NEW challengES IN Instabilities OF Structures and Soft Materials

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ABSTRACT

In automotive, aerospace and civil engineering fields, lowering energy consumption is a crucial objective. New challenging slender structures are investigated with the objectives of minimizing the weight and enhance their functions through, thickness reduction, architected metamaterials, extremely soft materials that can sustain large deformations under various stimuli, which inevitably leads to complex responses involving multiple bifurcations. Such instabilities can occur across different length scales from microscopic material level to macroscopic structural level with possible interactions. This requires advanced mathematical models and experimental techniques to compute complex solutions involving secondary bifurcations in the post-buckling branches.

Determination of the load-bearing capacity of thin objects submitted to mechanical or thermo-mechanical loading, including geometrical imperfection, residual stresses, presence of rigid or soft contact induced by adjacent structures or confinement medium, stiffened configurations and multi-layered shells and plates, complex material behaviour and curved geometries, are few examples among the new challenging problems targeted in this symposium. We hope to bring together experts working on these different aspects to review the emerging challenges and share the latest advancements in this vibrant research field. Topics of particular interest include but are not limited to :

• geometric and material instabilities in soft materials

• wrinkling, creasing, folding and ridging in extreme materials under various stimuli

• shape buckling of flexural structures such as plates, shells and membranes

• growth-induced deformations in biological tissues, biomaterials, bio-inspired structures

• micro-structural and macroscopic modelling in composites across length scales

• novel mathematical modelling method and constitution theory

**REFERENCES**

[1] K. Kpogan, H. Zahrouni, M. Potier-Ferry, H. Ben Dhia. Buckling of rolled thin sheets under residual stresses by ANM and Arlequin method. I[nternational Journal of Material Forming](http://link.springer.com/journal/12289). Vol. 10 (3), pages: 389-404, 2017

[2] Y. Cong, S. Nezamabadi, H. Zahrouni, J. Yvonnet. Multiscale computational homogenization of heterogeneous shells at small strains with extensions to finite displacements and buckling. International Journal for Numerical Methods in Engineering, Volume 104, Issue 4, 2015, Pages 235–259

[3] M. Jamal, L. Lahlou, M. Midani, H. Zahrouni, A. Limam, N. Damil, M. Potier-Ferry « A semi-numerical buckling analysis of imperfect shells under axial compression. International Journal of Solids and Structures 40 (2003) 1311-1327

[4] A. Limam, H.V. Tran, B. Tang , M. Jacquesson “ Buckling of thin cylindrical shell subjected to axial harmonic compression “ in: 15th European conference on spacecraft structures, materials and environmental testing , ESA/CNES, Noordwijk, Netherlands, 28 May - 1 June 2018.

[5] Y. Yang, H.H. Dai, F. Xu, M. Potier-Ferry. Pattern transitions in a soft cylindrical shell. Phys. Rev. Lett. 120, 215503, 2018.

[6] C. Fu, T. Wang, F. Xu, Y. Huo, M. Potier-Ferry. A modeling and resolution framework for wrinkling in hyperelastic sheets at finite membrane strain. J. Mech. Phys. Solids 124, 446-470, 2019.

[7] T. Wang, Y. Yang, C. Fu, F. Liu, K. Wang, F. Xu. Wrinkling and smoothing of a soft shell. J. Mech. Phys. Solids 134, 103738, 2020.

[8] Y. Yang, C. Fu, F. Xu. A finite strain model predicts oblique wrinkles in stretched anisotropic films. Int. J. Eng. Sci. 155, 103354, 2020.

[9] C. Fu, H.H. Dai, F. Xu. Computing wrinkling and restabilization of stretched sheets based on a consistent finite-strain plate theory. Comput. Method. Appl. Mech. Eng. 384, 113986, 2021.