Supporting Information: Generation of two-dimensional pulses in lipid monolayers by rapid photoswitching

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In this document we present supplementary measurements regarding the pressure pulse excitation and its dependence on light intensity as well as additional simulations illustrating the influence of the nonlinearities for large excitation amplitudes and confirming the scaling argument that nonlinearities will play a role if typical displacement gradients U/L are sufficiently large.

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Supplementary measurements regarding the pressure pulse excitation

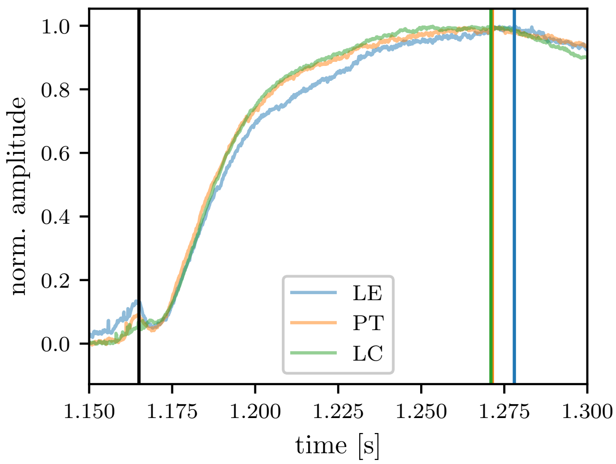

Figure S1: Normalized pulses measured inside the area excited by the flash. Black line marks the time when the flash is triggered, coloured lines mark the maximum pulse amplitudes. The times from flash to maximum are 113.03ms for LE, 106.4ms for PT and 105.9ms for LC.

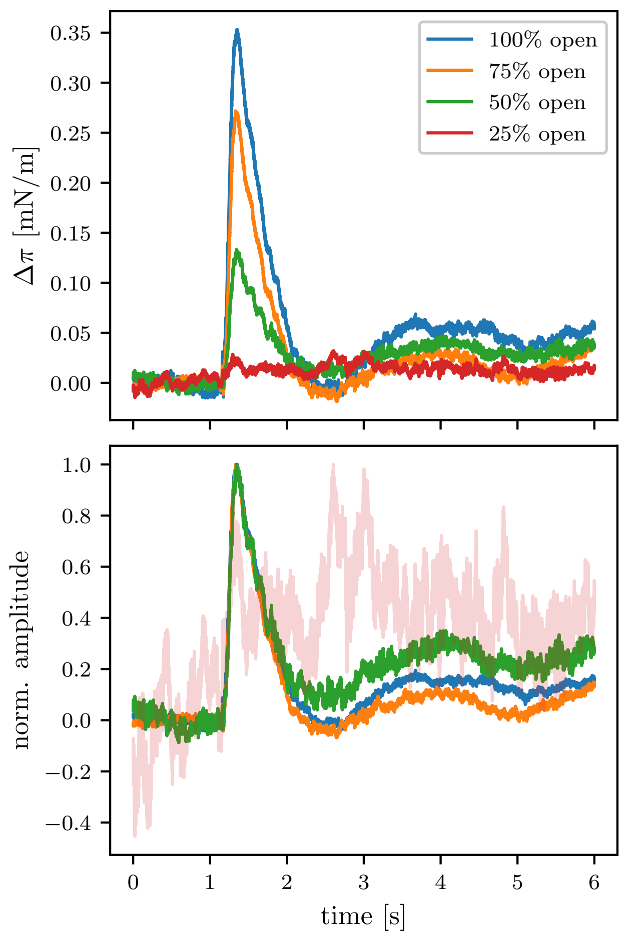

Figure S2: Pulse measurements for different flash intensities at $\pi_0 = 10\text{mN/m}$. Since the flash only has one power setting, intensity was varied by closing an aperture. Normalised pulses show only negligible deviations in pulse morphology, except for the lowest intensity with the aperture 25% open, where the pulse was not distinguishable from noise.

Nonlinear effects for small amplitudes

The simulations in Figs. S3, S4 , and S5 were all performed on the same set of material parameters, on the same (trans) isotherm that the main text uses, as well as the same set of parameters for the driving term $f(t)$. Here $f(t)$ is directly applied on the boundary, in form of a Dirichlet boundary condition, while keeping its general shape $f(t) \sim U_{max}$. To verify our scaling arguments, solely U_{max} will be changed in magnitude to increase the strain on the layer and thus change the elastic modulus. The scaling analysis shows that for large displacement gradients or strains $U/L \sim 1$, non-negligible nonlinear effects due to the elastic material components will occur. This can also be seen directly from the isothermal elastic modulus $k_{2d}(a)$, where the area per lipid $a = a_0\,(1 + \partial_x u)$ will be left unchanged if $\partial_x u = \epsilon \ll 1$.

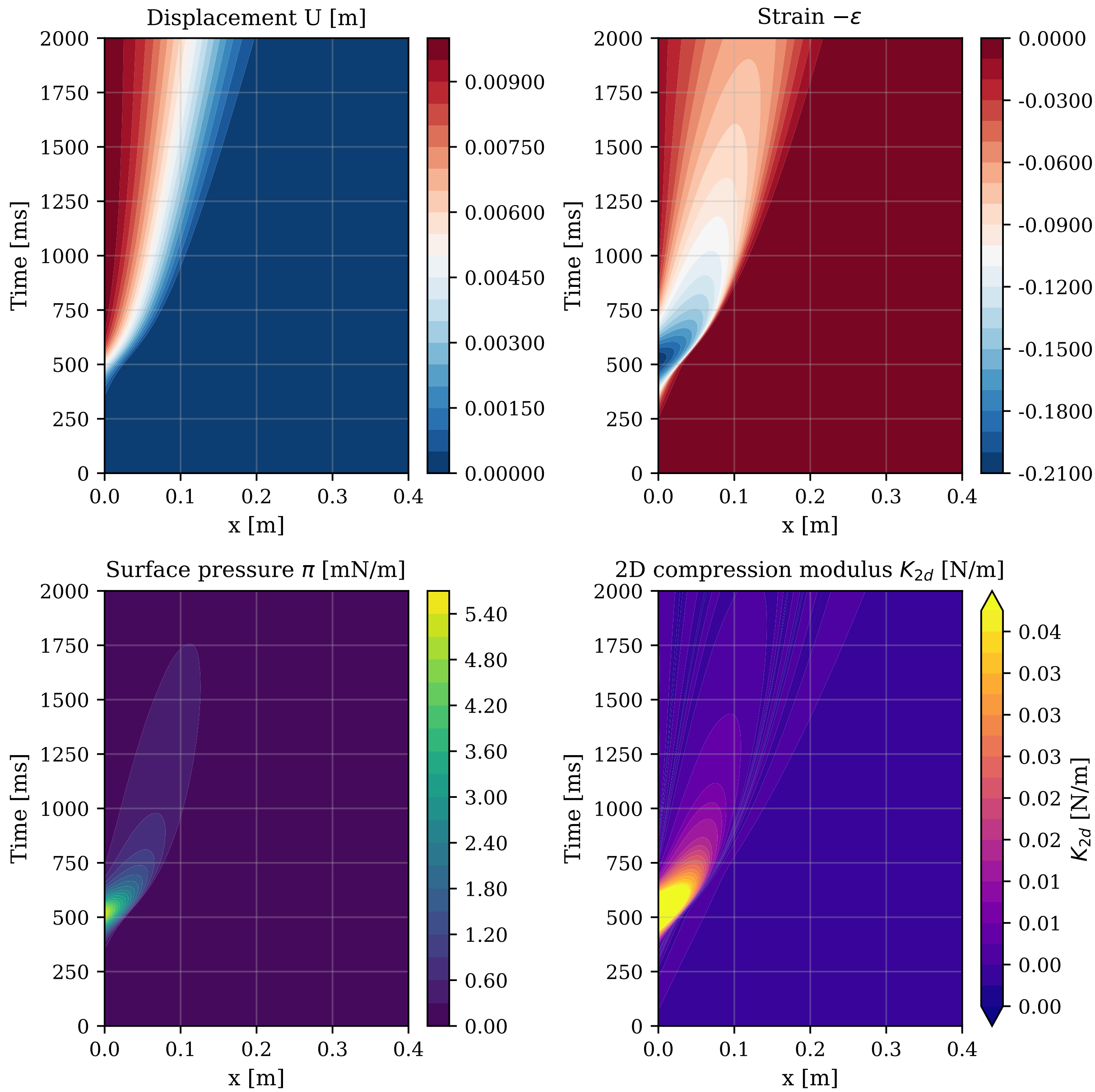

Figure S3: Spatial and temporal representation of wave propagation for $u(0,t)_{\max} = 0.01\,\mathrm{m}$. The elastic modulus is updated after each computational step according to the prescribed isotherm in order to include nonlinear elastic effects. The bottom-right panel shows the modulus in both time and space, revealing substantial variations in its value and, consequently, nonlinear effects. Consistent with this behaviour, the maximum strain is $|\epsilon|_{\max} = 0.21$.

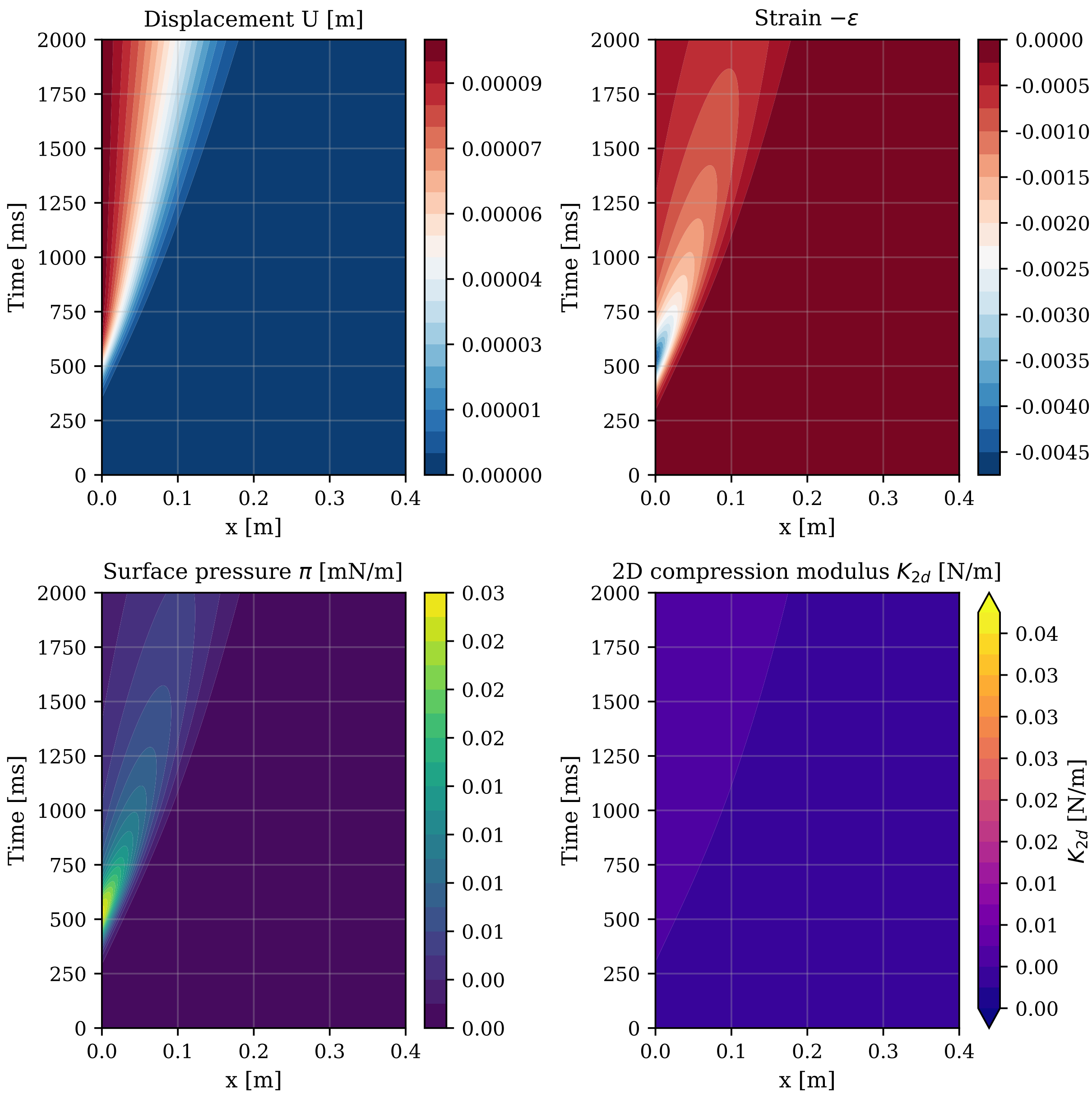

Figure S4: Spatial and temporal representation of wave propagation for $u(0,t)_{\max} = 0.0001\,\mathrm{m}$. The elastic modulus is updated after each computational step according to the prescribed isotherm in order to include nonlinear elastic effects. In contrast to higher driving amplitudes, the bottom-right panel, which shows the elastic modulus, exhibits almost no variation, indicating nearly linear behaviour. In this case, the maximum strain is $|\epsilon|_{\max} = 0.0045$, sufficiently small for the scaling condition $\epsilon \ll 1$ to imply negligible nonlinear effects. This strain magnitude corresponds to the simulations performed for the experimental setup (as in the main text).

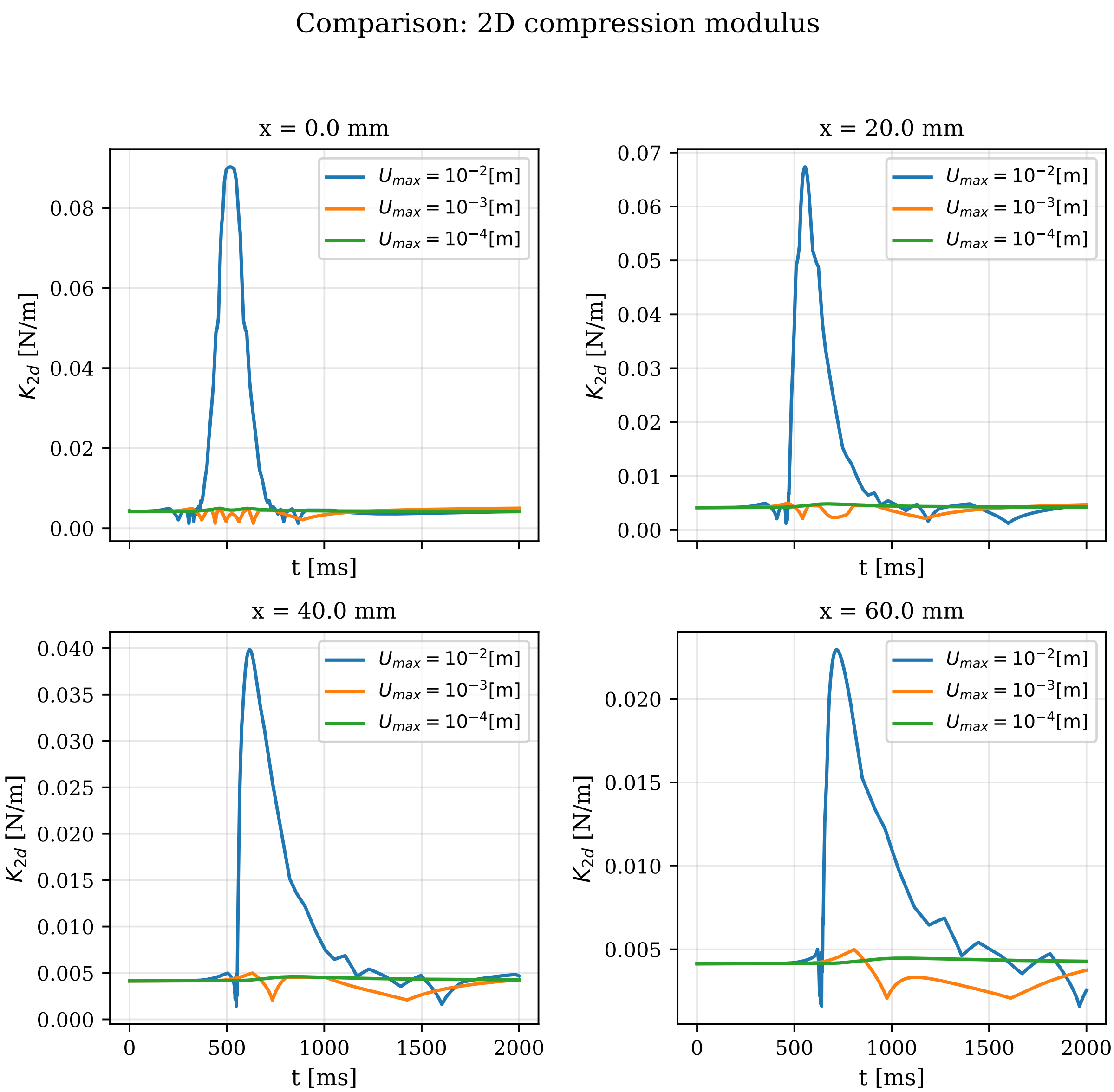

Figure S5: Comparison of the calculated nonlinear isothermal elastic modulus. The same setup for all three simulations was unchanged, including material parameters, where only the initial boundary condition, i.e. the maximal amplitude has been changed.