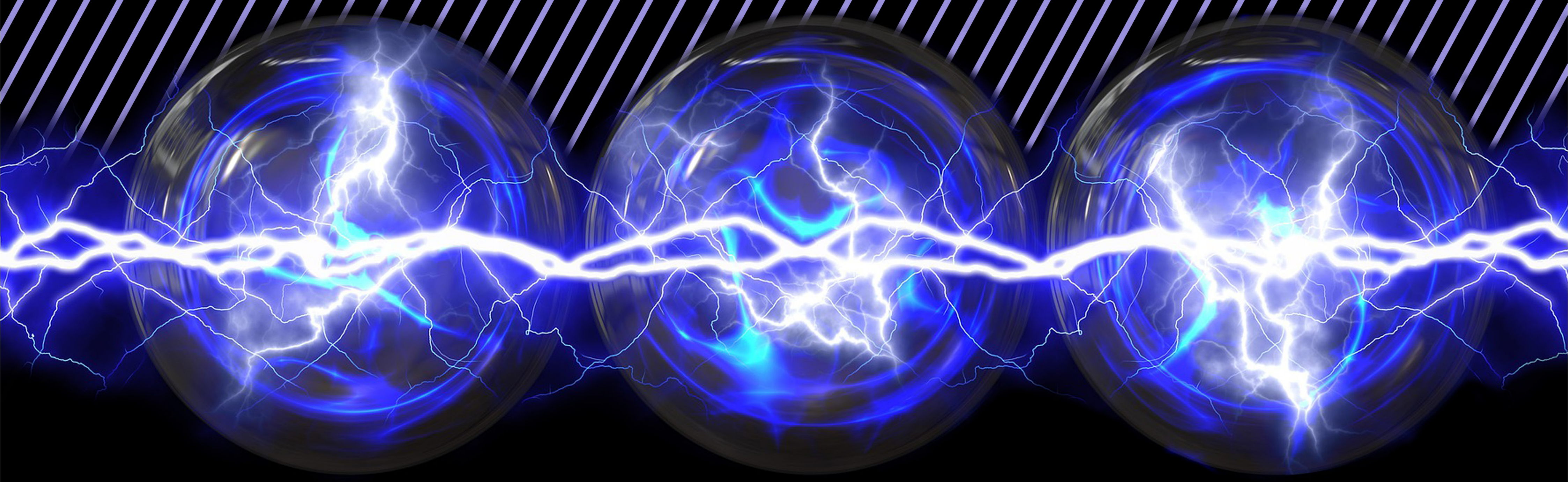
INSTITUTE OF SMART STRUCTURES AND SYSTEMS

SUKSHMA WEBINAR SERIES

10th September 2021
5:30 PM

Join in:
meet.google.com/snu-iimd-gts



ARRAYS OF MICROCANTILEVERS INTERACTING THROUGH FRINGING ELECTROSTATIC FIELDS

Large arrays of micro- and nanoelectromechanical coupled nonlinear resonators have been shown to possess rich dynamics such as parametric resonances, intrinsically localized modes, abrupt transitions between standing wave patterns, and sensitivity to environmental parameters. Here we investigate collective resonant dynamics of arrays of microcantilevers coupled elastically, through a flexible overhang, and electrostatically, through fringing fields.

In the first part of the talk the main results of theoretical and experimental investigation of this type of devices are summarized. Arrays of various geometries including interdigitated cantilevers of nominally identical and linearly varying length were fabricated using a silicon on insulator (SOI) wafer with a highly doped single crystal silicon device layer. The devices were driven inertially, using an external piezoelectric transducer, and electrostatically, by applying a voltage difference between the adjacent beams of the array. Spectral characteristics of individual array elements under ambient and vacuum conditions were measured using laser Doppler vibrometry. Time-harmonic modulation of the effective coupling stiffness parameterized by voltage results in excitation of the parametric resonance accompanied by an abrupt modal pattern switching during the actuating signal frequency sweep. Our experimental results show that high vibrational amplitudes and transitions between the standing wave patterns can be achieved by excitation through the parametric resonance mechanism. Moreover, we found that within a certain excitation frequency range, the resonators begin oscillating via nondegenerate (combination) parametric resonance across the entire array consisting of 200 different cantilevers of linearly varying length.

In the second part of the talk theoretical results are presented in more details. A compact reduced order Galerkin model is used for numerical and analytical asymptotic investigation of the array's dynamic response. First, finite element modal analysis is implemented to determine the spectral behavior of the array and to extract, in a consistent systematic manner, a fully populated coupling matrix. Then, to investigate the switching between vibrational modes of the array of nominally identical cantilevers, the two stage Galerkin projection is implemented. The equations governing the array's dynamics are reduced to two nonlinearly coupled Mathieu–Duffing equations, which are then analyzed numerically and asymptotically. At sufficiently high actuating voltages, the regions of the parametric resonance associated with different modes of the array overlap, resulting in an abrupt switching between the modes previously observed in the experiments.

ABOUT THE SPEAKER

Professor Slava Krylov

Microsystems Design and Characterization Laboratory, School of Mechanical Engineering, Faculty of Engineering, Tel Aviv University and Center for Nanoscience and Nanotechnology, Tel Aviv University, Tel Aviv,69978, Israel.

Prof. Slava Krylov (Senior Member, IEEE) received the M.Sc. and Ph.D. degrees from Saint Petersburg State Marine Technical University, Saint Petersburg, Russia, in 1989 and 1993, respectively. He was with Israel Aircraft Industries and then was a Principal Scientist and the Co-Founder of an optical MEMS startup. He was a Mary Shepard B. Upson Visiting Professor with Cornell University, Ithaca, NY, USA, and a Visiting Researcher with the National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA. In 2002, he joined Tel Aviv University, where he is currently a Professor with the School of Mechanical Engineering and The Henry and Dinah Krongold Chair of Microelectronics. His research interests include design and modeling of MEMS/NEMS, dynamics and stability of micro actuators, inertial and flow sensors, and optical MEMS.