Evolution of the contact between rough viscoelastic solids after decreasing loads: memory erasure and monotonic increase

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The true contact area partly determines the friction force, yet its evolution in rough viscoelastic interfaces under decreasing loads remains incompletely understood. In experiments where a rough contact between polymethyl-methacrylate blocks is unloaded, Dillavou and Rubinstein [1] observed that, after the load is reduced, the contact area decreases over long times, characteristic of long-term memory in glassy systems. However, the modeling elements essential to reproducing the area decrease and long-term memory remain uncertain. Here, we investigate these effects with linear fractional viscoelastic rough-contact models [2]. Extending established contact theories and numerical schemes to fractional viscoelasticity (characterized by a broad relaxation spectrum), we reproduce the logarithmic ageing widely observed under steady load, but find that unloading erases any memory of the previous contact area. The contact reacts as if it had always been subjected to the reduced load, even over short times, unlike the behavior of a standard linear solid. Furthermore, none of our simulations display a post-unload decrease in contact area; we demonstrate analytically that no linear viscoelastic model is able to reproduce the area decrease. Consequently, local internal variables must be introduced to account simultaneously for persistent contact memory and the observed reduction of the contact area after unloading.

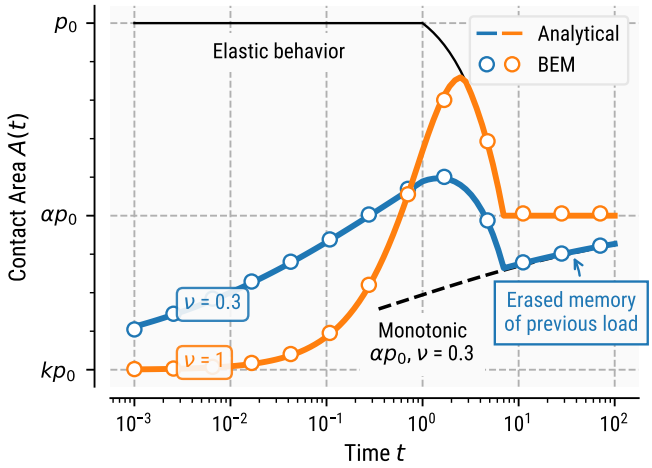

Figure 1: Evolution of the true contact area under constant load p_0 until time $T = 1$, then linear load decrease until $T + \Delta T = 6$, with load held constant at αp_0 afterwards. The exponent ν controls the breadth of the relaxation spectrum ($\nu = 1$ is a standard linear solid, $\nu = 0.2$ has a wide spectrum).

References

[1] Sam Dillavou and Shmuel M. Rubinstein. Nonmonotonic Aging and Memory in a Frictional Interface. *Physical Review Letters*, 120(22):224101, June 2018.

[2] Zichen Li, Renald Brenner, and Lucas Frérot. Evolution of the contact between rough viscoelastic solids after decreasing loads: Memory erasure and monotonic increase. (arXiv:2511.19402), November 2025.