Electronic Supplementary Information (ESI)

Reversible magnetomechanical collapse: virtual touching and detachment of rigid inclusions in a soft elastic matrix

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In the figure on the next page, we illustrate the strong local deformation fields occurring between the two approaching particles. There, we show results from direct purely elastic finite-element simulations of the Neo-Hookean model when the two particles of radius a are driven towards each other within the soft elastic matrix, see the main article. The initial center-to-center particle separation was $r_{12}^{(0)}/a \approx 3.57$. All results are obtained directly from the simulations, without extrapolation of the deformations, down to center-to-center particle distances $r_{12}/a \approx 2.1$. (This implies an approach of the surface-to-surface distance down to $a/10$.) More precisely, states for (a) $r_{12}/a \approx 2.9$, (b) $r_{12}/a \approx 2.4$, and (c) $r_{12}/a \approx 2.1$ are displayed.

We depict the components u_1 and u_2 of the local displacement field along the axes x_1 and x_2, respectively. Furthermore, to characterize the degree of compression of the deformed matrix along the corresponding principal axis, the spatial variation of the smallest principal stretch λ_3 is illustrated. The pure stretch of a line element is defined as

$$\lambda = \frac{ds}{dS} > 0 \,,$$

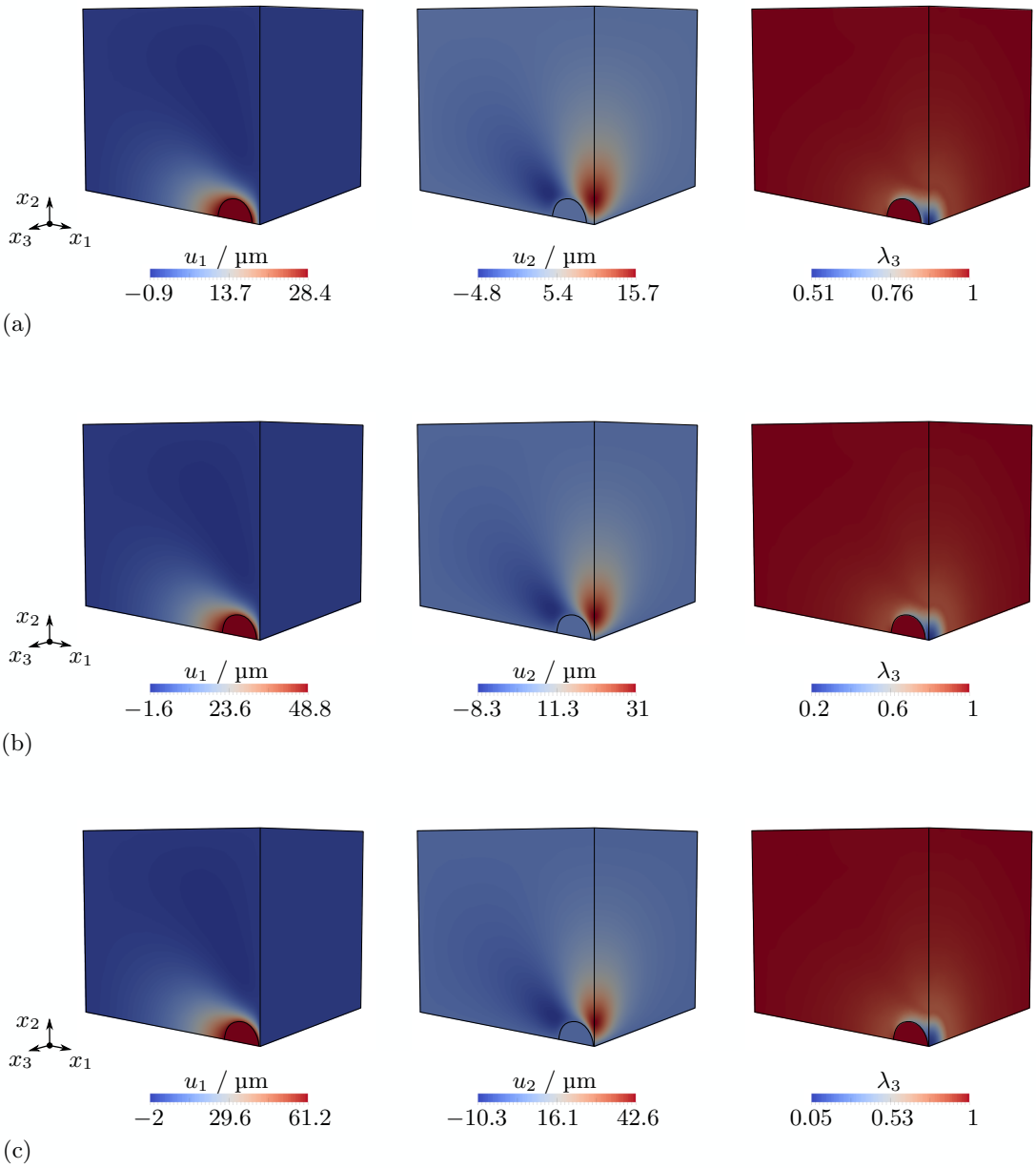

Figure: Results from the mechanical part of the direct finite-element simulations of the elastic Neo-Hookean model in the set-up described in the main article. Components u_1 and u_2 along the axes x_1 and x_2, respectively, of the local displacement field are shown, together with the spatial variation of the smallest principal stretch λ_3 within the polymer matrix. $0 < \lambda_3 < 1$ indicates compression along the corresponding principal axis. From top to bottom, the inter-particle distance decreases as (a) $r_{12}/a \approx 2.9$, (b) $r_{12}/a \approx 2.4$, and (c) $r_{12}/a \approx 2.1$.

where ds and dS denote the infinitesimal length in the deformed and in the undeformed state, respectively. Basically, the quasi-incompressible matrix ($\nu = 0.49$ within the simulation) is squeezed out from between the particles by the particle approach. Between the particles, a region of extreme compression occurs along the corresponding local principal axis of deformation.