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# Steady state motion of a heat conduction system

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It has been known that a Brownian particle immersed in a fluid under temperature gradient (Figure 1) moves in one direction [1]. In this presentation, we consider microscopic mechanisms of the particle motion. Among several concepts [2], we propose one mechanism that steady state motion is induced by the heat flux passing *inside* the particle.

In order to demonstrate our concept clearly, we consider rather special systems, as shown in Figure 2. A solid material (say Silicon), which consists of many atoms, is set in a long tube, and gases (say Helium) with different temperatures $T_{\mathrm{L}}$ and $T_{\mathrm{R}}$ are inserted in the left and right regions, respectively. The pressures take the same value $p$. The gases cannot mix each other because the solid material becomes a separating wall. The wall of the tube is assumed to be thermally insulating and friction-less. We then show that the solid material moves to the high temperature side induced by the heat flux inside the solid material. Concretely, we predict that the velocity of the solid material $V$ is related with the heat flux density $J_Q$ as

$$V = -\frac{\pi J_Q}{8p} \tag{1}$$

in an asymptotic regime. Since heat flows from the hotter to the colder side, Eq. (1) indicates that the solid moves toward the hotter side. Remarkably, all physical quantities in Eq. (1) are observable in experiments. Based on this result, we conjectured that a Brownian particle in a fluid under temperature gradient (Figure 1) moves to the high temperature side if the thermal conductivity of the particle is sufficiently large.

In the poster, we explain the relation given in Eq. (1). We also show that the motion of Silicon is observed in laboratory experiments. In particular, when $T_{\mathrm{L}} = 293\mathrm{K}, T_{\mathrm{R}} = 303\mathrm{K}, p = 1\mathrm{atm}$, and the length of Silicon is equal to 1cm, the velocity of Silicon is estimated as $4.2 \times 10\mathrm{cm/s}$.

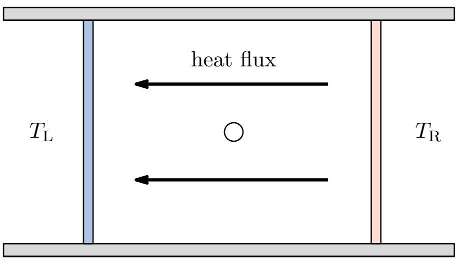


Figure 1: A Brownian particle in a fluid under temperature gradient

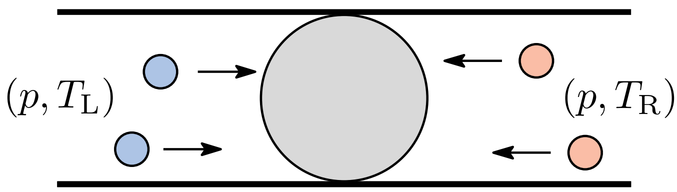


Figure 2: Special systems

[1] S. de Groot and P. Mazur, *Non-Equilibrium Thermodynamics* (Dover Publications, New York, 1984).
[2] S. Duhr and D. Braun, Proc. Natl. Acad. Sci. U.S.A. **103**, 19678 (2006).