An instability mechanism in foam drainage

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ABSTRACT

When the drainage rate in foam exceeds a critical value, the liquid distribution becomes inhomogeneous and steady convection rolls are induced [1]. Even though this effect is known for 20 years, the mechanism is still debated. We present experiments in a very long vertical foam channel under forced drainage, including liquid fraction measurements and a spatially resolved measurement of the foam velocity. At 30 % of the critical drainage rate a static, elastic shear deformation of the foam and inhomogeneous water distribution is observerd. At 110%, convection rolls are localized near the bottom and expand with increasing drainage rate. Reducing the channel length increases the critical value. Our experiments prove, that the anisotropic drainage due to shear deformation of the foam [2] is at the origin of the Convective Instability. Phase-averaging simulations that couple drainage with elastic deformation of the foam reproduce the experimental findings. Linear stability analysis provides a stability criterion, that corresponds to the experimental and numerical findings. This critical liquid fraction is very low. Consequently, the mechanism should be considered in many experimental configurations.

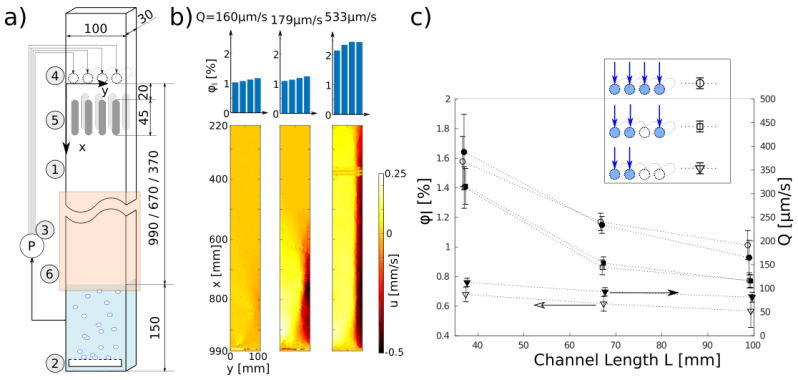

Figure 1: (a) Setup of the foam channel, (b) liquid fraction and velocity distribution, (c) critical liquid fraction and drainage flow for different channel length and modes of water addition.

[1] S. Hutzler, D. Weaire, R. Crawford. Convective instability in foam drainage. EPL. 41(4):461, 1998.

[2] S. J. Neethling, Effect of simple shear on liquid drainage within foams, PRE 73(6):061408, 2006.