Self-phoretic oscillatory motion in a one-dimensional channel

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Abstract:
We study a simple model for a particle that is active due to self-phoresis and that has been proposed to model symmetric camphor grains. The particle generates a concentration field through the continuous emission of a chemical substance, and its motion is driven by gradients of this field as it diffuses within a confined channel whose ends perfectly reflect the chemical. The reflection of the chemical field leads to an effective confinement of the particle, which itself is reflected before encountering the channel ends. The system displays a transition from a passive state, where the particle rests at the channel midpoint, to an active state characterized by highly regular, non-chaotic oscillations. We analytically construct the phase diagram and derive the oscillation frequency and amplitude in the vicinity of the transition. A perturbative analysis perfectly describes the dynamics of the particle even for oscillations as large as half the channel size. Furthermore, we develop an analysis which explains the mechanism of particle reflection close to the channel edges in the regime of large activity.