DY 14: Fluid dynamics II

Time: Tuesday 11:15–13:00 Location: H2

DY 14.1 Tue 11:15 H2

Boudany effects in fluids with internal orientational degree of freedom. — •Sebastian Heidenreich[1], Patrick Ilg[2], and Siegfried Hess[1] — [1]Technische Universität Berlin, D-10623, Germany — [2]ETH Zürich, Wolfgang-Pauli-Str. 10, 8093 Zürich

In nano- and microfluidics the length scales of devices are comparable to the molecular lengths and fluid-wall interactions become significant for the flow behavior. In our contribution we consider fluids with an internal orientational degree of freedom. We use the relaxation equation [1], an amended Landau-de Gennes potential [2] to model the spatially inhomogeneous orientational dynamics and the momentum balance equation to couple the velocity on the orientation. In order to model fluid-wall interactions we use different boundary conditions on the alignment tensor (anchoring) as well as on the alignment flux tensor (consequences of irreversible thermodynamics [3]). We show analytically that for stationary flows (plane Couette and Poiseuille flows) in the isotropic phase boundary conditions on the alignment flux tensor lead to an apparent velocity slip. Furthermore the interplay between the flow velocity and the orientation dynamics in the nematic phase under consideration of the different boundary conditions is presented.

[1] S. Hess, Z. Naturforsch. **30a**, 728, 1224 (1975)
[2] S. Heidenreich, P.Ilg and S. Hess, Phys. Rev. E **73**, 061710 (2006)
[3] L. Waldmann, Z. f. Naturf. **22a**, 1269 (1967); L. Waldmann and H. Vestner, Physica **99A**, 1 (1979); S. Hess and H. M. Koo, J. Non-Equilibrium Thermodyn. **14**, 159 (1989)

DY 14.2 Tue 11:30 H2

Influence of inhomogenous magnetic field on the electric potential distribution in liquid metal channel flow — •Egbert Zienicke and Evgeny Votyakov — Institut für Physik, Technische Universität Ilmenau, Postfach 100565, 98684 Ilmenau

If an electrical conducting fluid, for example a liquid metal, flows through a stationary external generated magnetic field, electrical currents are induced which on their turn act on the fluid by the Lorentz force. The flow in the channel together with the magnetic field create an electrical field, respectice an electrical potential distribution inside the liquid metal. We derive by physical inspection and numerical simulations of MHD channel flow how the potential distribution changes from homogenous magnetic field to streamwise inhomogenous, and to streamwise and spanwise inhomogenous magnetic field (corresponding to magnetic poles above and below the channel). In the latter case closed level lines of the electric potential in the middle plane appear for high enough magnetic field, indicating the possibility of reverse flow under the magnet [1]. This finding is also confirmed experimentally by potential measurements in a liquid metal channel [2].

References

[1] E. Votyakov, E. Zienicke, Fluid Dynamics and Materials Processing, accepted for publication.
[2] O. Andreev, Y. Kolesnikov, A. Thess, Phys. Fluids 18 (2006) 065108

DY 14.3 Tue 11:45 H2

Response thin liquid films with splitted tongues? — •Bernhard Heislbetz — DLR Lampoldshausen, Institut für Raumfahrtantriebe, D-74239 Hardthausen

The stability of free fluid films in the presence of a harmonic modulated pressure or gravity field is investigated analytically. A linear stability analysis for the infinitesimal disturbances of the hydrodynamic problem for inviscid and also viscous fluids shows, that the dynamic of the interfaces of fluid films can be described by two coupled differential equations of the Mathieu-type. In the range of very thin film thicknesses we can show, that the time evolution of the film shapes is governed by an membrane-like equation coupled with an linear KdV-equation. By means of multiple time scale analysis we exemplify if and why thin liquid films response with splitted tongues.

DY 14.4 Tue 12:00 H2

Linear analysis of instability in a binary-liquid layer — •Ion Dan Borcia and Michael Bestehorn — Lehrstuhl für Theoretische Physik II, Brandenburgische Technische Universität Cottbus, Germany

Oscillatory and monotonic long wave Marangoni instability in a binary-liquid layer with deformable interface in the presence of Soret effect was studied using two simplified sets of equations [1,2]. The vertical dependency of the temperature and concentration was approximated with polynomials. The actual work is devoted to the study of the validity domain of this approximation in the parameter space, for the early stage of the instability. Thus, we compare the results from previous models with those computed for an extended system considering the temperature distribution and the concentrations described by time-dependent three-dimensional equations.

[1]I.D. Borcia, R. Borcia, M. Bestehorn, Europhys. Lett., 75(1),112 (2006).
[2]I.D. Borcia, R. Borcia, M. Bestehorn, J. Optoelectr. Adv. Mater., 8(3), 1033 (2006).

DY 14.5 Tue 12:15 H2

Verdampfungsinduzierte Musterbildung in dünnen Filmen — •Domnic Merkt und Michael Bestehorn — Technische Universität Cottbus, Lehrstuhl nichtlineare Dynamik und statistische Physik, Erich Weinert Strasse 1, 03046 Cottbus

Wir stellen eine Erweiterung der sogenannten Dünnfilmgleichung vor, die das für diese Systeme typische "Coarsening" unterdrückt und zur Bildung von regelmäßigen, stationären Mustern der Oberfläche mit endlicher Wellenzahl führt (Hexagone, Streifen). Der zur Musterbildung notwendige Mechanismus beruht hier auf der Berücksichtigung von Verdampfung und Kondensation der Flüssigkeit bei spezieller Systemkonfiguration. In diesem Vortrag wird diese Erweiterung physikalisch motiviert und es werden lineare sowie nichtlineare Ergebnisse vorgestellt.

Invited Talk DY 14.6 Tue 12:30 H2

Instabilities and pattern formation in phase-separating fluids — •Jürgen Vollmer — Fachbereich Physik, Philipps Universität, Renthof 6, 35032 Marburg, Germany

The thermodynamic equilibrium of fluid mixtures and their isothermal relaxation to equilibrium after a rapid temperature quench are well understood due to extensive experimental, numerical and theoretical studies in the past decades. In many technological and natural processes one is however confronted with phase-separating systems where the temperature is slowly drifting. In this case it is of interest to follow the evolution of the local composition also while the temperature is evolving. A simple estimate shows that even for very small drift the composition cannot quasi-statically (in the sense of local thermodynamic equilibrium) follow the change of temperature. The temporal evolution of the composition consequently becomes a problem of pattern formation: For small temperature drift convection arises, and a large drift induces repeated waves of precipitation.

We derive a phase diagram accounting for the cross-over between the quasi-static, convective and oscillatory regimes, and present a minimal theoretical model addressing the parameter dependence of the oscillations. The latter agrees well with recent experimental data of D. Vollmer and G.K. Auernhammer (MPI Polymer Research, Mainz).