UNIVERSITY OF TRENTO

Department of Civil, Environmental and Mechanical Engineering

SOLID AND STRUCTURAL MECHANICS GROUP

Waterbomb Origami Structures as Dynamical Systems

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3 pm – 4 pm, DICAM, 2R room

Abstract

Origami-inspired structures have recently emerged as a promising framework for the design of adaptive and lightweight systems with programmable stiffness and deployability. This work investigates the dynamic behavior and stability of graded Waterbomb origami tubes, emphasizing their geometric characteristics. The Waterbomb geometry, constructed from a tessellated pattern of mountain and valley folds, is modeled as a nonlinear lattice system with rigid panels, whose unit cells are modulated through geometric gradation along the axial direction. Both deterministic and stochastic gradation rules are implemented, giving rise to ordered and disordered configurations governed by a five-dimensional nonlinear iterated map. Numerical analyses reveal distinct dynamic regimes: wave-like folding modes with energy exchange between layers, and finite-size instabilities leading to localized deformation. The results demonstrate how stochastic gradation promotes energy dispersion and enhances dynamic stability. Complementary 3D models were developed and assembled in the laboratory to validate geometric predictions and to visualize the folding-induced wave-like patterns observed in simulations. This study provides insight into the design of architected origami-based structures for morphing systems and adaptive metamaterials.

About the speaker

Americo Cunha Jr is an Associate Professor of Applied Mathematics at Rio de Janeiro State University and a Research Staff Member at the National Laboratory for Scientific Computing (LNCC), Brazil. He was a Visiting Scholar at Princeton University from 2022 to 2023 and a Visiting Professor at the University of Trento in 2026. He holds dual doctoral degrees in Mechanical Engineering and Mechanics from the Pontifical Catholic University of Rio de Janeiro, Brazil, and Université Paris-Est, France, respectively. He is an Editor of Nonlinear Dynamics and an Associate Editor of the ASME Journal of Vibration and Acoustics and the Journal of Vibration Engineering & Technologies. His research focuses on nonlinear dynamics, uncertainty quantification, functional metamaterials, energy harvesting, scientific machine learning, and origami-inspired engineering, with additional applications in mathematical epidemiology. He received the 2023 Young Scientist Award from the Brazilian Association for Computational Methods in Engineering (ABMEC).

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