and frictional interfaces of relevance to the failure of both modern composite materials and to earthquake rupture processes. His research interests span a multitude of length and time scales ranging from sub-μm (reliability of thin films) to 105m (dynamic earthquake fault ruptures) and from nano-seconds (hypervelocity impact in space) to years (creeping interfaces and ruptures). His most recent interests include the analysis of coupled solid/fluid mechanics of near-fault Tsunami-genesis and the dynamics of Magneto-Flexoelectric solids. Website: http://rosakis.caltech.edu/