

is given by

$$F_{\text{nor}}^{\text{el}}(a, \varphi) = k_{\text{tor}} S_{\text{nor}}^{\text{el}}(a, \varphi), \quad (8)$$

where k_{tor} is the normal force calibration constant measured in the units of force per unit deflection signal (note that for the attractive force the deflection signal is negative). This constant is connected with the torsional spring constant discussed above as

$$k_{\text{tor}} = K_{\text{tor}} m_{\text{tor}}, \quad (9)$$

where the deflection coefficient m_{tor} is measured in the units of length per unit deflection signal. The obtained experimental data for $S_{\text{nor}}^{\text{el}}$ and for the respective force $F_{\text{nor}}^{\text{el}}$ from Eq. (8) was fitted to Eq. (7). The resulting mean values of V_0 and k_{tor} found from the fit are

$$V_0 = -39.6 \pm 1.6 \text{ mV}, \quad k_{\text{tor}} = 7.00 \pm 0.08 \text{ nN/unit } S. \quad (10)$$

Measurement of the lateral Casimir force as a function of absolute separation requires knowledge of the lateral force calibration constant

$$k_{\text{ben}} = K_{\text{ben}} m_{\text{ben}}, \quad (11)$$

where m_{ben} is the bending deflection coefficient. If the separation on contact z_0 is determined, absolute separation between the mean values of the corrugations on both surfaces is given by [4, 11]

$$a = z_0 + z_{\text{piezo}} + S_{\text{nor}} m_{\text{tor}}, \quad (12)$$

where z_{piezo} is the distance moved by the plate owing to the voltage applied to the piezo-electric actuator, S_{nor} is the photodiode difference signal due to the force (either electric or Casimir).

The determination of k_{ben} and z_0 is achieved by measuring the cantilever deflection signal due to the lateral electrostatic force which arises when a voltage is applied to the grating. The measurements of this signal were performed at small separations from close to z_0 to $z_0 + 120 \text{ nm}$. Note that calibrations using the lateral electrostatic force were done after the measurements of the deflection signal due to the lateral Casimir force are performed, but are reported in this section for the benefit of the reader. First, a voltage of 141.456 mV was applied to the grating. The sphere was kept at a distance 3.96 nm from z_0 . The phase shift between corrugations was changed continuously at a frequency 0.103 Hz with the x -piezo to a maximum translation of 3.3 μm .