پژوهشکده فیزیک
پژوهشگاه دانش‌های بنیادی (مرکز تحقیقات فیزیک نظری و ریاضیات)
IPM
Institute for Research in Fundamental Sciences
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Physics Colloquium
سخنرانی عمومی فیزیک

Dance of Cause and Effect: Fluctuation Induced Reduction of Dissipation in Classical Fluids

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Date and time
Wednesday, 11th of Esfand, 1400 (2th of March, 2022), 6 pm

Abstract

About seventy years ago, G I Taylor noticed that the tails of two closely swimming spermatozoa, oscillate in a synchronized fashion as if both of them are controlled from one regulating center. The two sperms, on the other hand, has no mean of communication, but the viscous fluid in which they are swimming. To address the why question, behind the observation, he suggested the minimization of total dissipation in the viscous medium. Sixty years later, Taylor's original idea was put to more detailed analytical investigations; non-intuitively, it failed to attribute the observed synchronization to the expected reduction of dissipation. We begin with a very different problem: (a) The motion of two passively trapped beads, which interact through hydrodynamic interactions, and face a driven flow. Both theoretically and experimentally we observe that they almost follow the very motion they would have, if they were to swim on their own in the opposite direction of the driven flow. Calling the phenomenon, the reverse dance, we successfully attribute it to the reduction of the total dissipation. We then (b) extend the minimalistic approach, to two sets of beads; each supposed to mimic the tail of one spermatozoon. Facing a driven flow, on top of their intrinsic oscillation, this is a minimalistic model to verify Taylor's idea. The question is, does this simple model lead us to synchronization as well as reduction of fluid's dissipation? And if so, can it explain why Taylor's original model failed to correctly attribute synchronization with reduction of dissipation?

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