Mathematics reveals new insights into Marangoni flows

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The Marangoni effect is a popular physics experiment. It is produced when an interface between water and air is heated in just one spot. Since this heat will radiate outwards, a temperature gradient is produced on the surface, causing the fluid to move through the radiation process of convection. When un-dissolvable impurities are introduced to this surface, they are immediately swept to the side of the water's container. In turn, this creates a gradient in surface tension which causes the interface to become elastic.

The structures of these flows have been well understood theoretically for over a century, but still don't completely line up with experimental observations of the effect. In a new study published in *EPJ E*, Thomas Bickel at the University of Bordeaux in France has discovered new mathematical laws governing the properties of Marangoni flows.

The Marangoni effect can have a variety of applications, for example in welding and computer manufacturing. Therefore, Bickel's findings could provide important new information for researchers and engineers working with fluid-based systems. Bickel found that in deeper water, the region in which impurities are swept away decreases in size with an increase in the surface's elasticity. Outside of these regions, Marangoni flows are cancelled out by counterflows originating from the impurities, meaning the fluid becomes static. The region can even disappear if the surface's elasticity is too great, in which case the concentration of impurities on the interface becomes constant. Furthermore, the boundary of the region becomes more blurred in shallow water.

Bickel uncovered these mechanisms through mathematical derivations, starting from the known properties of Marangoni flows. He then incorporated aspects including water depth and impurity concentration, and he calculated their effect on the overall system. Bickel's research shows that even in old, well-studied physics experiments, mathematical analysis can still reveal new processes.

More information: T. Bickel, Effect of surface-active contaminants on radial thermocapillary flows, *The European Physical Journal E*

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