Photoacoustic spectroscopy with a levitated nanosensor

A nanosphere levitated in optical tweezers moves as a harmonic oscillator. As such, it is a promising platform to sense a variety of forces, such as gravity, electrical forces and collisions with other molecules of the background gas (see Figure 1a for the characterization of force sensitivity).

A gas enclosed in a volume supports discrete acoustic waves, that can be selectively launched by a modulation of the gas temperature, e.g., via an amplitude-modulated driving of one of the gas absorption lines. This principle is known as photoacoustic spectroscopy and is currently used to analyze the environmental gas composition. A nanoparticle levitated at the center of the acoustic resonator will be driven by the launched acoustic wave (see Figure 1b). By measuring the nanoparticle's motion, we aim to detect the presence and the concentration of a specific gas in the background atmosphere.

The objective of this project is to build and characterize this photoacoustic spectrometer based on a levitated nanoparticle. You will

- Understand the principle of optical levitation and position measurements.
- Measure the photoacoustic signal induced by a known gas, e.g., acetylene.
- Characterize the sensitivity of the instrument, e.g., minimum detectable concentration.

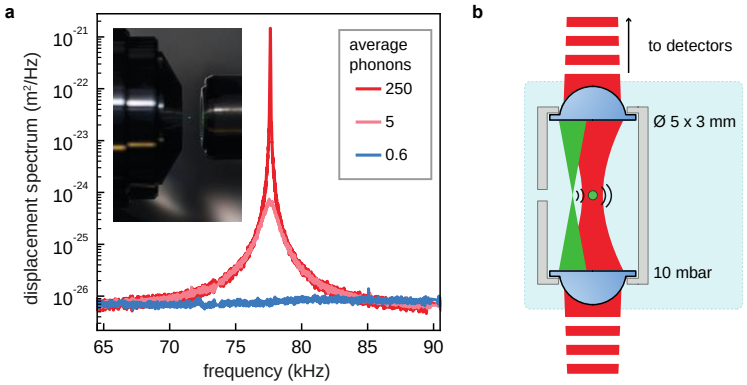

Figure 1 **Photoacoustic spectroscopy. a,** High-precision displacement measurement of a levitated nanoparticle. The highest force sensitivity is $2\ zN/\sqrt{Hz}$. **b,** Conceptual sketch of a photoacoustic sensor based on a levitated bead in a gas cell. The amplitude-modulated green laser drives a resonance of the gas and excites an acoustic wave within the cell.

Are you interested? Please contact Massimiliano Rossi (m.rossi-1@tudelft.nl)!