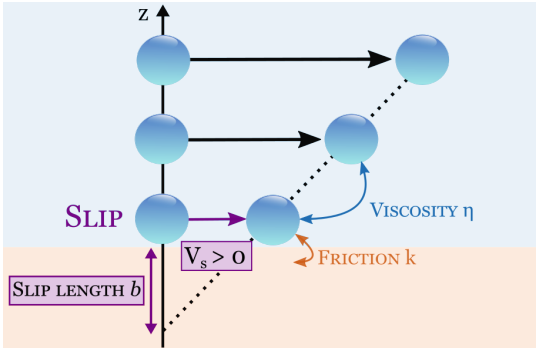
Effect of temperature on wall slip of a model fluid

Suzanne Lafon [1], Laurent Joly [2], Samy Merabia [2], Alexis Chennevière [3], Frédéric Restagno [1]

[1] Laboratoire de Physique des Solides, Université Paris-Saclay, Orsay ; [2] Institut Lumière-Matière, Université Claude-Bernard, Villeurbanne ; [3] Laboratoire Léon Brillouin, CEA-Saclay

Wall slip boundary condition



Continuity of stress τ at the L/S interface [1]:

$$\tau_{wall} = \eta \frac{\partial v}{\partial z} = k V_s$$

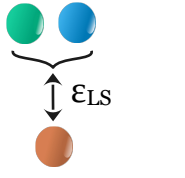
$$b = \frac{viscosity}{friction} = \frac{\eta}{k}$$

System and method

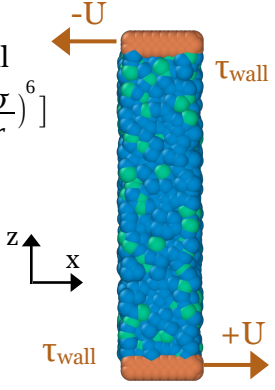
We use a Kob-Andersen [2] fluid sheared by two smooth walls [3].

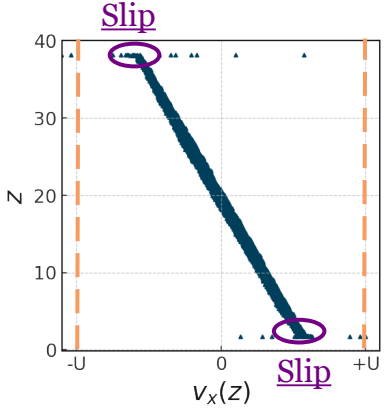
Lennard-Jones interaction potential

$$U(r) = 4\epsilon_{ij}\left[\left(\frac{\sigma}{r}\right)^{12} - \left(\frac{\sigma}{r}\right)^{6}\right]$$



Variable L/S interaction





Temperature dependency

Viscosity and friction are assumed to be activated processes: [4]

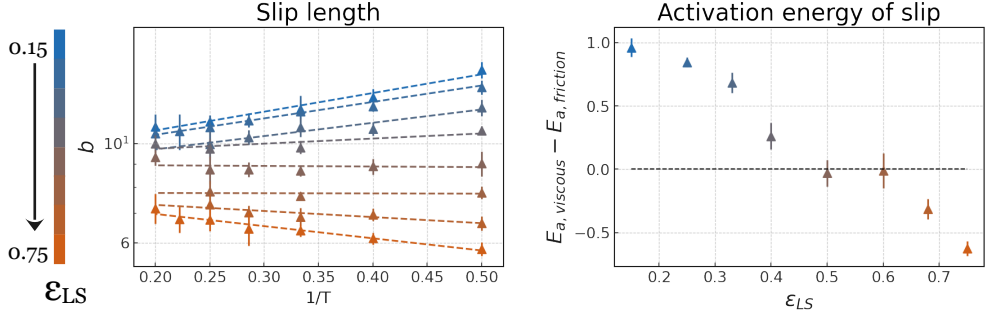
$$\eta = \eta_0 e^{E_{a,viscous}/k_B T}$$

$$k = k_0 e^{E_{a,friction}/k_B T}$$

$$\rightarrow \quad b = \frac{\eta_0}{k_0} e^{(E_{a,viscous} - E_{a,friction})/k_B T}$$

Results

b(T) can also be described by an activated-like process and its monotony depends on the strength of the L/S interaction.



b is in *σ* units (typically 3Å) and *T* is in ε_{LL}/k_B units. T_g is around 0.5.

Conclusion

The effect of temperature on slip is not straightforward. For a Kob-Andersen fluid at sufficiently large temperatures, viscosity, friction and slip are activated processes with activation energies $E_{a,viscous}$, $E_{a,friction}$ and $E_{a,viscous} - E_{a,friction}$ respectively. Therefore, the monotony of *b(T)* depends on the sign of this difference of energies, which is a function of the strength of the L/S interaction.

[1] C. L. Navier, "Mémoire sur les lois du mouvement de fluides" (1823) ; [2] W. Kob & H. C. Andersen, *Phys. Rev. E* ***51***, 4626 (1995) ; [3] C. Herrero, G. Tocci, S. Merabia & L. Joly, *Nanoscale* ***12***, 20396 (2020) ; [4] M. Hénot, M. Grzelka *et al.*, *Phys. Rev. Lett.* ***121***, 177802 (2018)