Optomechanical detection of single bacterium mechanical modes

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Low-frequency phonon modes of biological particles such as proteins, viruses and bacteria involve coherent structural vibrations at frequencies in the THz and GHz domains (Figure 1). These modes carry information on its structure and mechanical properties that play a pivotal role in many relevant biological processes. Despite the rapid advances of optical spectroscopy techniques, detection of low-frequency phonons of single bioparticles has remained elusive. Here we harness a particular regime in the physics of mechanical resonator sensing that serves for detecting them. By depositing single bacterium on ultra-high frequency optomechanical disk resonators, we demonstrate that the vibration modes of the disk and bacterium hybridize when their associated frequencies are similar (Figure 2). A general theoretical framework is developed to describe the different regimes that can be found when an analyte adsorbs on a mechanical resonant sensor. Our model allows retrieving the mechanical frequencies and losses of the bacterium modes. This work opens the door for a new class of vibrational spectrometry based on high frequency mechanical resonators with the unique capability to obtain information on single biological entities [1].

References

[1] E. Gil-Santos, et. al. "Optomechanical detection of low-frequency phonon modes of single bacterium". Submitted to Nature Nanotechnology (sent to reviewers)

Figures

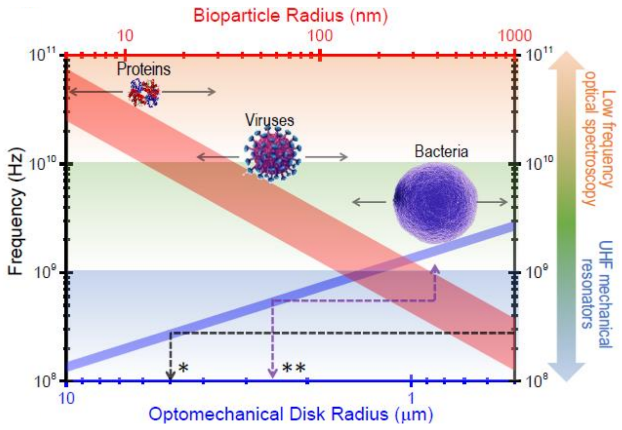

Figure 1: Frequency of the radial breathing mode of a 320 nm thick optomechanical disk (blue region) and of the fundamental mode of a quasi-spherical biological particle adsorbed on a rigid support (red region), as a function of the disk and bioparticle radii, respectively.

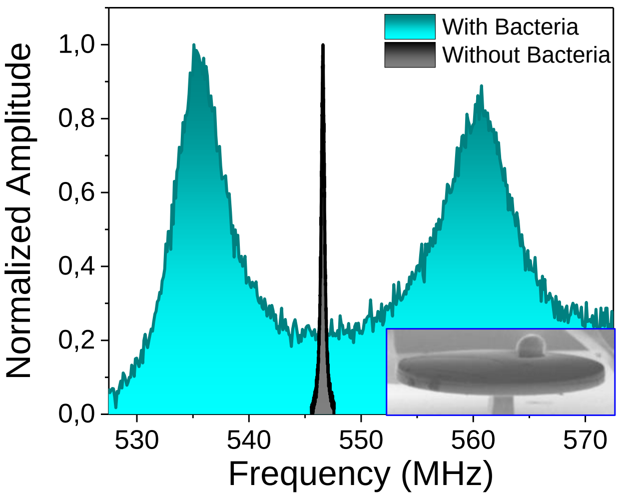

Figure 2: Effect of bacterium adsorption on the radial breathing mode of an optomechanical disk (2.5 μm in radius and 320 nm in thickness). The inset shows a scanning electron microscopy image of the optomechanical disk with an attached Staphylococcus epidermidis cell.