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DEPARTMENT OF MECHANICAL ENGINEERING

SEMINAR

to be held on Thursday, March 26, 2020, 11:00
in the Seminar Room (#117) of the Mechanical Engineering Building (#55)
at the Campus of the Ben-Gurion University of the Negev

Dipolar thermocapillary motor and swimmer

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Abstract:

When an interface between two immiscible fluids is subjected to a non-uniform temperature distribution, the dependence of surface tension on temperature gives rise to tangential stresses which drive the fluid along the interface. This phenomenon, termed the thermocapillary effect, is of central importance in the field of microfluidics due to the dominance of surface forces over body forces at the micro-scale. The study of thermocapillary driven flows is typically restricted to "open" systems, i.e., ones where the fluidic system is almost entirely exposed to its surrounding environment. However, a large number of natural and engineered fluidic systems, such as lab-on-a-chip devices, are composed of solid boundaries with only small open regions exposed to the surrounding. This prevents the widespread use of thermocapillary actuation in the microfluidic community.

In this work we study the flow generated by the thermocapillary effect in a liquid film which is overlaid by a discontinuous solid surface, i.e., where most of the system can be considered "closed". We demonstrate that if the openings in the solid are subjected to a temperature gradient, the resulting thermocapillary flow will lead to a nonuniform pressure distribution within the underlying liquid layer. This pressure distribution will generate flow in the rest of the system. For an infinite solid surface containing circular openings, we show that the resulting pressure distribution yields dipole flows which can be superposed to create complex flow patterns. In addition we demonstrate how a confined dipole can act as a thermocapillary motor for driving fluids in closed microfluidic circuits. For a mobile, finite-sized solid floating on a fluid surface, we show that an inner temperature gradient, which can be activated by simple illumination, results in the propulsion of the surface, creating a thermocapillary surface swimmer.

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Bio: Valeri Frumkin received his Ph.D. in applied mathematics from Technion, where he studied thermocapillary instabilities in thin liquid films and their potential application to microfluidics. Valeri is currently an experimental post-doctoral fellow in Moran Bercovici's Microfluidics Technologies Laboratory, where he is realizing thermocapillary effects and interfacial phenomena for actuation and control of liquids in a microfluidic evironment. As a Fulbright Scholar, Valeri will start a second post-doctoral position at the Massachusetts Institute of Technology, with Prof. John W. M. Bush, where his research will focus on hydrodynamic quantum analog systems.

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