conditions in the configuration of corrugated sphere and plate. In the FEA computation, it is difficult to use the whole corrugated sphere and plate due to computer limitations. This necessitates the use of truncated spheres and parts of the plates. Such a replacement is justified as the primary contribution to the force comes from sphere-plate regions which are in close proximity. However, the error introduced by the truncation has to be independently confirmed to be negligible by varying the size of the regions of the sphere and plate used in the computations.

Computations were performed as a function of the common size l of a truncated section of the corrugated sphere and a square corrugated plate. The separation distance and phase difference between the corrugations on both surfaces were set to $a = 250\,\text{nm}$ and $\varphi = \pi/2$, respectively. The system was enclosed in a grounded rectangular box which represents the boundary conditions at infinity. Next, boundary conditions (applied voltages) identical to the experimental parameters were assigned to all objects. The rectangular enclosure and the sphere were both set to be grounded. The rectangular box was automatically set to be at infinity by Comsol Multiphysics. Next the Poisson equation was solved for the given boundary conditions. Then the normal electrostatic force was calculated by integrating the zz-component of the Maxwell stress tensor over the surface of corrugated sphere and compared with Eq. (7). To make sure that the solution converged, the size of the corrugated objects and the number of the surface mesh elements were both varied and the force recalculated. For each l, the number of the mesh elements was increased from one million to 22 millions until the calculated force converged. The size of the truncated section of the corrugated plate and sphere was increased from $l = 14\,\mu$m to $l = 50\,\mu$m. The convergence of the force was observed for $l > 45\,\mu$m. The corresponding difference of Eq. (7) from the FEA results varied from –36% to 2.8% when l increased from $14\,\mu$m to $50\,\mu$m, respectively, with convergence at the largest values of l. Thus, we confirmed from simulations that Eq. (7) is valid with an error less than 2.8%. It turns out that this error is almost phase independent and, thus, does not propagate to the lateral electric force.

Now we return to the experimental electrostatic calibrations using the normal electric force. The deflection signal $S_{\text{nor}}^{\text{el}}$ was measured for eight different voltages between –0.52 V and 0.47 V applied to the grating at the constant grating-sphere separation $a = 1\,\mu$m where the Casimir force is negligibly small (see below for the determination of absolute separations using the lateral electrostatic force). The respective experimental normal electrostatic force