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Frequency tuning and coherent dynamics of nanostring resonators

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Individual micro- and nanomechanical elements are extensively studied due to their importance in force and mass sensing applications, while resonator networks are key for the investigation of coupling physics and synchronization effects.

In my talk I will discuss both cases: (i) utilizing the nanostring for sensing the magnetoelastic coupling constant of a magnetic thin and (ii) frequency control of a nanostring resonator network.

Sensing requires that the mechanical properties of the vibrational element are altered by an external stimulus and thus become encoded in its resonance frequency and damping rate. In other words the property of interest has to couple to the mechanical degree of freedom. Here, the magnetostriction present in the in thin magnetic film modifies the total stress in the bilayer nanostring based on the magnetic film and a silicon nitride layer and hereby changes the resonance frequency of its fundamental vibrational mode. This allows for a quantitative determination of the magnetostriction constant of the magnetic material. I will discuss the measurement techniques as well as the sensitivity of the sensing platform.

Nanomechanical resonator networks are ideal candidates for the investigation of strong coupling physics, synchronization, non-linear dynamics. Furthermore, they are discussed for all-mechanical information processing and quantum storage platforms. All of these applications, however, require the possibility to tune the relevant mode frequencies independently and to operate the resonators in the strong coupling regime. I will discuss how the fundamental mode frequencies of both nanostrings can be tuned independently using a strong drive tone resonant with one of the higher harmonic modes. This tuning concept relies on an effective increase of the pre-stress in a highly excited nanobeam, known as geometric nonlinearity. With the two nanobeams tuned in resonance, we observe coherent excitation exchange between the fundamental modes of the two nanostrings corresponding to Rabi oscillations of a quantum two-level systems. In addition, experimental investigation of classical Landau-Zener dynamics demonstrates that this coupling and tuning concept paves the way for a selective phonon transfer between two spatially separated mechanical resonators.

Author: Dr HUEBL, Hans (Walther-Meissner-Institute of the Bavarian Academy of Sciences and Humanities)

Presenter: Dr HUEBL, Hans (Walther-Meissner-Institute of the Bavarian Academy of Sciences and Humanities)