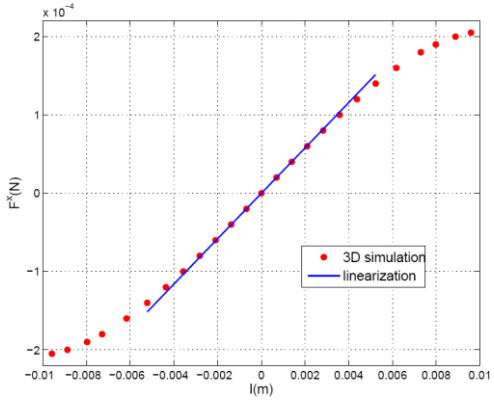
Calibration of a micro-nano-force sensor using diamagnetic levitation

Research framework

When high bandwidth in micro and nano force measurement is not mandatory, the use of rigid *macroscopic* force-displacement transducers is a possible alternative to force sensors based on elastic microstructures. The SPECIMeN team is developing a 1-DoF nanoforce sensor using passive stable *magnetic springs* based on diamagnetic levitation. The transducer used is a capillary tube with a mass comprised between 20 to 80 mg.

Force sensor calibration

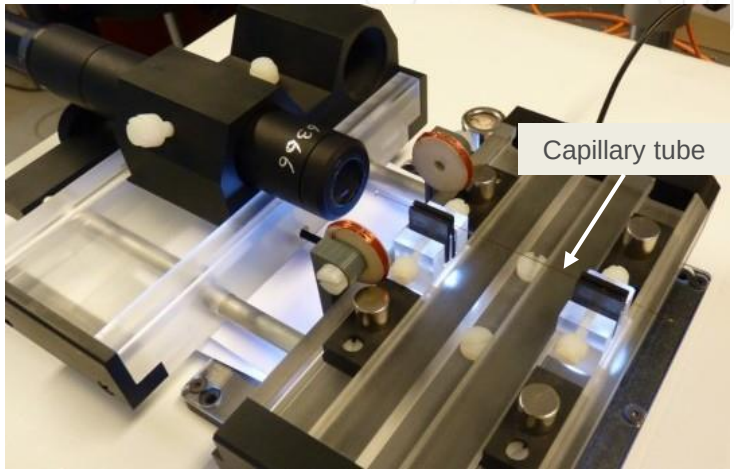
The theoretical main advantage of such nanoforce sensors, based on “heavy” and rigid test specimen on which the force is applied, is that the mass of the test specimen can be easily known with a precision balance contrary to microscopic elastic transducers.



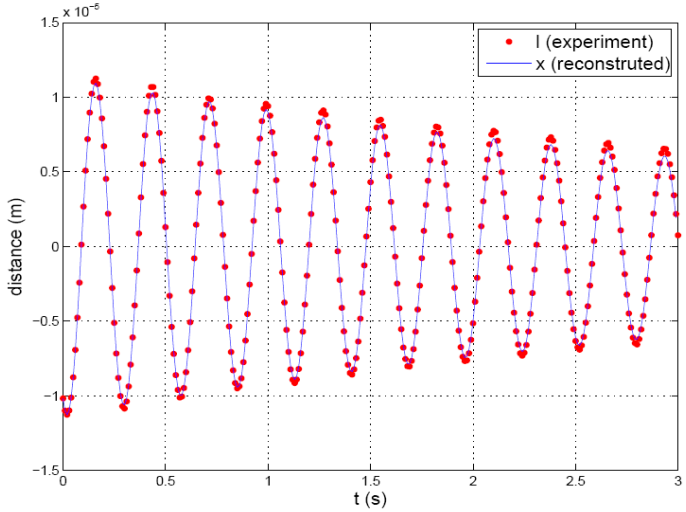
Non linear static force-displacement response of the capillary tube

The dynamic response of the force-displacement transducer is linear over long displacements (±1 mm). The magnetic stiffness K^x_m and the viscous damping coefficient K^x_v are identified knowing the test specimen mass and its linear zero input response (see figure on the right).

This second-order dynamic model is used to deconvolve the noisy measurement of the transducer in order to correctly estimate the force applied on the test specimen by taking into account the inertia caused by its mass.



Capillary tube in diamagnetic levitation



Zero input response of the capillary tube (measurement and modelling)

Major article: J. Abadie, E. Piat, S. Oster, M. Boukallel, Modeling and experimentation of a passive low frequency nanoforce sensor based on diamagnetic levitation, Sensors and Actuators: A Physical, 2012, 173(1):227-237.

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