NUS National University of Singapore
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Damage Waves in Earth and Engineering Structures as precursors to catastrophic failure

by Prof. Klaus Regenauer-Lieb
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Faculty of Engineering,
National University of Singapore

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Abstract:

We propose a non-local, meso-scale theory for modelling precursor phenomena to catastrophic failure. The approach is based on representing discrete phenomena, triggered by local Thermo-Hydro-Mechano-Chemical (THMC) instabilities, through cross-diffusion (quasi-soliton) wave equations.

We report the recent discovery of a slow cross-diffusion wave phenomenon in multiphase materials and show early laboratory experiments of these self-oscillatory damage waves preceding large scale instabilities. The diffusion wave phenomenon is well known in many disciplines (e.g. mathematical biology, computational chemistry, shallow water theory, ice waves) where reactions compete with diffusion processes. They are also encountered in systems where quantum particles interact, such as in quantum optics where they are known as quasi-solitons. They show a peculiar behaviour upon collision and can, in optics, release sporadic bursts of light or in ocean waves so-called rogue waves that seem to come from nowhere. This is explained by the unique capability of quasi-solitons to transport wave energy from large to small scale in a forward and inverse THMC energy cascade.

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Speaker's Biography

Prof. Klaus Regenauer-Lieb is an expert in geomaterials under extreme conditions and Director of International Relations at the School of Minerals and Energy Resources, UNSW, Sydney Australia. He holds a PhD from the Geothermal Institute, the University of Auckland with a broad background from the world leading institutions comprising the Swiss ETH Zurich, the Minnesota Supercomputer Institute and other international institutions. He is working towards a merger of Engineering and Science Disciplines in order to develop new ways of unlocking future energy and mineral deposits. His interdisciplinary publications are at the forefront of new fields in mathematical geophysics, computational geodynamics, geomechanics and reservoir engineering. Together with his research team, he has developed a next generation engineering framework for future energy and mineral exploration, reservoir characterisation and exploitation. This novel framework allows the resource industry to intelligently predict where to best look for particular resources, how to characterise and upscale the material behaviour and how to best stimulate the reservoir.

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