INTERPOLATION OF FEM RESULTS AND FITTING WITH EXPERIMENTAL DATA

From the FEM results, we generate surfaces of normalized indentation depth δ / R and contact radius a / R in terms of $\left(W_{ad} / \mu R,\ W_{ad} / \sigma\right)$. A spline interpolation method using Green function approach[20] is employed to interpolate the scattered FEM results. Physically, this corresponds to forcing a thin elastic plate to pass through the known data points with a shape that minimizes its strain energy.

Note that in the attempt to extrapolate a / R , the result may be greater than 1, which is not possibly physically. To handle such cases, we assume that the surface is symmetric about $a / R = 1$, so if the extrapolated value for $(a / R)_{extrapolated} > 1$, $\left(a / R\right) = 2-\left(a / R\right)_{extrapolated}$. Fig. 7 below shows the generated surface plotted with the FEM results in black dots.

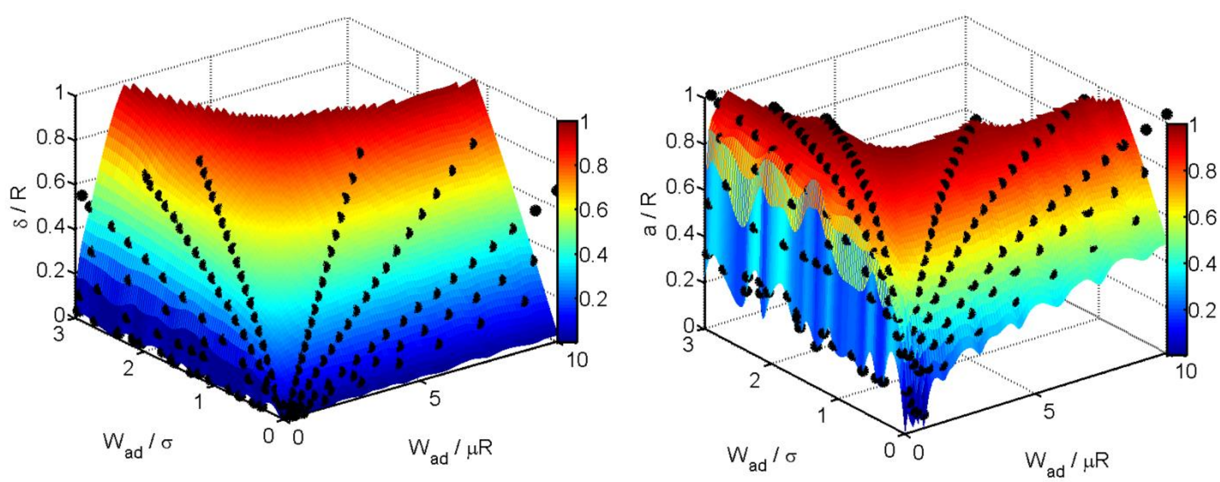

FIG. 7. The surfaces of indentation depth (left) and contact radius (right) are interpolated over a grid of $\left(W_{ad} / \mu R, W_{ad} / \sigma\right)$. The color maps indicate values of δ / R and a / R. The scattered black dots are results from FEM simulations.

When conducting least-square fit of the experimental results reported by Style *et al* [10] using the surfaces interpolated from FEM results, we use $\left(W_{ad} / \mu R,\ W_{ad} / \sigma\right)$ as the fitting parameters. We noticed that experimental measurements of the contact radius were less scattered than those of the indentation depth. Hence in Fig. 5, $\left(W_{ad} / \mu R,\ W_{ad} / \sigma\right)$ used only minimizes the sum of squares of errors in the contact radius. We then plotted the resulting indentation depths to compare with the measurements in experiments.

Because the fitting functions are nonlinear, the pair of parameter values $\left(W_{ad} / \mu R, W_{ad} / \sigma\right)$ that result in a local minimum of root mean square deviation between finite element results and experiment is not unique. Hence some physical ground is required in to ensure that the surfaces of deformation constructed by FEM simulations result in physically appropriate values of parameters. For example, if the contact scale is small and the material is relatively stiff, JKR theory is used first to get a reasonable value of $W_{ad} / \mu R$. Then a fitting against the FEM results is done in the proximity of that value to obtain more refined values of $\left(W_{ad} / \mu R, W_{ad} / \sigma\right)$. This approach is used in the fittings of the cases where Young's moduli are 500 kPa (green) and 250 kPa (black). Similarly if the material is so soft that it behaves like a liquid (the red and blue cases in Fig. 5), the equations of surface tension dominated limit should is used to obtain a rough estimate of W_{ad} / σ, before fitting the FEM results to experimental data.