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An in-depth review on nanomechanical resonators

Researchers from ICFO, Soochow University in China and Michigan State University publish a remarkable in-depth review n the physics of nanomechanical systems and the world f vibrations

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Back in the 17th century, Robert Hooke and Isaac Newton had a well-known dispute over who got the credit for certain breakthroughs in physical science, astronomy, and optics, but Hooke successfully became the one to understand the dynamics of an elastic spring, where the displacement is linear with the force, proposing the law of elasticity which now carries his name.

Nanomechanical vibrational systems act as mechanical oscillators but at a much smaller scale, the nano-scale. At these extremely small scales, quantum and classical fluctuations become significant so that the description of vibrations can go beyond the usual Hooke's law and the displacement is no longer linear with the force. So, new physics theories are needed to describe these types of systems.

These extremely tiny resonators have attracted a considerable interest in the field of physics because they have proven to be amazing sensors and even quantum systems. Key to their remarkable performances in such diverse contexts is the combination of low mass and hig quality factor. Low mass makes resonators responsive to ultra-weak perturbation while hig quality factor implies that energy losses are very low

So far, many studies related to the field have been able to intensely investigate the basi physical phenomena occurring to these systems in particular situations, but none hav accomplished reviewing the field from a very general point of view. That is why researchers **Adrian Bachtold,** group leader at ICFO, in collaboration with **Joel Moser**, from Soochow University, in China, and **Mark Dykman**, from Michigan State University in USA, decided to join forces and write a manuscript that would encompass all the physics related to describing these nanomechanical vibrational systems.

In their manuscript, published in **Review of Modern Physics**, the three researchers reviewed, at a conceptual level, the basic theoretical ideas and explicative experiments centered on mesoscopic resonators, those systems that range in size between the atomic and the macro words. Their thorough review delves into the world of dissipation, fluctuations, nonlinearity and scenarios where the systems are found far from thermal equilibrium. They gave a brief introduction on the physics of nanoresonators, and then, step by step, introduced new variants and effects on the system that enriched the physics behind.

As Adrian Bachtold mentions, ï¿½this review reflects the years of gathering information, fruitful conversations, and many constructive discussions, and intends to show the nontrivial physics of nanomechanical systems as well as how these systems can definitely become a platform for studying a broad range of nonlinear and nonequilibrium phenomena in a controlled settingï¿?

. The rapid progress of nanotechnology has been an important drive for exploring n
w phenomena with nanomechanical resonators. For example, significant interest is bei
g focused on the coupling of nanomechanical modes and qubits, or even, how qubits can
e used to entangle different mesoscopic vibrational resonators. Another important role th
t these systems may provide is by means of their high sensitivity. They can be used
s cantilevers for the next generation of scanning probe microscopes or force sensor
. The review goes into revealing many other applications, and demonstrates the richness
f the physics behind this field, hinting that although there are many current ongoi
g experiments making outstanding advances, this area of research is awaiting for many n
w phenomena to be discovere