Eur. Phys. J. E (2015) **38**: 31
DOI 10.1140/epje/i2015-15031-6

The European Physical Journal E

Editorial

Editorial: Thermal non-equilibrium phenomena in multi-component fluids*

Published online: 29 April 2015 –

Non-equilibrium thermodynamics is a field of increasing interest for its scientific and technological impact. In particular here we deal with multi-component fluids, where in addition to viscous and thermal effects, diffusive transport must be taken into account. Even though thermodynamics of irreversible processes allows for a phenomenological understanding of these phenomena, no complete theory is available to describe the behaviour of multi-component fluids in non-equilibrium conditions. Recent developments, some of them covered in this Topical Issue, led us to believe that there has been an important breakthrough in the understanding of thermally induced phenomena such as thermodiffusion.

The goal of this Topical Issue is to describe the state of the art of the understanding of thermodiffusion. This phenomenon, also called the Ludwig-Soret effect [1,2], describes the coupling between a temperature gradient and the resulting mass fluxes. It was discovered more than 150 years ago, but no unique theoretical explanation is yet available, and experimental data is not exhaustive.

Measurements of the Soret coefficient are performed by different techniques, but the weakness of this effect makes it difficult to quantify in many practical cases. About ten years ago, conflicting data for the Soret coefficients of binary mixtures (mixtures of two components) was common in the literature. That is why, during a conference, it was decided to perform a benchmark test, the so called "Fontainebleau benchmark" [3].

A few months ago (June 2014) at the 11th edition of the International Meeting on Thermodiffusion held in Bayonne, France, six different teams from all over the world agreed that the times were ripe for performing a benchmark measurement on ternary mixtures, involving both ground- and space-based experiments, the latter performed on board the International Space Station. In this Topical Issue, the reader will find a total of seven papers devoted to this benchmark: six "contribution" articles [4–9] plus one summarizing all the experimental data contained in the other papers and providing an average value for the quantities of interest [10]. The experiments took place within the cooperative framework of the international project DCMIX (Diffusion Coefficients in ternary MIXtures), representing a significant investment by national and international space agencies such as ESA, NASA, CSA and ROSCOSMOS that should benefit the community at large [11].

The present Topical Issue is complemented by another 17 papers. Their subjects are listed here, in no particular order. A number of papers report experimental measurements of mass diffusion, Soret and thermodiffusion coefficients in binary and/or ternary fluid mixtures, whether in free media or in a porous matrix [12–15]. Some papers describe experiments [14,16,17] or theory [18] on non-equilibrium fluctuations in multi-component fluids under thermal stress, a theme that we suggest as very promising for the future developments of non-equilibrium thermodynamics. Another group of papers deals with convection induced by the coupling of buoyancy with density gradients driven by the combined effects of temperature and concentration gradients [19–24]. The behaviour of ferro-fluids and/or colloids is experimentally and numerically studied in two papers [15,25]. Two other papers report an experimental [17] and a numerical study [26] of the behaviour of a binary mixture close to its critical consolute temperature. One paper describes the effect of temperature on deep-water sediments [27]. Finally, one theoretical paper [28] explores the relationship between the Soret and Dufour coefficients from the point of view of the Onsager theory of irreversible processes.

We believe that the "Bayonne benchmark" for ternary mixtures, as well as all the other papers presented in this issue, will represent a milestone in the study of multi-component mixtures subjected to a temperature gradient, contributing to a deeper understanding of the physics of realistic non-equilibrium complex systems. These systems can be mixtures with hundreds of components like oil fluids contained in natural reservoirs, or mixtures in living systems.

* Contribution to the Topical Issue "Thermal non-equilibrium phenomena in multi-component fluids" edited by Fabrizio Croccolo and Henri Bataller.

We want to express our thanks to all the authors and reviewers for timely submitting well-formatted contributions that simplified the editing of this Topical Issue of the European Physical Journal E. We are also indebted to all the journal staff for their competence and patience, with particular thanks to Solange Guéhot.

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