Theoretical Understanding of Targeted Energy Transfers for Suppressing Aeroelastic Instabilities in a Nonlinear Aeroelastic Test Apparatus

Young S. Lee[a,*], Postdoctoral Researcher; D. Michael McFarland[a], Research Associate Professor; Gaetan Kerschen[b], Assistant Professor; Alexander F. Vakakis[c], Professor; Lawrence A. Bergman[a], Professor

[a] Department of Aerospace Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois, USA
[b] Aerospace and Mechanical Engineering Department (LTAS), University of Liege, Liege, Belgium
[c] Division of Mechanics, National Technical University of Athens, Greece; Department of Mechanical Science and Engineering and Department of Aerospace Engineering (adjunct), University of Illinois at Urbana-Champaign, Urbana, Illinois, USA
[*] Contact email: yslee4@uiuc.edu

Since a mechanism of triggering aeroelastic instability (or limit cycle oscillations; LCOs) in a 2-degree-of-freedom (DOF) rigid wing was investigated [1], a series of papers have been devoted to demonstrating applicability of passive, broadband targeted energy transfers (TETs) through a nonlinear energy sink (NES) to suppressing aeroelastic instability [2]; and to examining robustness enhancement of such suppression mechanisms by utilizing multi-DOF NESs [3]. Furthermore, experimental demonstration of LCO suppression mechanisms was performed in a nonlinear aeroelastic test apparatus (NATA) at Texas A&M University [4]. In this paper, we analytically study the LCO triggering of the NATA, based on which one can understand how the TET mechanisms observed in experiments worked out by attaching an NES to the wing structure. Utilizing a numerical continuation method, bifurcation analysis of LCOs is performed. Unlike the mathematical model, the experimental system involves friction at joints or contacts. Effects of such friction present for both structural modes (i.e., heave and pitch modes) are investigated in detail. By comparing friction effect to TET efficiency, we conclude that the aeroelastic instability occurred in the NATA was mitigated significantly due to TET activation, rather than due to friction.

References:

1. Y. S. Lee, A. F. Vakakis, L. A. Bergman and D. M. McFarland, "Triggering Mechanisms of Limit Cycle Oscillations in a Two-Degree-of-Freedom Wing Flutter Model," *Journal of Fluids and Structures*, **21** (5-7), 485-529, 2005.
2. Y. S. Lee, A. F. Vakakis, L. A. Bergman, D. M. McFarland and G. Kerschen, "Suppressing Aeroelastic Instability Using Broadband Passive Targeted Energy Transfers, Part 1: Theory," *AIAA Journal*, **45** (3), 693-711, 2007.
3. Y. S. Lee, A. F. Vakakis, L. A. Bergman, D. M. McFarland and G. Kerschen, "Enhancing Robustness of Aeroelastic Instability Suppression Using Multi-Degree-of-Freedom Nonlinear Energy Sinks," *AIAA Journal*, **46** (6), 1371-1394, 2008.
4. Y. S. Lee, G. Kerschen, D. M. McFarland, W. J. Hill, C. Nichkawde, T. W. Strganac, L. A. Bergman and A. F. Vakakis, "Suppressing Aeroelastic Instability Using Broadband Passive Targeted Energy Transfers, Part II: Experiments," *AIAA Journal*, **45** (10), 2391-2400, 2007.