Title: Ph.D position in experimental and numerical characterization of the behavior of shear cracks along rough interfaces

Academic Environment

The Ph.D. position is offered at Centrale Nantes, within the Research Institute in Civil and Mechanical Engineering (GeM). Centrale Nantes is a top-ranking school on the international stage producing world-class fundamental and applied research. The Ph.D. student will be supervised in conjunction by Vito Rubino (https://rubino.people.caltech.edu) and Ioannis Stefanou (http://coquake.eu/index.php/group). The position is fully funded for three years under the NExT Junior Talent program.

Scientific background:

Understanding the behavior of dynamic shear cracks and friction evolution is relevant for a wide range of problems in different fields, such as fiber pull-out in the failure of composite materials, bimaterial structures, vehicle brake systems, and adhesive joints, produced using advanced manufacturing techniques for automotive, electronics and biology applications. Shear ruptures are also relevant to the study of earthquakes occurring as ruptures along faults in the Earth's crust. Interface roughness controls how rupture behavior along interfaces, and it influences a broad class of fracture mechanics issues including dynamic crack propagation, which results in catastrophic failure.

Project description and goals

The goal of this research project is to investigate the role of roughness on shear crack propagation and friction evolution using a combined experimental and numerical approach. This project will enhance our understanding of fundamental physical process governing failure of materials and interfaces. It will also entail the advancement of experimental and computational mechanics techniques.

More in detail, the project has the following objectives:

- Develop an advanced experimental setup featuring low to ultrahigh-speed diagnostic tools based on digital image correlation.
- Investigate the role of roughness on shear crack propagation and friction evolution using the proposed innovative experimental approach, combined with numerical simulations.
- Interpret experimental results with the aid of theory and machine learning to understand and predict the patterns of stable vs. catastrophic rupture.
- Transfer knowledge from earthquake mechanics to advanced engineering design and manufacturing.

Keywords: Fracture mechanics, Dynamic friction, Digital image correlation, Laboratory experiments

References

- Rubino, V., A.J. Rosakis and N. Lapusta, Intermittent lab earthquakes in dynamically weakening fault gouge, *Nature,* 2022. https://doi.org/10.1038/s41586-022-04749-3
- Rubino, V., A.J. Rosakis and N. Lapusta, Spatiotemporal properties of sub-Rayleigh and supershear ruptures inferred from full-field dynamic imaging of laboratory experiments, *Journal of Geophysical Research: Solid Earth,* 125, e2019JB01892, 2020. https://doi.org/10.1029/2019JB018922
- Rubino, V., A.J. Rosakis and N. Lapusta, Full-field ultrahigh-speed quantification of dynamic shear ruptures using digital image correlation, *Experimental Mechanics*, 1-32, 2019. https://doi.org/10.1007/s11340-019-00501-7
- Stefanou, I., G. Tzortzopoulos, Preventing instabilities and inducing controlled, slow-slip in frictionally unstable system, *Journal of Geophysical Research: Solid Earth*, 2021JB023410, 2022. https://doi.org/10.1029/2021JB023410
- Braun P., G. Tzortzopoulos, I. Stefanou, Design of Sand-Based, 3-D-Printed Analog Faults with Controlled Frictional Properties, *Journal of Geophysical Research: Solid Earth,* 126 (5), e2020JB020520, 2021. https://doi.org/10.1029/2020JB020520

Requirements

Successful candidates are expected to have a Master's degree level in Mechanical or Civil Engineering or related disciplines, with a strong background in solid/continuum mechanics. Experience in experimental and computational mechanics is appreciated. Candidates are also expected to be highly motivated to fulfill the requirements of the doctoral Thesis. Fluency in spoken and written English is required. French is a plus but not required. The PhD student will carry out their research project, write scientific articles and their PhD Thesis in close collaboration with their supervisors.

Applications

Highly-motivated candidates with the required skills should submit an application (including a CV, cover letter describing interests and qualifications related to the project, and contact details of two references) to Dr. Vito Rubino at vito.rubino@caltech.edu. Starting date is no later than September 30th 2022.