Proposed Master Project at NTNU: Energy variation in LLS Fiber Bundle Model

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Background: Fiber bundle model (FBM) is a simple and efficient model to describe the fracture-failure in composite materials under stress. NTNU physics department is involved in FBM studies since 1992. Extensive research works have been done at NTNU on equal-load-sharing (ELS) and local load-sharing (LLS) versions of FBM -both theoretically and through numerical simulations [1,2]. The NTNU fracture group has been recognized as one of the leading groups on this topic and currently this group is a part of the editorial team for a Research Topic "*The Fiber Bundle*" in the Frontiers in Physics.

Problem formation: It is obvious that if we increase stress or load on a composite material, at some point the system will collapse i.e., the material can not bear the load and breaks into pieces. But when does this collapse point come? Is there any prior signature? Can we somehow predict this collapse point? These are some long-standing questions in the field of fracture-failure of materials. In a very recent work [3] it has been observed that in equal load-sharing (ELS) Fiber bundle model the elastic energy variation can tell us exactly when the bundle will collapse.

The aim of this Master project is to extend and explore the energy concept (developed in [3]) to a more realistic load-sharing scheme -the LLS model. The elastic energy and damage energy will be measured numerically as a function of external stress (stretch of the bundle) in 1-D and 2-D systems. The simulation codes have been developed (in C, C++) in-house and are available for re-use and further improvement.

Other aspects: Strength estimation and prediction of collapse point is a central issue for **sustainability** of composite materials and structures including buildings, bridges etc. While better understanding of the fracture-failure process can help better designing of materials and structures, new knowledge on the prior signatures of upcoming collapse will surely help mitigation plans to avoid accidents and save human lives.

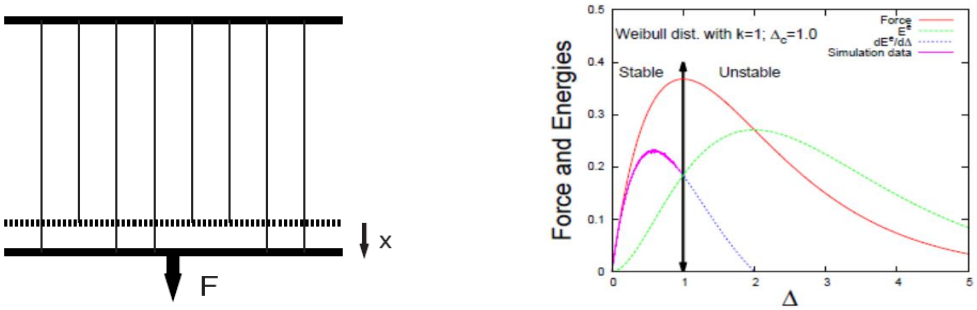

Fig: The ELS fiber bundle model (left) and the energy variations with stretch (right) for Weibull fiber strength distributions.

References:

[1] S. Pradhan, A. Hansen and Bikas K. Chakrabarti, "*Failure processes in elastic fiber bundles*", Rev. Mod. Phys. Vol. 82, No 1, 499-555 (2010). [2] A. Hansen, P. C. Hemmer and S. Pradhan, "*The Fiber Bundle Model: Modeling Failure in Materials*", Wiley-VCH, Berlin (September 2015). [3] S. Pradhan, J. T. Kjellstadli and A. Hansen, "*Variation of elastic energy shows reliable signal of upcoming catastrophic failure*", Front. Phys. Vol. 7 106 (2019).