Heat transport by bouncing grains

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Résumé

The famous experiment of Chladni, wherein sand grains bounce over a vibrated elastic plate, produced a mesmerizing figure that revealed the shape of acoustic eigenmodes to his contemporaries (1). Some years ago, the same experiment also revealed that Fick's law cannot account for the accumulation of random walkers in places of lesser diffusivity—a natural explanation for the formation of the Chladni figure (2,3). Using a simpler bouncing-grain experiment, we investigate the thermodynamic consequences of this departure from Fick's law, and cast the Chladni figure in terms of non-equilibrium steady state. The heterogeneity of the figure, indeed, generates a continuous heat flux, which we measure and interpret. Finally, we try to pinpoint what distinguishes the statistics of bouncing grains from those of classical Brownian particles.

(1) E.F.F. Chladni, *Entdeckungen über die Theorie des Klanges*, Zentralantiquariat der Deutschen Demokratischen Republik (1787).
(2) I. Grabec, *Vibration driven random walk in a Chladni experiment*, Physics Letters A **381**, 59 (2017).
(3) A. Abramian et al., *Chladni patterns explained by the space-dependent diffusion of bouncing grains*, Physical Review Research **7**, L032001 (2025).

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