same statistical procedure, as in the first set of measurements, were used to determine these errors with the only difference that for the second set the averaging was performed at all separations over five periods [the respective Student coefficient is $t_{(1+\gamma)/2}(4) = 2.78$ with $\gamma = 0.95$]. The total error in the measurement of separation, $\Delta a = 4.7\,\mathrm{nm}$, turned out to be a bit larger than in the first set of measurements. The total error of the lateral force measurements demonstrates similar irregular behavior on separation distance. This can also be explained by the influence of local deviations of groove shape from sinusoidal form keeping in mind that with larger corrugation amplitude the role of such deviations should be larger. In Table 2 we present the mean values, the variances of the mean, the systematic errors, and the total experimental errors (at a 95% confidence level) of the maximum magnitudes of the lateral Casimir force at different separations for the second set of measurements. The total relative error of the lateral force measurements at separations $a = 134$, 145.2, 156.5, and 179 nm varies as 23%, 16%, 14%, and 13%, respectively, all calculated at a 95% confidence level.

V. COMPUTATION OF THE LATERAL CASIMIR FORCE USING THE PROXIMITY FORCE APPROXIMATION

In this section and in Sec. VI we compare the obtained experimental results for the lateral Casimir force with two theoretical approaches applicable in the case of corrugated surfaces: the PFA and the exact scattering approach, respectively, with no fitting parameters. As was mentioned in the Introduction, the PFA approach was also used to compare with theory the measurement data of the first observation of the lateral Casimir force in Refs. [37, 38]. However, in those papers the real properties of Au were described using the simple plasma model and fourth-order perturbation theory with respect to the relative skin depth at zero temperature. Here, we develop a more complete description of the experimental data in the framework of the PFA approach based on the Lifshitz formula at the laboratory temperature. This will help us to separate diffraction type contributions to the lateral Casimir force which are beyond the PFA.

We start with the Lifshitz formula for the normal Casimir force acting between a sphere