

Light propelled thermocapillary vessel

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Self-propelled micro-systems that consume energy available in their surrounding to ensure their motion often lead to spectacular collective behaviors that are not observed with systems at equilibrium. Biological systems are particularly well known to exhibit such behaviors. As an attempt to understand this collective behavior various mechanisms have been proposed to create simple self-propelled systems that may lead to complex collective interactions. The individual behavior of these objects, though, is intriguing in itself and constitute an essential prerequisite to investigate their collective behavior. In this framework, most of the studied systems rely on small bodies immersed into a liquid. The self propulsion of small bodies trapped at an interface have been much less considered. Nevertheless the so-called *soap-boat* constitutes a famous example where a small interfacial vessel is self propelled by a difference of surface tension generated by a flux of surfactant at the rear of the vessel [2]. Such a capillarity induced actuation is pedagogically interesting but works only in transient regime. The flux of surfactant is generally imposed and prevent the tuning of the actuation. Moreover the experimental characterization of the concentration field of surfactant, responsible for the vessel motion, is not straightforward.

In order to obtain a more controllable system, we recently developed a *sun-boat* based on a thermally induced difference of surface tension generated by a light source. From an energy conversion point of view the sun boat is a particular heat engine that relies on surface thermodynamics that is both surface tension differences and surface enthalpy differences. This type of propulsion, based on thermocapillarity and reminiscent of the thermal Marangoni effect, has recently been put forward to induce the self *rotation* of asymmetric microgears at an interface [3]. To be able to study *translational* motion we prepared small vessels few millimeter long that present a difference of radiation absorption coefficient between their bow and their stern. The light being uniformly shined perpendicularly to the surface, the difference of absorption results in a difference of temperature and subsequently a difference of surface tension that propels the vessel. The system can work in permanent regime as long as the heat transferred to the liquid is dissipated in the surrounding. The velocity of the vessel can easily be adjusted tuning the intensity of the light. Moreover the temperature fields at the interface that control the vessel motion, can be qualitatively measured by means of infra-red visualization. Experimental results allowed us to relate the permanent velocity of the vessel to the interfacial difference of temperature. The observed behavior suggests the presence of a transversal flow that significantly impact the heat transfer at the vicinity of the vessel and subsequently the velocity of the boat in a unexpected manner.



Figure 1: Infra-red view of a sun boat at a water/air interface (left) and schematic of the propulsion mechanism (right)

References

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