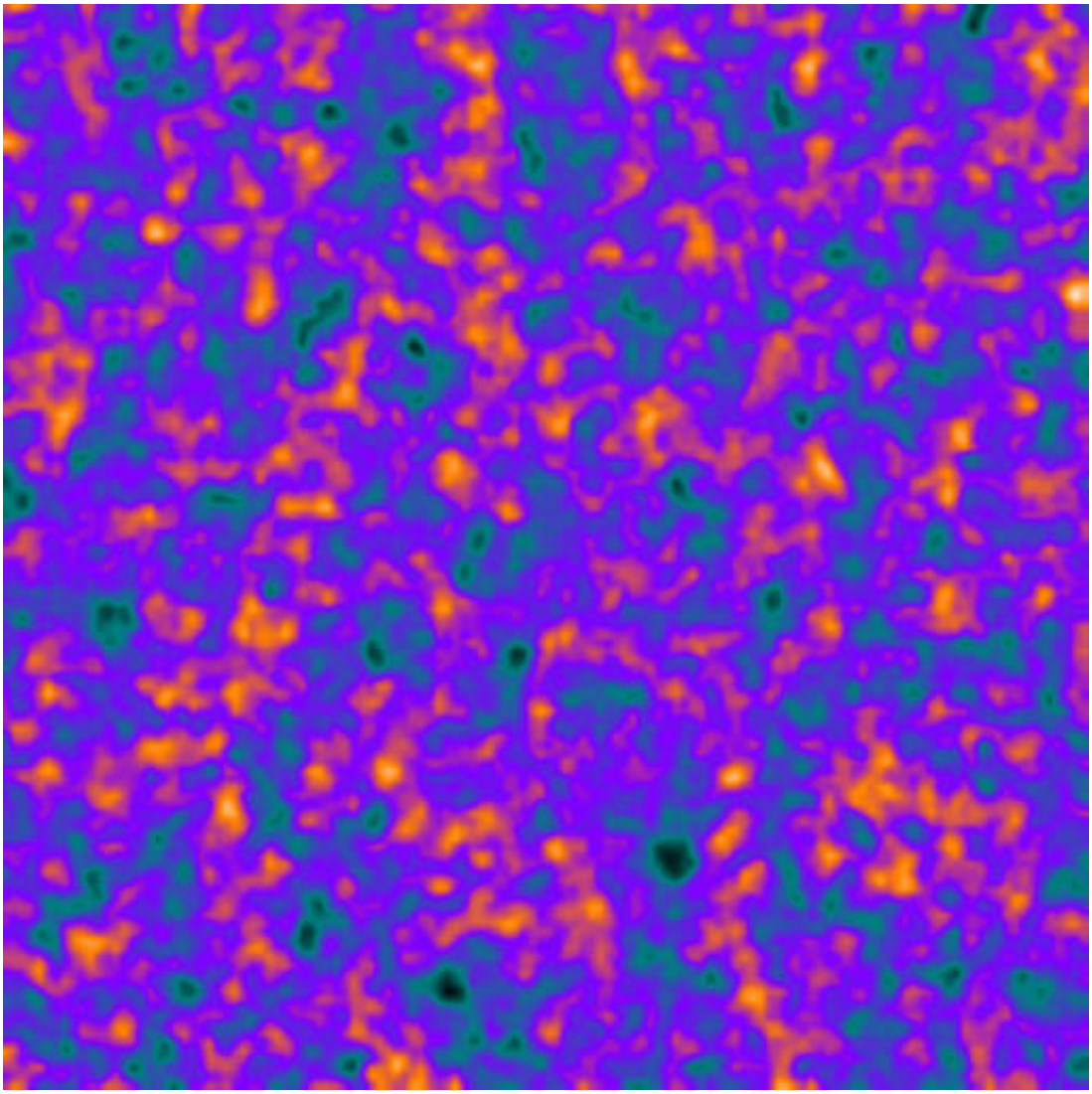
Physicists reveal cocktails with Dr Jekyll and Mr Hyde features

November 3 2016



False colour image of the long-range concentration fluctuations arising in a critical binary mixture. Credit: SciencePOD

Disturbing a mix of two liquids can yield some surprising effects. For example, if one portion of the mixture is brought to a different composition, it starts a process called diffusion, which continues until the liquid mix reverts to the resting point, which physicists refer to as equilibrium. Understanding the underlying physical phenomenon matters because diffusion is ubiquitous in physical and biological processes, such as the transport of nutrients within our cells. Now, an Italian team of physicists has found that two-liquid cocktails display long-range correlations, both at equilibrium and when disturbed. This means that large regions with slightly different physical properties coexist within the same fluid.

Outside the equilibrium condition, the authors explain, this is due to the coupling between the difference in concentration between different portions of the liquid and spontaneous fluctuations, which are also observed when the mix is at equilibrium. These findings have been published in EPJ Evas part of the Topical Issue "Non-isothermal transport in complex fluids" by Fabio Giavazzi from the University of Milan, Italy, and colleagues. They imply that the long-range effects, observed when the mixture is not at equilibrium, need to be taken into account as an additional contribution to the effects observed when the mixture is at equilibrium, so as to understand the diffusion mechanisms.

Often gravity masks the underlying physical phenomenon. Now Italian physicists have found a new way to overcome this difficulty by studying a liquid mix close to a peculiar equilibrium point with an optical microscope. They scrutinised the cocktail both when the two liquid components were at a low enough temperature to remain two distinct liquids, and just above the transition temperature, where they begin mixing into a cocktail. The authors initially focused on the liquid mix at equilibrium, and subsequently on the period during which it shifts from its initial equilibrium state to the final equilibrium state, after being disturbed by a temperature change.

Outside of equilibrium, the authors focused on the concentration gradient in the liquid induced by the temperature change. They found that during this transition several parameters, including the mixture's diffusion coefficient D, vary in time in the same manner and appear to be enslaved to the speed of the transition. Their experimental observations match theoretical expectations.

More information: Fabio Giavazzi et al. Equilibrium and non-equilibrium concentration fluctuations in a critical binary mixture, *The European Physical Journal E* (2016). DOI: 10.1140/epje/i2016-16103-9

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