

New insights into self-phoresis

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The notion of phoresis describes the motion of a particle in a fluid due to an externally imposed gradient (in chemical composition, in temperature, in electric potential, ...) *and in the absence of a net force or torque*: therefore, the particle's momentum is balanced by the momentum of the flow in the ambient fluid, and the particle is not dragged, but it *swims* instead. Phoresis is a long known phenomenon that can be described in the context of linear-response theory. For instance, in the particular case of chemiophoresis, i.e., of phoresis driven by an external gradient $(\nabla n)_{\text{ext}}$ in the concentration of a solute in the ambient fluid, the phoretic velocity \mathbf{V} of the particle can be obtained as

$$\mathbf{V} = \mathcal{L}_{\text{lin}} (\nabla n)_{\text{ext}},$$

for a sufficiently small gradient over the scale of the particle size, in terms of the phoretic coefficient \mathcal{L}_{lin} given by a Green-Kubo expression.

A closely related phenomenology is observed for self-phoretic particles, which have attracted much attention in the last years as physical realization of artificial swimmers. In this case, the particle's surface is catalytically active, so that it induces a gradient $(\nabla n)_{\text{act}}$ in the chemical composition of the ambient fluid. Thus, the experimental observations involving self-phoretic particles are customarily addressed

as an instance of phoresis in an activity-induced gradient,

$$\mathbf{V} = \mathcal{L}_{\text{lin}} (\nabla n)_{\text{act}}.$$

However, an additional role of the particle's chemical activity has been recently identified, namely, as responsible for a specific *activity-induced response*, so that one has to write

$$\mathbf{V} = (\mathcal{L}_{\text{lin}} + \mathcal{L}_{\text{act}}) [(\nabla n)_{\text{ext}} + (\nabla n)_{\text{act}}]$$

in the more general scenario, where \mathcal{L}_{act} is the activity-induced contribution to the phoretic coefficient. We will describe the theoretical framework behind this result and argue that the piece \mathcal{L}_{act} could actually be as large as \mathcal{L}_{lin} in realistic configurations, disproving the claim that “self-phoresis is phoresis in a self-induced gradient”. We will also discuss possible experimental realizations aimed at controlling the relative importance of the two different contributions to the phoretic response.

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- [1] A. Domínguez, M. N. Popescu, C. M. Rohwer, S. Dietrich, *Self-Motility of an Active Particle Induced by Correlations in the Surrounding Solution*, Phys. Rev. Lett. **125**, 268002 (2020); doi: 10.1103/PhysRevLett.125.268002