NJIT

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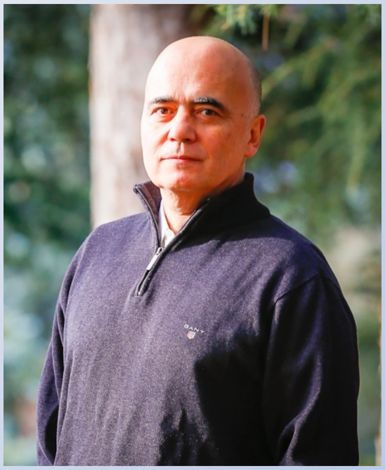
Flutter and divergence instabilities and Hopf bifurcation in elastic structures

Wednesday, 12:30-1:30

Abstract

Flutter and divergence instabilities and Hopf bifurcations may occur in elastic structures subject to nonconservative loads such as follower forces and forces acting on a fixed line. This was theoretically shown by Ziegler (1956), Beck (1952), Reut (1939), among many others (see the review by Elishakoff, 2005). However, the practical realization of these nonconservative forces was considered for sixty years very difficult and often declared impossible. Koiter (1996) wrote a very direct statement on this point and proposed the "elimination of the abstraction of follower forces as external loads from the physical and engineering literature on elastic stability" and concluded with "beware of unrealistic follower forces". In this talk we will show theoretically and experimentally how to obtain follower forces of the Ziegler type and related instabilities by exploiting Coulomb friction, a result which sheds light on the interplay between friction and instability (Bigoni and Noselli, 2011). The destabilizing effect of dissipation will be given an experimental proof (Bigoni et al. 2018). We will introduce forces acting on a fixed line and explain how these can be realized to demonstrate instabilities (Bigoni and Misseroni, 2020). It will finally be shown that flutter and divergence instabilities (including Hopf bifurcation and destabilizing effects connected to dissipation phenomena) can be obtained in structural systems loaded by conservative forces, as a consequence of the application of non-holonomic constraints. These constraints can be realized through a "perfect skate" (or a non-sliding wheel), or, more in general, through the slipless contact between two circular rigid cylinders, one of which is free of rotating about its axis. The motion of the structure produced by these dynamic instabilities may reach a limit cycle, a feature that can be exploited for soft robotics applications, especially for the realization of limbless locomotion (Cazzolli et al. 2020).



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Biography

Davide Bigoni is a mechanician working in solid and structural mechanics and material modeling, wave propagation, fracture mechanics. His approach to research is the employment of a broad vision of mechanics, with a combination of mathematical modelling, numerical simulation, and experimental validation. From 2001 Davide Bigoni holds a professor position at the University of Trento, where he is leading a group of excellent researchers in the field of Solid and Structural Mechanics. He has authored or co-authored more than 150 journal papers and has published a book on nonlinear Solid Mechanics. He was elected in 2009 Euromech Fellow (of the European Mechanics Society), has received in 2012 the Ceramic Technology Transfer Day Award (of the ACIMAC and ISTEC-CNR), in 2014 the Doctor Honoris Causa degree at the Ovidius University of Constanta and in 2016 the Panetti and Ferrari Award for Applied Mechanics (from Accademia delle Scienze di Torino). He has been awarded an ERC advanced grant in 2013. He has been guest lecturer for the Midwest Mechanics Seminars in 2018, he is fellow of the Accademia di Scienze e Lettere of Milan from 2019. An anniversary issue of the Journal of the Mechanics and Physics of Solids has been dedicated to him in 2020. He is co-editor of the Journal of Mechanics of Materials and Structures and associate Editor of Mechanics Research Communications and in the editorial board of 8 international journals.

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