18.357: Lecture 9

Marangoni Flows II:

Chemical Marangoni flows and surfactants

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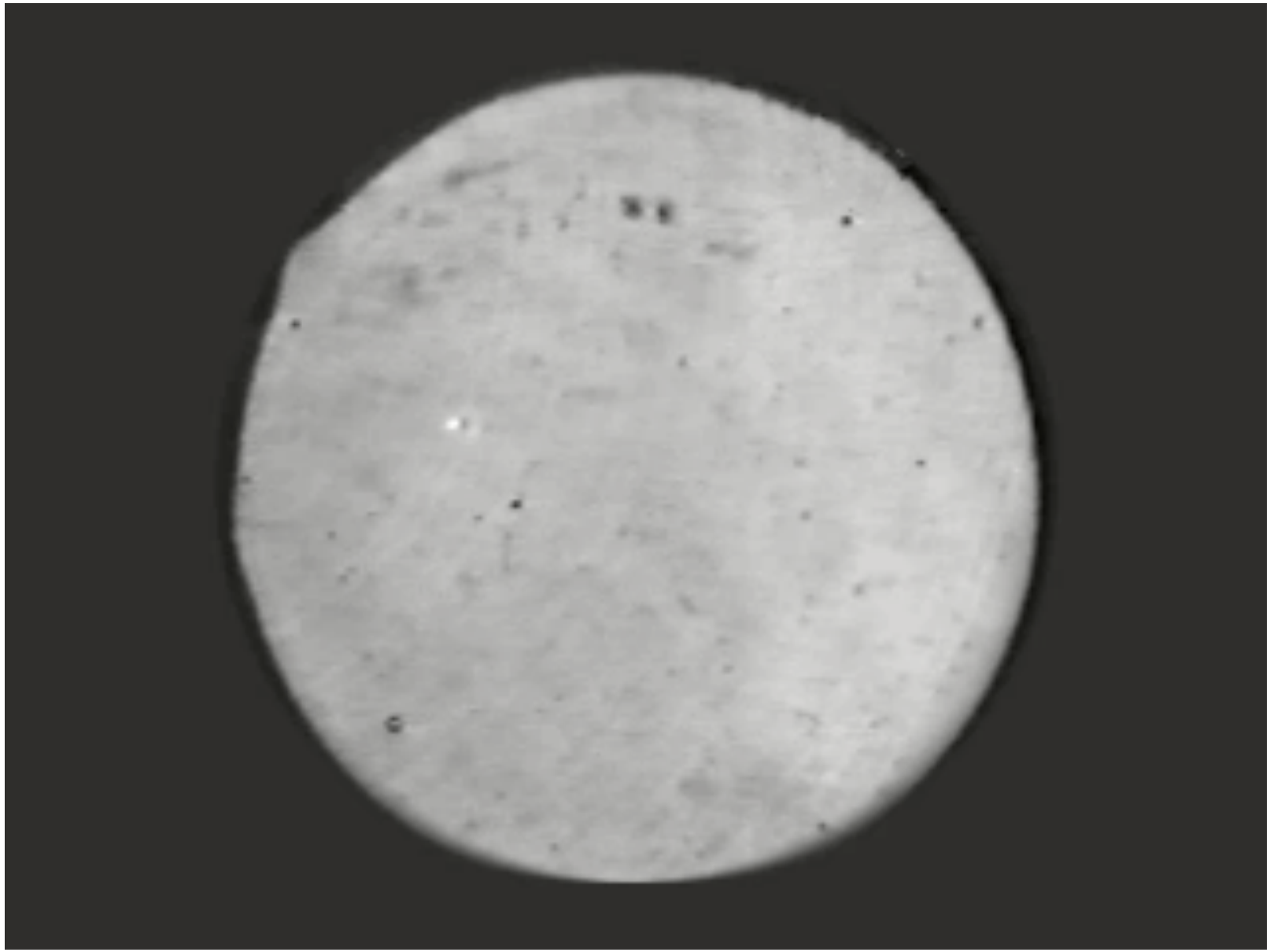
Thermal convection in a plane layer



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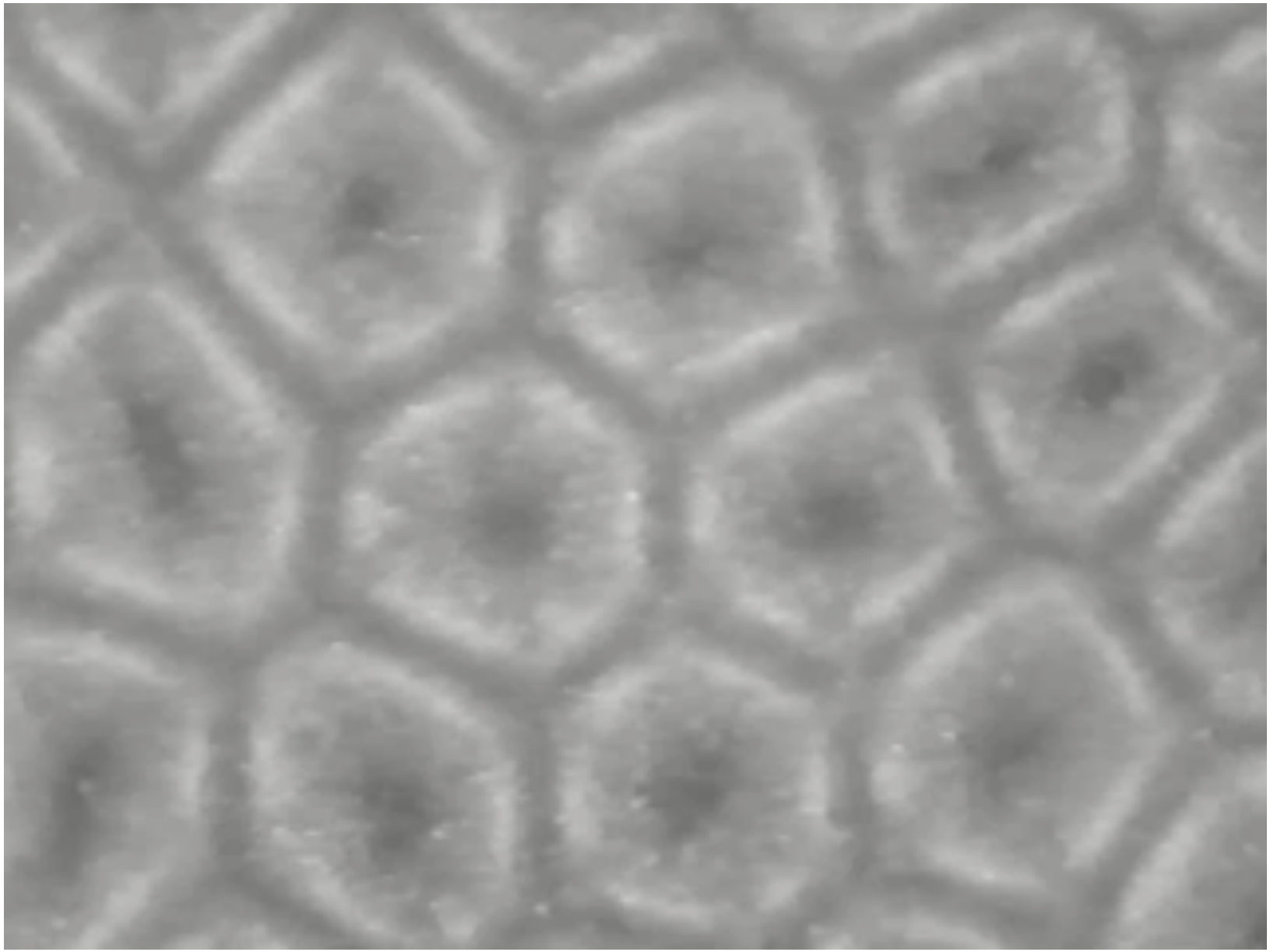
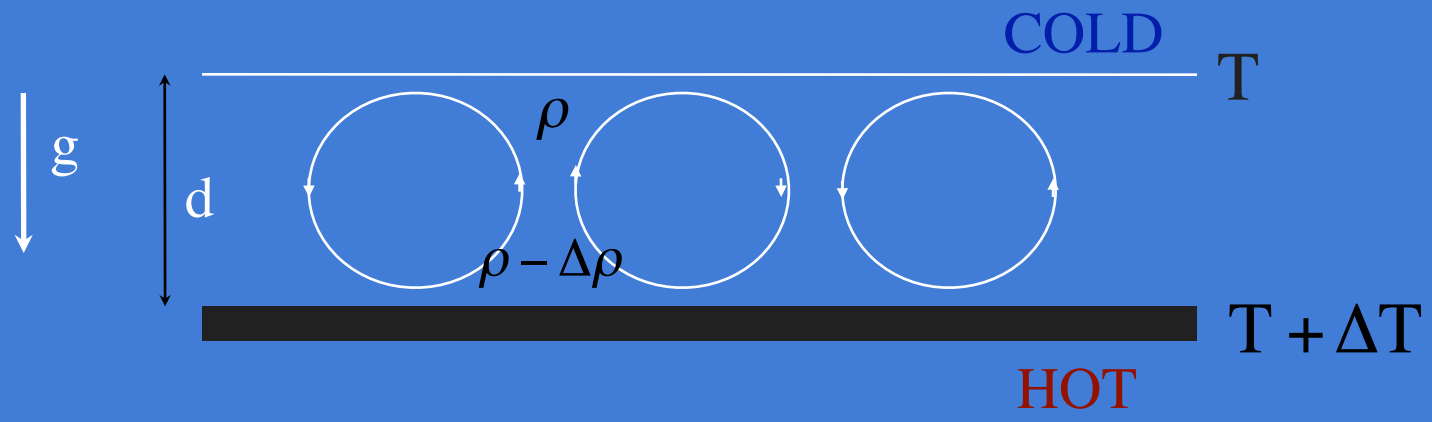


THERMAL CONVECTION

Rayleigh-Benard $\rho(T) = \rho_0[1 + \alpha(T - T_0)]$

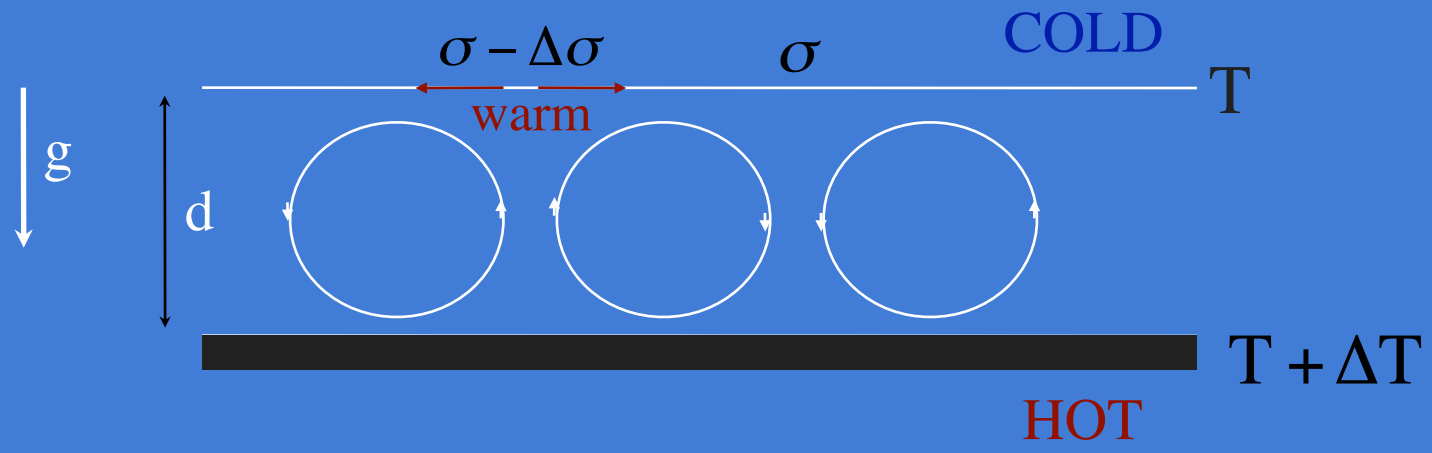


Stability prescribed by:

$$Ra = \frac{g\alpha\Delta T d^3}{\kappa\nu}$$

Rayleigh number

Marangoni-Benard $\sigma(T) = \sigma_0 - \Gamma(T - T_0)$

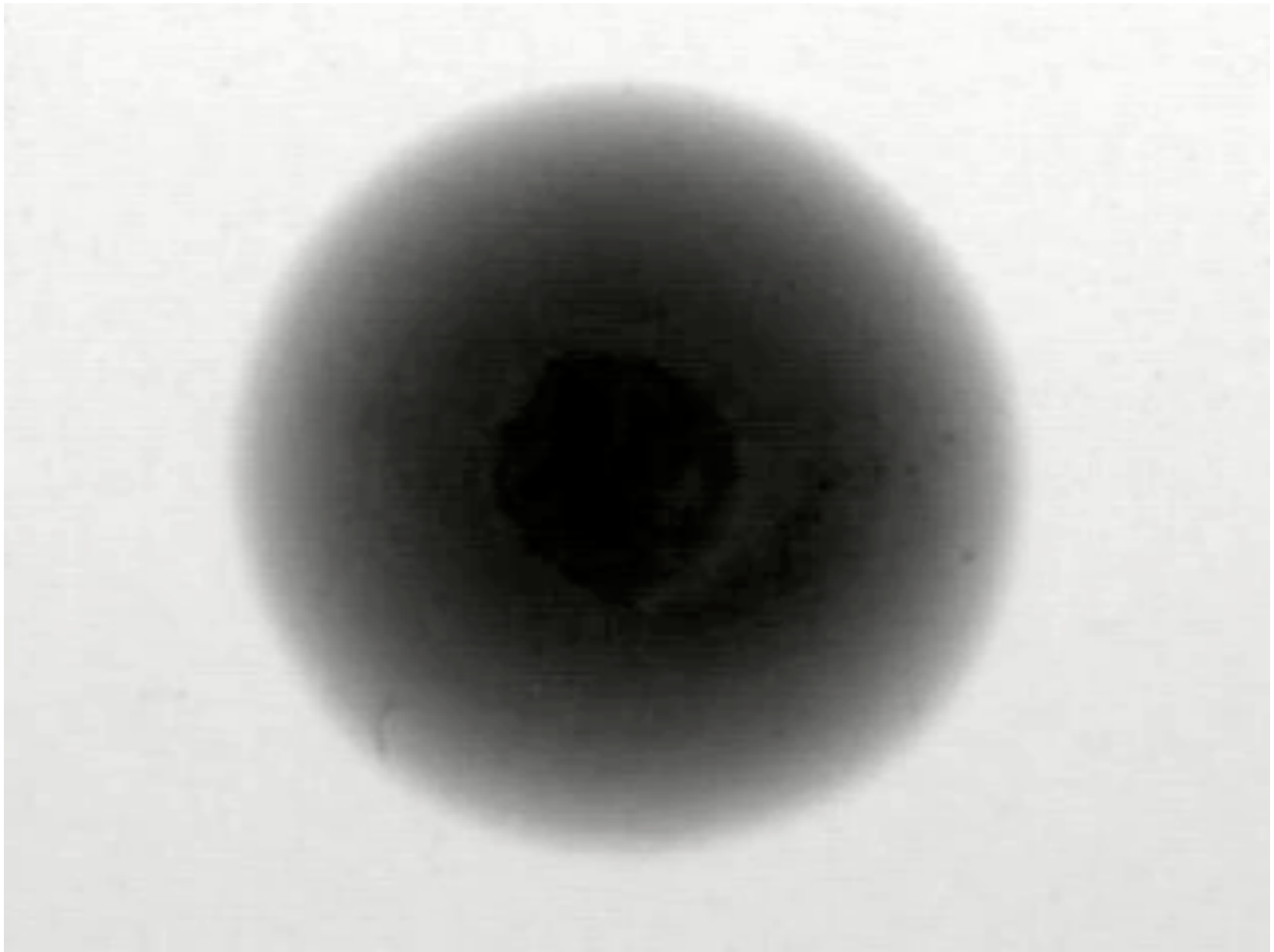


$$Ma = \frac{\Gamma\Delta T\, d}{\kappa\mu}$$

Marangoni number

Note: Marangoni convection dominates for thin films

The flow in an evaporating coffee drop



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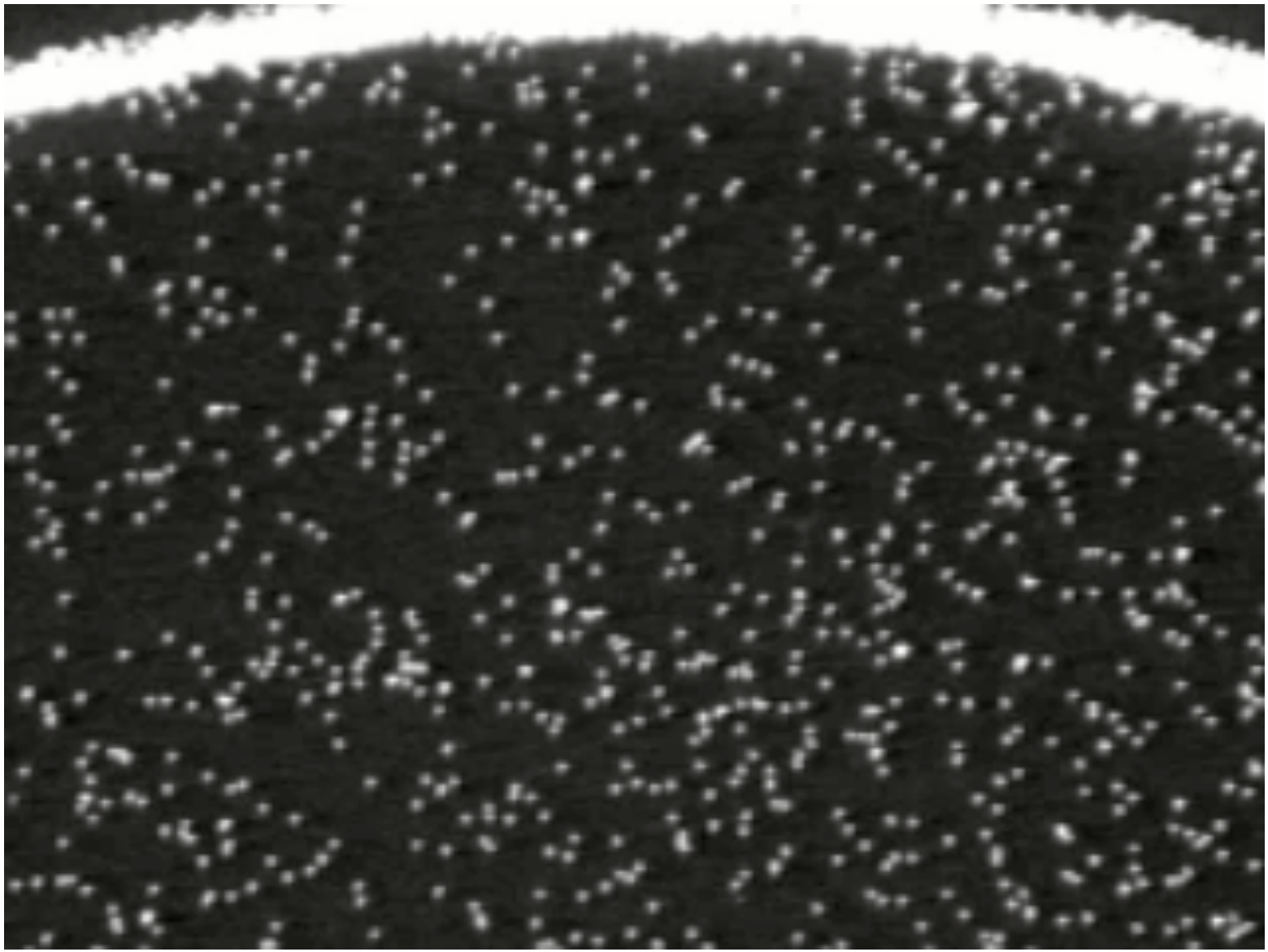
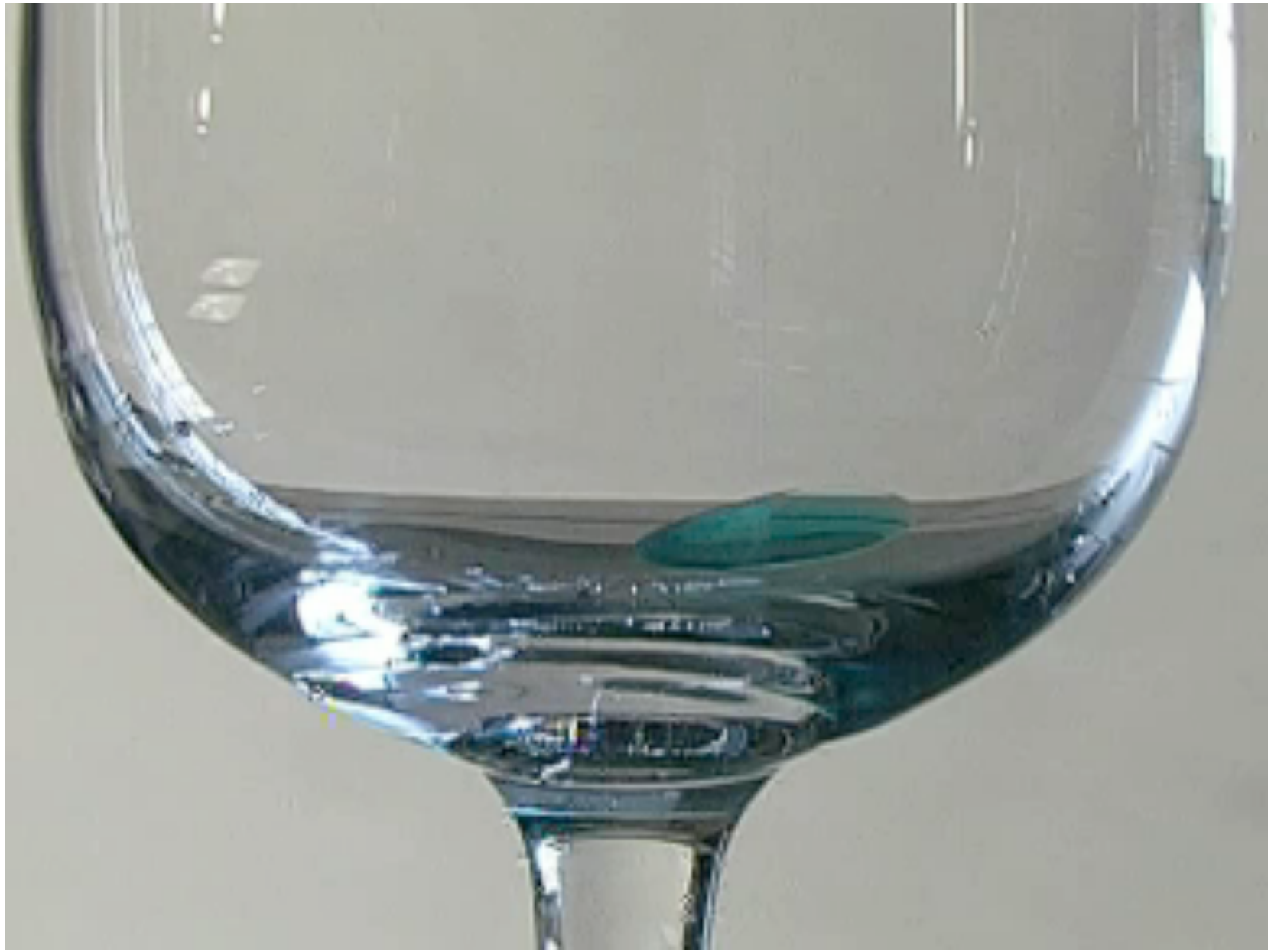
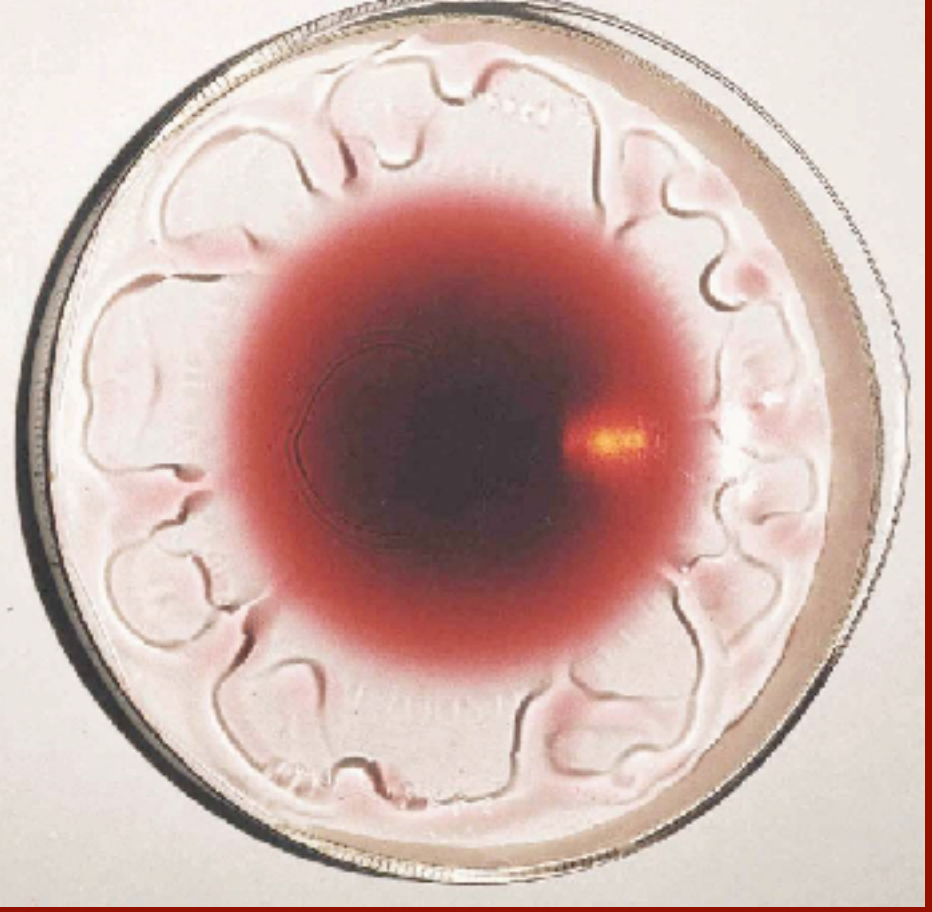
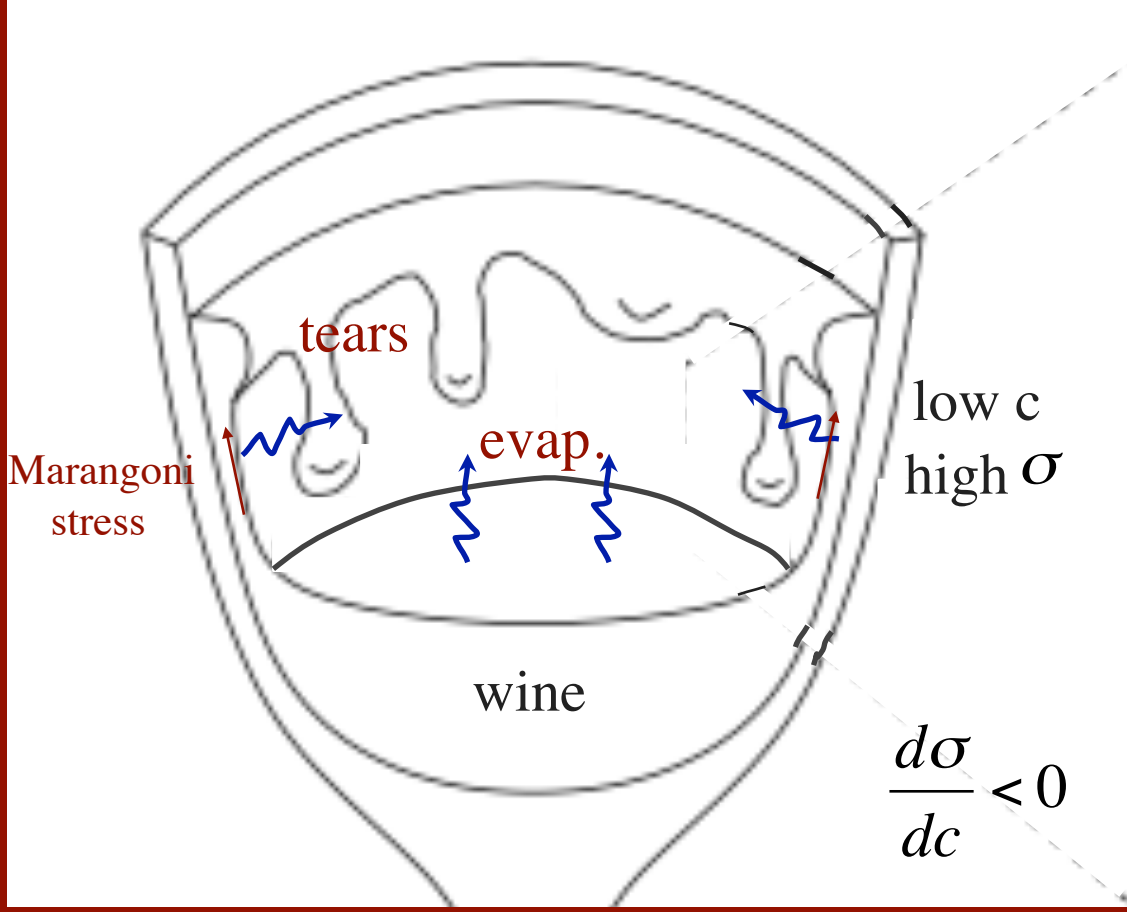


The tears of wine







The Tears of Wine (Thomson 1855)

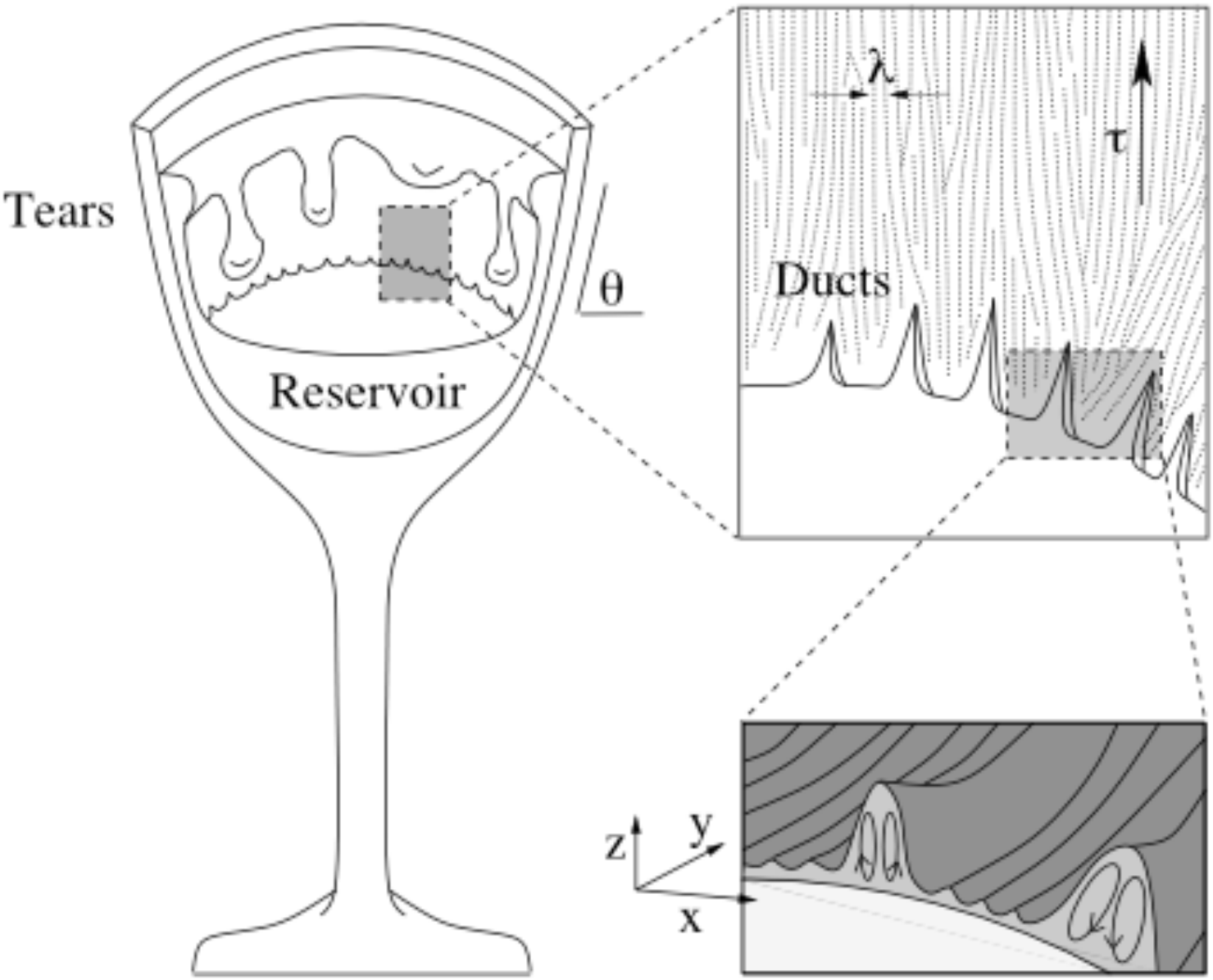
"Who hath sorrow? Who hath woe? They that tarry long at the wine.
Look not though upon the strong red wine that moveth itself aright.
At the last it biteth like a serpent and stingeth like an adder."

- Proverbs 23: 29-32

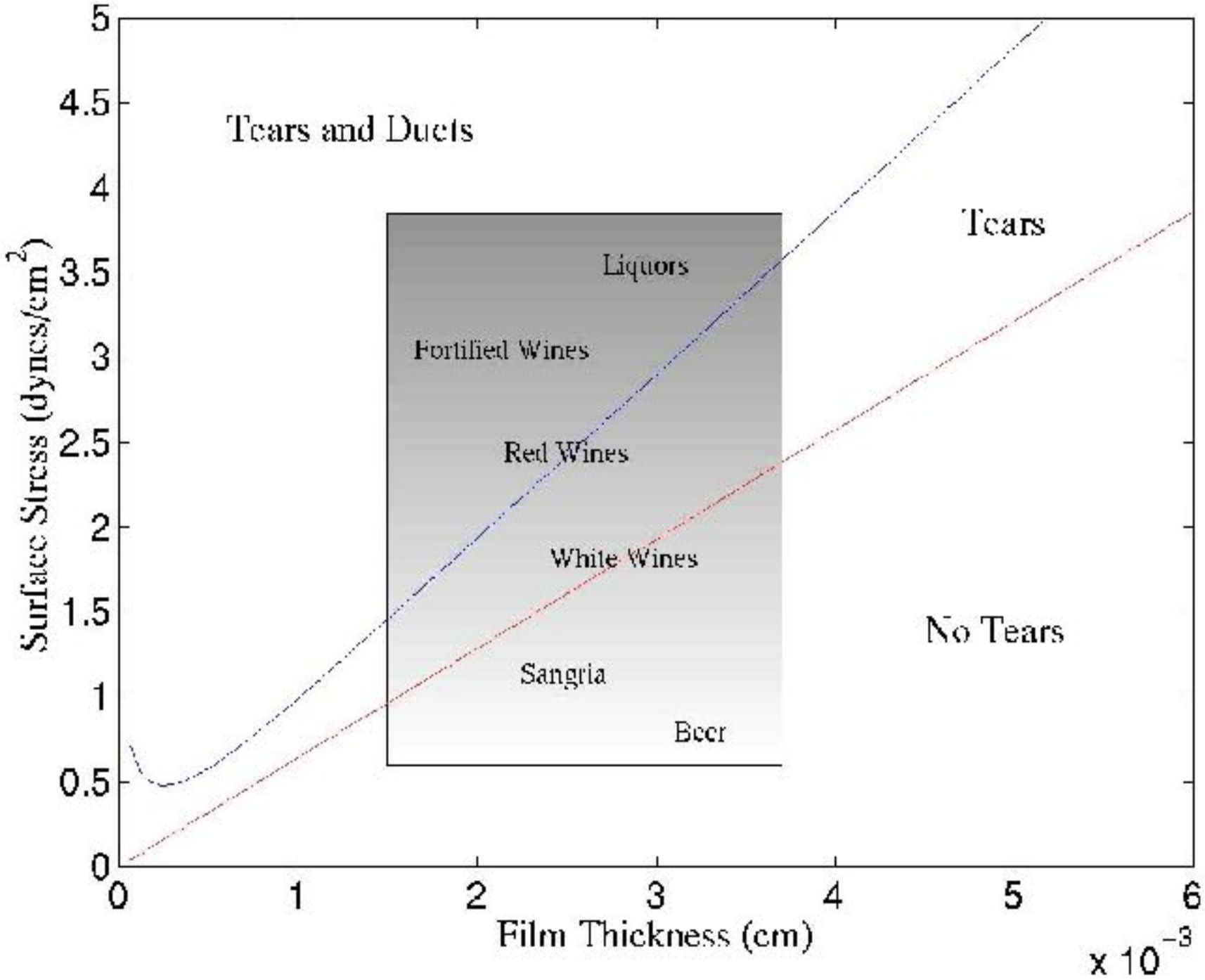
Tear line

Reservoir

The tear ducts of strong wine (Hosoi & Bush 2001)

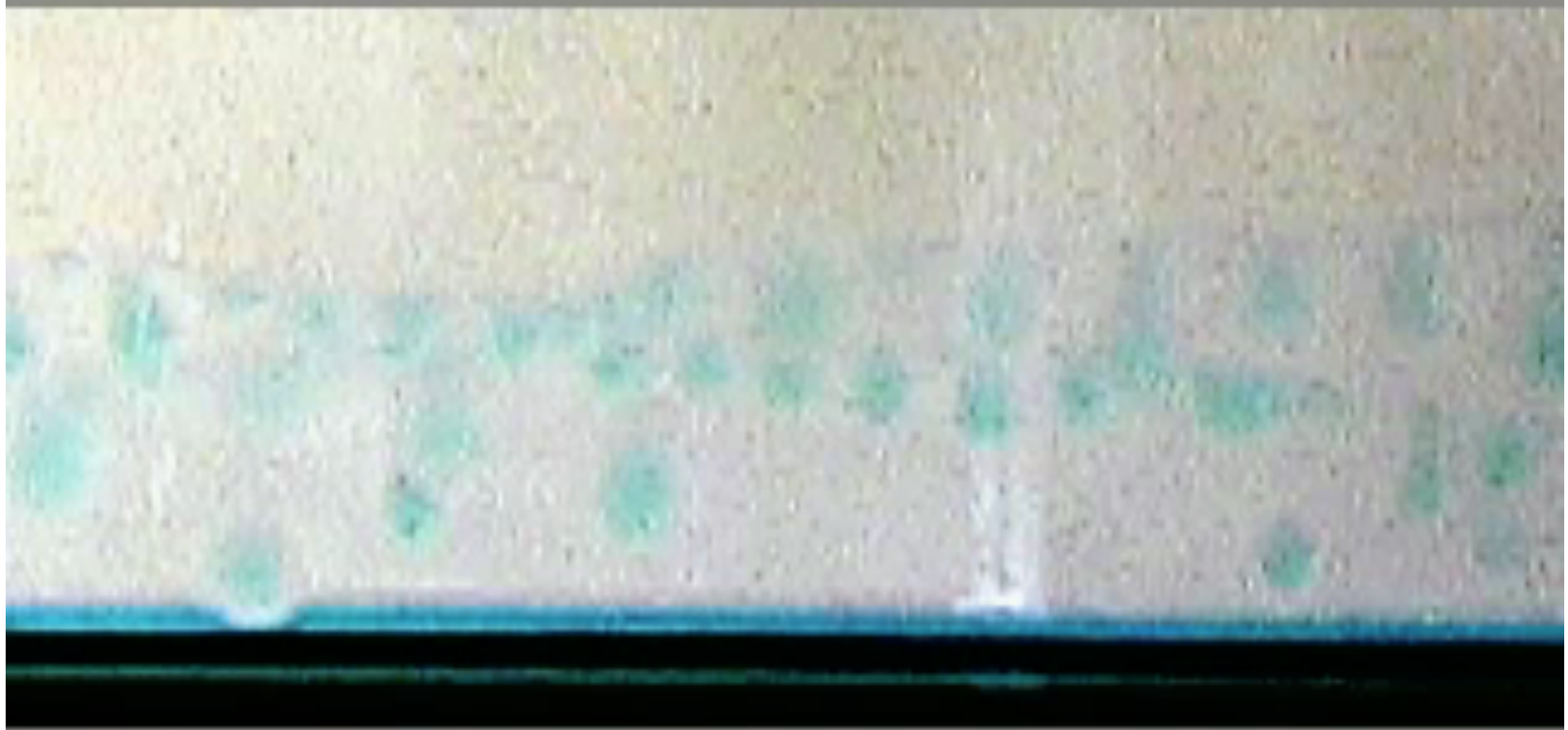


- layer marked by streamwise vortices, Marangoni convection rolls


Tears and Duels
Tears
No Tears
Liquors
Fortified Wines
Red Wines
White Wines
Sangria
Beer
Surface Stress (dynes/cm^2)
Film Thickness (cm)
x 10^{-3}
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
1
2
3
4
5
6

Nibbling tears of wine

- falling tears have lower alcohol, higher surface tension than bulk



- tears recoil as they enter the bath due to the Marangoni stresses