MODELING NONLINEAR WAVES IN GRAPHENE

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Introduction. The graphene-based resonator and its application to mass sensing based on nonlinear waves have been poorly studied numerically [1]. The project's main objective is to model and understand how graphene behave in free and forced vibrations and calculate the nonlinear resonance frequencies.

Materials and methods. A conceptual framework was developed for modeling and simulation of nonlinear vibration of graphene-based resonator in the following table:

Materials:	Graphene-based Resonators
Methods:	Nonlinear Continuum Mechanics, Symbolic and Numerical Computations;
Phase Plane Analysis, Multi-Scale Perturbation Method;	Frequency Sweep

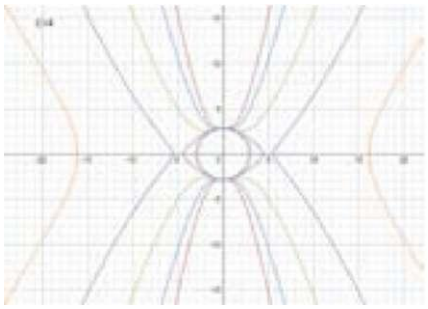

Figure 1

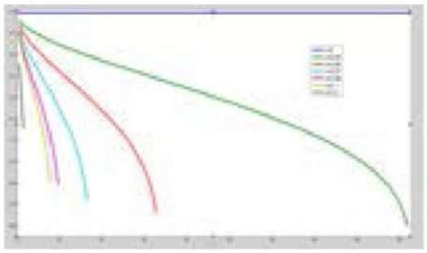

Figure 2

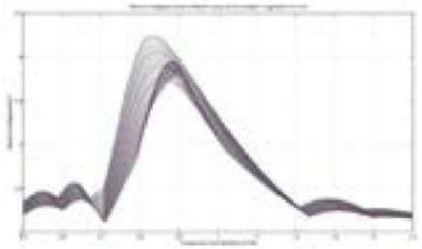

Figure 3

Results and discussion. A simplified nonlinear spring model is derived based on the nonlinear continuum constitutive equation in [2]. We found that third-order elastic stiffness constant plays an important role in the nonlinear vibration of the model and that, within a range of energy level, there exist periodic solutions and the oscillations are sinusoidal. However, as the energy approaches a threshold level, the limiting oscillations deviate drastically from the sinusoidal oscillations predicted by linear models (Figures 1,2). Our initial results provide quantitative energy regimes in which a graphene resonator can operate in near harmonic and non-harmonic motions (Figure 3).

Conclusions. The initial results of this project provide some insight information and useful data on the patterns of axial vibration of a graphene monolayer which can useful for design of graphene-based resonator. By extending this simple nonlinear spring-mass model to more realistic models, it is possible to provide new design guide to help make more efficient resonators and wave guides and shorten the design cycle and provide more accurate assessment of the mechanical behavior of the devices.

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References.

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2. E. Cadelano, Graphene Under Strain-A Combined Continuum-Atomistic Approach, Ph.D. Thesis, 2010.