

## Instabilities in fluid mixtures

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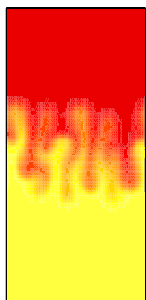
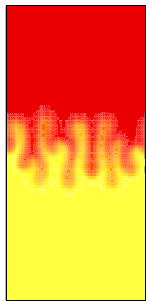
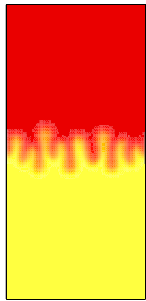
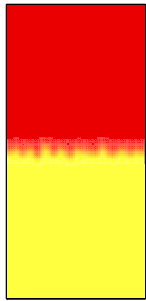
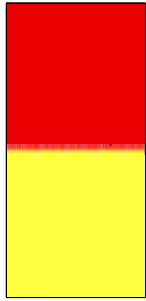
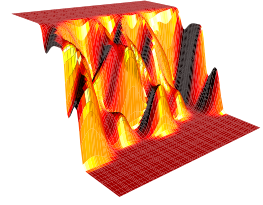
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# Instabilities in Fluid Mixtures

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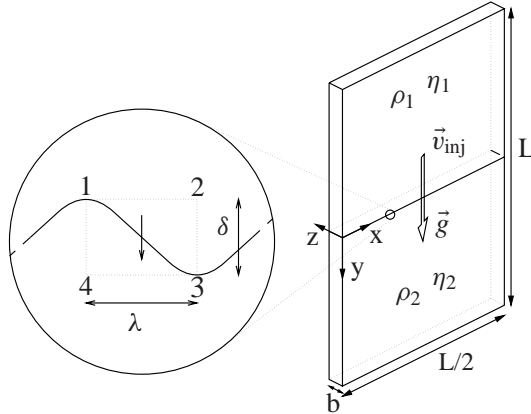


## 1. Introduction

To investigate macrovoid formation in porous membranes [?], the mechanical and thermodynamical stability of inhomogeneous, multi-component fluid systems in a flow field is considered.

## 2. Displacement Flows

First the stability of an isothermal, miscible, binary displacement flow in a Hele-Shaw geometry ( $b \ll L$ ) is considered [?].



Stability depends on the pressure difference

$$p_4 - p_3 = (\rho_2 - \rho_1)g\delta - (\tilde{\eta}_2 - \tilde{\eta}_1)v_{inj}\delta$$

where  $\tilde{\eta} = 12\eta/b^2$ . The perturbation is unstable if  $p_3 > p_4$ .

The governing equations are given by

$$\nabla \cdot \vec{v} = -\zeta \nabla \cdot (D \nabla c), \quad \zeta = (\rho_1 - \rho_2)/\rho_2$$

$$dc/dt + c \nabla \cdot \vec{v} = \nabla \cdot (D \nabla c)$$

$$\rho d\vec{v}/dt = -\nabla p - \tilde{\eta}(\vec{v} + \vec{v}_{inj}) + \rho \vec{g}$$

$$\rho = \rho_1 c + \rho_2(1 - c)$$

$$\eta = \eta(c)$$

$$D = D(c)$$

A typical time evolution of the density field in case  $\rho_1 > \rho_2$  (Rayleigh-Taylor instability), for constant viscosity and diffusion is shown on the left.

## 3. Thermodynamics

To include surface tension and phase separation a Ginzburg-Landau type free energy functional [?] is used

$$F[c] = \int \{f(c) + \frac{1}{2}\kappa(\nabla c)^2\}dV$$

To obtain the governing equation, the Fickian diffusion terms must be replaced by Cahn-Hilliard terms [?]

$$M \left( \frac{\partial^2 f}{\partial c^2} - \kappa \nabla^2 \right) \nabla^2 c$$

and a force, induced by composition gradients, must be added to the momentum equation

$$-\kappa \nabla \cdot (\nabla c \otimes \nabla c)$$

## 4. Conclusions

- The miscible model does not predict all the qualitative aspects of macrovoid formation in porous membranes.
- The Ginzburg-Landau model describes interfaces with a finite thickness, which justifies the use of a continuum surface tension method [?].

## 5. References

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