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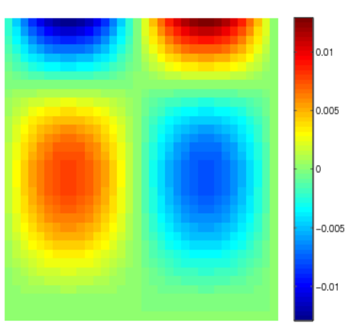
Thin polymer films are increasingly used in advanced technological applications. The use of these films as coatings is often limited by their lack of stability due to their wettability properties on the used substrates. However, the instabilities may be employed to create complex morphologies for polymeric functional layers . Furthermore, the development of microfluidics applications such as DNA micro-arrays, thermal control of semiconductor devices, and massively parallel drug screening requires a fundamental understanding of static and dynamic interfacial phenomena at adaptive interfaces and for confined geometries.

Fluids of interest in biology, chemistry, and in various applications are rarely simple single-phase fluids. These systems pose interesting fundamental questions that are not yet entirely resolved even for the bulk of the film, and become more challenging as free interfaces and wetting properties are involved. For instance, experiments with films of polymer blends, find that phase separation within the film or phase enrichment at the boundaries may cause the dewetting of the film itself.

Within the vast field of complex fluids binary mixtures, such as polymer blends, are specially interesting since they are one of the simplest systems with known evolution equations to explore novel features in complex fluids. Normally, the dynamics of a binary mixture is described by the so called model-H coupling momentum transport (Navier-Stokes) and nonlinear diffusion (Cahn-Hilliard). We extende this model-H by incorporating boundary conditions that allow to describe an evolving free surface. The project FOBIMI has focused on the study of relevant basic and technological problems arising in films of binary mixtures such as polymer blends. Based on extensions of model-H and the Canh-Hilliard equation FOBIMI has studied the interplay between surface tension and finite surface deflections on the phase separation of binary mixtures, the influence of convective and diffusive transport in the stability of binary mixtures and the modeling of polymer blends subjected to the action of external electric fields.

<u>Convective transport and stability in polymer blends</u>

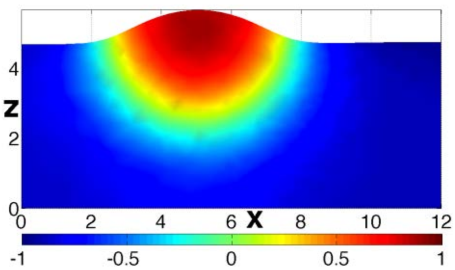


1 Convective transport on a polymer blend of several tens of nanometers thickness [2].

We have studied the linear stability with respect to lateral perturbations of free surface films of polymer mixtures on solid substrates for the case of stratified and homogeneous steady films. To this aim, the linearized bulk equations and boundary equations have been solved using continuation techniques for several different cases of energetic bias at the surfaces corresponding to linear and quadratic solutal Marangoni effects. For purely diffusive transport, an increase in the film thickness either exponentially decreases the lateral instability or entirely stabilizes the film. Including convective transport leads to a further destabilization as compared to the purely diffusive case. In some cases the inclusion of convective transport and the related widening of the range of available film configurations -it is then able to change its surface profile- change the stability behavior qualitatively. We furthermore have studied the dependence of the instability on several other parameters, namely, the Reynolds number, the surface tension number, and the ratio of the typical velocities of convective and diffusive transport

Surface deflection and composition

Real world mixtures are rarely critical -same average composition of the two components- since having a balanced overall composition of the two components is not frequent, and active energetic surfaces can attract preferentially one of the components enhancing bulk differences on average composition of the species. This makes relevant the study of off-critical films of binary mixtures.



2 Steady droplet of a liquid above another separated by a diffuse interface [4].

We have calculated the bifurcation diagrams of off-critical films of polymer blends with free surfaces, by studying their free energy, and the L2-norms of surface deflection and the concentration field, as a function of lateral domain size and mean composition. To treat the problem of films with arbitrary surface deflections our calculations are based on minimizing the free energy functional at given composition and geometric constraints using a variational approach based on the Cahn-Hilliard equation. The problem is solved numerically using the finite element method (FEM). We show that films of polymer blends with free surfaces exhibit a rich family of solutions such as laterally modulated states, vertically layered or droplets of a phase above or contained in the other phase.

External fields on polymer blends

The replication of patterns on scales less than 100nm is of great interest in soft lithography techniques. We have developed a long wave model to study the instabilities, and therefore the pattern forming capabilities, of polymer blends subject to an external electric field. We find how characteristic length scales of dielectric liquid under the plates of a condenser can be modulated according to the electric permittivity of the solute introduced in the liquid.

[1] U. Thiele, S. Madruga, and L. Frastia. Decomposition driven interface evolution for layers of binary mixtures: I. model derivation and base states. Phys. of Fluids, 19:122106(1–23), 2007.

[2] S.Madruga and U. Thiele. Decomposition driven interface evolution for layers of binary mixtures: II. influence of convective transport on linear stability. Phys. of Fluids, 21:062104, 2009.

[3] Madruga, S.; Thiele, U. European Physical Journal Special Topics 2010, 192, 101–108.

[4] Free surface liquid films of binary mixtures –two-dimensional steady structures in the off-critical case. F. Bribesh, S. Madruga and U. Thiele. *Submission to Langmuir scheduled for summer 2012.*