Da restituire compilata in lingua inglese, in formato word

PhD in Mechanical Engineering

Research Title: Advanced theories based on peridynamics and nonlocal mechanics for the multi-scale/multi-field analysis of smart and bio-structures

Funded by	Compagnia di San Paolo

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Context of the research activity	It is common knowledge that the mechanical behaviour of modern structures for advanced industrial applications, multifield problems, MEMS devices, and bio-mechanics is governed by complex phenomena at the meso- and micro-scale. In many cases, in fact, mechanical fields, as well as materials, are discontinuous. For this reason, standard methodologies based on continuum mechanics needs to come up beside techniques that account for singularities and nonlocal strain gradients. To account for length-scale effects, discontinuities (e.g. fracture), and microscopic phenomena, available knowledge of nonlocal elasticity and peridynamics will be, thus, extended to include multi-fields, including thermal, electrical, and magnetic fields, or any combination of thereof. Moreover, molecular dynamics will be employed to assess such an extension. Integral, continuous models will be built as well. RVE's (Representative Volume Elements), 1D (beams), 2D (plates and shells), and 3D (solid elasticity) models will be developed via Carrera Unified Formulation (CUF). CUF allows for the straightforward implementation of refined

	kinematics in an automatic manner. Over the last decades, CUF has unveiled enhanced capabilities when dealing with metallic, composite and smart structures. Moreover, by exploiting its hierarchical and variable-kinematics capabilities, CUF has been recently extended to global/local and multi-scale analysis of multi-component and composite structures. The resulting "component-wise" approach revealed surprising accuracy at both global and RVE scales. Multi-scale approach applied to composite laminate, and multi-field analysis of a smart actuator. The extension of advanced models to the integral formulation of continuum mechanics as per the peridynamic theory will allow for an efficient formulation of fracture. Molecular dynamics, non-local models, and CUF-based structural models will be coupled each other by building and effective Multiscale framework that will allow to settling a global/local scenario for the study of microscopic and multifield behaviours of structures. The main aim of the developed models will be a direct application to practical engineering problems. Examples are smart structures (e.g., piezo-electric materials and metamaterials), graphene structures and CNTs, as well as biostructures.

Objectives	The main objective of the Ph.D. candidate will be the formulation of advanced theories of structures and elasticity models based on CUF and peridynamics. The developed models, thanks to the hierarchical and variable-kinematic features of CUF, will allow a computationally efficient and effective treatment of fracture mechanics at micro, meso, and macro scales. Furthermore, the extension to multi-field formulations will unveil new possibilities in the mathematical modeling of smart structures, including sensors and actuators, MEMS devices, bio-structures, and all those applications in which a correct description of the thermal, electrical, and magnetic fields (or a combination of thereof) is of primary importance. Of fundamental relevance will be the collaboration with a joint Ph.D. candidate enrolled in City University of Hong Kong, and whose research activities will be coupled and interfaced with those from the Polito candidate for the development of an enhanced and integrated framework for the multi-scale analysis.

	The Ph.D. candidate enrolled in Polito, in particular, will be involved in the following research topics and objectives: ▪ Global-local formulation of RVE's (Representative Volume Elements), 1D (beams), 2D (plates and shells), and 3D (solid elasticity) models based on variable-kinematic theories and peridynamics. ▪ Extension to multi-fields for the uncoupled and coupled thermal, electrical, and magnetic analyses of structures at various scales. ▪ Coupling with CityU nonlocal and molecular dynamics models in a multi-scale scenario. Exploring possible applications to smart structures, such as MEMS devices, piezo sensor/actuators, and bio-applications. The Polito PhD candidate will spend **18 months** in City University of Hong Kong.

Skills and competencies for the development of the activity	▪ Excellent academic background in Mechanical/Aerospace Engineering. ▪ Excellent mathematical skills. ▪ Appropriate competencies in English speaking and writing. ▪ Appropriate experience with commercial Finite Elements software tools for mechanical and multi-field analyses.