Acoustic vibrations of nano-objects for sensing applications

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One of the technological challenges of these last years is the development highly efficient nano-sensing device, to determine for example the size, the mass, or even the presence or not of a given molecule. An interesting route to develop such sensors is to use the mechanical properties of mechanical nano-resonators, whose high frequencies of vibration (GHz to THz) are ideal to develop nano-clocks or nano-balances. The simplest nano-resonator, and maybe the easiest to produce, is the nanoparticle in which the vibration frequency is directly proportional to its reciprocal dimensions (inverse diameter for a sphere, inverse length for a wire, or inverse thickness for a nanoplatelet).

After a short presentation of the origin of the acoustic vibration of a nano-object, I will present two specific cases, to show that these simple nano-objects have promising potential to develop nano-sensing devices.
The first system studied is a dimer of gold nanoparticles whose ultra low frequency vibration modes (<5GHz~0.15 cm^{-1}) arising from the hybridization of the individual vibration modes of each nanoparticle, is highly sensitive to the elastic properties of the surrounding medium.[1]
The second system consists of nano-platelets of semi-conductor whose thicknesses can be controlled from 2 to 14 monolayers. Detecting the resonant breathing frequency across the thickness of the nano-platelets reveals a significant sensitivity to mass loads attached to the free surfaces of the nano-platelets.[2]

1. Girard, A. *et al.* Mechanical coupling in gold nanoparticles super-molecules revealed by plasmon-enhanced ultra low frequency Raman spectroscopy. *Nano Lett.* **34,** acs.nanolett.6b01314 (2016).
2. Girard, A. *et al.* Mass load effect on the resonant acoustic frequencies of colloidal semiconductor nanoplatelets. *to be published in Nanoscale*