Thermally-Driven Transport of Colloids in Complex Fluids

Hong-Ren Jiang[1], Hirofumi Wada[2], Natsuhiko Yoshinaga[3], and Masaki Sano[4]

[1] *Institute of Applied Mechanics, National Taiwan University, Taipei City 106, Taiwan*

[2] *Department of Physics, Ritsumeikan University, Kusatsu, 525-8577, Shiga, Japan*

[3] *WPI-AIMR, Tohoku University Katahira 2-1-1, Sendai, Japan*

[4] *Department of Physics, The University of Tokyo, Hongo 7-3-1, Tokyo 113-0033, Japan*

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In complex fluids like colloidal suspensions and polymer solutions, the thermal gradient drives the solute particles and molecules either to the cold or to the warm [1]. The direction and magnitude of the solute migration generally depend on specific interfacial and solvent properties. In a colloid-polymer mixture for which the depletion forces provide the dominant colloid-polymer interactions, a thermal gradient can drive the colloids towards the hot region, irrespective of their own thermophoretic properties [2]. We have experimentally realized this non-equilibrium transport properties of colloids by combining the microfluidic device and the optical heating method (laser focusing). We observed a massive amplification of the density of the trapped colloids (polystyrene beads) at the hot region with the concentration of added polymers (neutral polyethylene glycol of molecular weight 7500). We show that the origin of this dynamic attraction is a migration of colloids driven by a nonuniform polymer distribution sustained by the polymer's thermophoresis (Soret effects). The resulting transport velocity of the colloids can be fully explained by taking into account the diffusio-phoretic effects driven by the background gradient of the polymer solutes. (In the talk, I will also briefly review the hydrodynamic theory of thermo- and diffusio-phoresis originated by Derjaguin and Anderson [3].) Taken together, these results show how to control the thermophoretic properties of macromolecules. This effect allows us to transport and trap colloids as well as biological cells and macro-molecules such as DNA at any desired position by suitably controlling a temperature distribution and the polymer concentration.

References

[1] A. Wurger, Rep. Prog. Phys. **73**, 126601 (2010).

[2] H.-R. Jiang, H. Wada, N. Yoshinaga, and M. Sano, Phys. Rev. Lett. **102**, 208301 (2009).

[3] J. L. Anderson, Annu. Rev. Fluid. Mech. **21**, 61 (1989).