MECHANICAL ENGINEERING STUDENT SEMINAR

Thursday, January 16, 2024 at 13:00, D. Dan and Betty Kahn Building, Room 217.
Online: https://technion.zoom.us/j/91751809062

Inertia wheel stabilization of an elastically restrained slender body that undergoes self-excited oscillations in uniform flow

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Missiles can fail to follow their targets if their maneuvers reach a too high angle-of-attack. Maneuvering difficulties at high angles-of-attack are an outcome of significant force and moment fluctuations beyond the capabilities of the missile control surfaces. Moment and force fluctuations are caused by a combination of abrupt changes of circumferential orientation of forebody tip and vortex shedding from the missile slender body at high angles of attack. The outcome of these fluctuations is fluid-structure interaction between the maneuvering missile and its environment culminating with periodic and nonstationary self-excited oscillations due to a combination of galloping and vortex-induced vibrations. Stabilization schemes of undesired missile oscillations include feedback control of external control surfaces and of internal gyroscopic components.

In order to reduce the magnitude of self-excited oscillations in uniform flow, we investigate the nonlinear dynamics and stabilization performance of an elastically restrained rigid body augmented with an internal inertia wheel. The fluid-structure interaction dynamical system incorporates: (i) a rigid body restrained with a torsion spring mimicking small-scale yaw rotations of an inclined cylinder attached to a balance in a wind tunnel, ii) the self-exciting yaw moment acting on the body is obtained from a coupled wake-oscillator model, and (iii) the structural model is augmented with an internal inertia wheel designed to minimize self-excited oscillations using linear feedback. We employ an asymptotic averaging procedure to estimate a set of model-based system parameters as a function of angle-of-attack from computational fluid dynamics of restrained ogive slender bodies documented in literature. A combined analytical and computational methodology is employed to investigate the self-excited system response culminating with stability maps and bifurcation diagrams of the governing control parameters that are verified via numerical simulations.

Note: the seminar will be given in Hebrew

Seminars Coordinator: Assoc. Prof. Shmuel Gal.