



MECHANICAL ENGINEERING MSc SEMINAR (45 min.)

Thursday, October 15 2026 at 13:30-14:15, Lady Davis Building, Auditorium 250

Exploiting nonlinear dynamics for high-performance resonant sensing

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Microelectromechanical systems (MEMS) resonators are essential components in technology. They are used in timing references, atomic force microscopes, radio-frequency communications, signal processing, sensing and more. Sensors that utilize the dynamics of resonators are often called *resonant sensors*.

In resonant sensors, a measured quantity changes the effective mass or stiffness of a vibrating element. This change is often detected by tracking the shift in the natural frequency of this element. In order to increase the sensitivity of sensors, *mode localization* sensors have been developed. These sensors are constructed from two linear resonators that are weakly coupled by a *linear* spring. In mode localization sensors, a small perturbation in the parameters of one of the resonators induces a large change in the distribution of vibrational energy between modes. Mode localization sensors provide substantially higher sensitivity compared to common sensors that rely on the frequency shift of a single resonator. However, the weak coupling introduces a trade-off between *sensitivity* and *linear measurement range*. In addition, *electrical feedthrough* from the excitation signal may obscure the signal of mechanical response.

In this talk, we will present a new type of *subharmonic mode-conversion sensor*. This sensor is constructed from two linear resonators that are *strongly* coupled by a *nonlinear* Duffing spring. This sensor solves the issue of electrical feedthrough and considerably extends the linear range of sensing, while retaining high sensitivity. In the new sensor, the sense mode is linear while the drive mode is nonlinear. The nonlinearity of the drive mode enables to efficiently transfer power from the high-frequency drive mode to the undriven low-frequency sense mode, utilizing a subharmonic response (i.e., *isola*) of the drive mode.