Journal of Computational and Nonlinear Dynamics

Guest Editorial

Special Issue: Selected Papers from DSTA 2019 Conference

This special issue is dedicated to selected papers from the 2019 Dynamical Systems—Theory and Applications (DSTA) conference held in Lodz, Poland, from December 2 to 5. The DSTA conferences have over a 25-year long history, and they have been organized under the patronage of the Committee of Mechanics of the Polish Academy of Sciences.

In recent times, a considerable volume of research efforts have been undertaken in the fields of identification and mathematical description of nonlinear dynamics and nonlinear vibrations associated with energy harvesting systems, piezo-electric material or smart material beams, nanoplates, and cracks at different length scales. With regard to them, algebraic and differential mathematical models, as well as efficient computational techniques for dynamical analysis of the physical effects such as influence of magnetic fields, coupled oscillations in the vicinity of resonances, nonideal sources of excitation, transient bursting states, generation of flexural waves, and hysteretic damping are covered through the seven carefully selected papers included in this special Issue. The different contributions reflect the interest in the study of mechanical, electrical, magnetic, and other properties of nanostructures, the use of vibration energy in many natural and artificial systems, and coupled oscillators, such as FitzHugh–Nagumo subjected to external noise.

In the paper titled "Nonlinear Vibrations of Embedded Nanoplates Under In-Plane Magnetic Field Based on Nonlocal Elasticity Theory," by Mazur and Awrejcewicz, the authors treat geometrically nonlinear vibrations of the rectangular simply supported graphene sheet embedded in a Winkler-type elastic medium under the influence of an in-plane uniaxial magnetic fields. Nonlinear governing equations have been considered in terms of deflection, the stress Airy function, von Kármán theory, nonlocal elasticity theory, and the Kirchhoff-Love hypotheses. The magnetic field has been considered by employing the Lorentz force. Application of the Bubnov–Galerkin method with the Navier form of the deflection has allowed the authors to explicitly obtain the formula to study the dependency of the linear and nonlinear frequencies. The influences of the nonlocal parameter, magnetic parameter, foundation parameter, boundary conditions, and aspect ratio on the linear frequency and the nonlinear frequency ratio have been investigated. One of the main conclusions is that the magnetic field affects the plates with the shapes differently than a square shaped plate.

In the recent decades, research on electromechanical systems that can harvest energy from an operating environment has increased substantially. Vibration-based energy harvesting is the technique examined in the paper titled "On the Positioning of a Piezoelectric Material in the Energy Harvesting from a Nonideally Excited Portal Frame," by Rocha, Tusset, Ribeiro, Lenz, Junior, Jarzebowska, and Balthazar. The authors focus on the application of the piezo-electric energy harvesting by using a portal frame structure with two degrees-of-freedom. The piezoelectric material is considered as a linear device by using a capacitive mathematical model. There is a quadratic coupling between the first and second modes of vibration of the portal frame, and this coupling helps realize a two-to-one internal resonance between the natural frequencies associated with the first and second modes. Energy transfer from the second mode to the first mode is studied for the different positioning of a piezoelectric material, which is coupled to the supported beam or to the column. Finally, the authors show that there is a considerably nonlinear behavior due to the nonideal motor. The saturation phenomenon is exploited to collect energy by coupling the piezoelectric material to the column.

In the paper titled "Spectral Element Approach for Flexural Waves Control in Smart Material Beam with Single and Multiple Resonant Impedance Shunt Circuit," by Machado, Fabro, and de Moura, the authors focus on dynamic analysis of a beam with piezocoupling, assuming a single and multiresonant shunt configuration. The spectral element beam-piezoconnected to the resonant shunt circuit is presented and validated with the beam responses. The effects of coupling of the beam with piezoshunted is demonstrated by examining the frequency response function (FRF) amplitudes, which are shown to be attenuated around the tuning frequencies. From the effective flexural wavenumber for the shunted beams, one can note a typical locally resonant behavior at the same attenuation frequencies as in the FRFs, showing the direct effect of the resonating circuit in the vibration attenuation. It is shown that the application of other complex shunting configurations as the multishunt leads to a multimodal attenuation configuration. Through numerical results, the authors show the efficiency of the multiresonant shunt. The effective flexural wavenumber can also be used to study the locally resonant behavior at the same frequencies of attenuation in the FRFs, indicating that each shunt circuit is independently associated with an attenuation frequency. Finally, the spectral element approach is accurate and effective for the design of smart metamaterial beams.

In ensembles of oscillators, intrinsic fluctuations often enable nontrivial dynamics in seemingly simple situations. One of such effects occurring in coupled FitzHugh–Nagumo oscillators subjected to external noise is studied in "Statistics of Lifetimes for Transient Bursting States in Coupled Noisy Excitable Systems," by Albanbay, Medetov, and Zaks. The authors model the system of two coupled neurons with the help of coupled analog electronic circuits, mimicking the FitzHugh–Nagumo neurons. They find that at the considered parameter values, the global deterministic attractor is the resting state. Additive noise invokes transient bursting: series of intermittent patches of spikes, followed by the abrupt decay to rest. Duration of this transient, small for weak noise, asymptotically diverges when the noise becomes stronger. Remarkably, in repeated trials at fixed parameters, the number of bursts until the ultimate decay strongly varies. Lifetime statistics for this transient in large ensembles of numerical realizations features the exponential distribution. Observations on transient bursting are confirmed by experiments with coupled analog electronic circuits, modeling the FitzHugh–Nagumo dynamics. The exponential character of the distribution is related to the probability that the system, disturbed by noise, escapes the local attraction basin of the resting state.

Vibration energy is abundantly present in many natural and artificial systems and can be assembled by various devices, mainly employing the benefits of the piezo-electric and electromagnetic phenomena. In the paper titled "Energy Harvesting for System of Coupled Oscillators Under External Excitation in the Vicinity of Resonance 1:1," by Zuppa, Awrejcewicz, Losyeva, Puzyrov, and Savchenko, the authors investigate an electromechanical system with two degrees-of-freedom. A dynamical vibration absorber is attached to the main mass, whose vibrations are to be reduced. The absorber consists of a spring, damping, and piezo-electric elements for energy harvesting. The goal is to reduce the maximal possible responses of the main structure in the vicinity of external 1:1 resonance and at the same time collect energy from the vibration of the system. An analytical approach is proposed to find the solution of the problem. It is shown that the piezo-electric element allows for effective energy harvesting and at the same has a very limited influence on reducing the amplitude of oscillations of the main mass. The analytical results are confirmed through numerical experiments.

In the paper titled "Periodically Forced Nonlinear Oscillators with Hysteretic Damping," by Bountis, Kaloudis, and Spitas, the authors treat the dynamical problem of a one-dimensional nonlinear oscillator driven by a periodic force under hysteretic damping. A small quadratic stiffness term is added in the constitutive equation and the periodic solution of the problem is found by using a systematic perturbation method. The analysis is repeated based on replacement of the quadratic term by a cubic term, which does not allow the solutions to escape to infinity. In both cases, the dependence of the amplitude of the periodic solution on the different parameters of the model and the differences in the responses from that of the linear model are examined. Finally, an alternative hysteretic damping oscillator model, which appears to be free from these difficulties and exhibits remarkably rich dynamical properties when extended into the nonlinear regime is discussed.

The investigations presented in "Breathing Crack Model Effect on Rotor's Postresonance Backward Whirl," by Alzarooni, Al-Shudeifat, Shiryayev, Nataraj are focused on the appearance of postresonance backward whirl in a rotor model with a breathing crack. This phenomenon could be employed as an indicator of crack and bearing damage in rotor systems that undergo recurrent passage through critical forward whirl rotational speed during startup and coast down operations. A finite element model is used to develop the linear-time-varying equations of motion of the considered accelerated cracked rotor. The whirl response is obtained through direct numerical integration, since in addition, the effect of bearing anisotropy on the postresonance backward whirl excitation is investigated. The authors found that the appearance of the postresonance backward whirl zones is significantly affected by the depth of the crack, angular acceleration rate, anisotropy of bearings, and the orientation of the unbalance force vector with respect to the crack opening direction.

This special issue would not have been possible with the terrific support of the ASME *Journal of Computational and Nonlinear Dynamics*, in particular, that of Ms. Amy Suski. Many thanks to her, for making this issue possible.

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