Guided accumulation of active particles by topological design of a second-order skin effect

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ABSTRACT

Collective guidance of out-of-equilibrium systems without using external fields is a challenge in active matter. Here we engineer a two-dimensional periodic topographical design with detailed balance in its unit cell where we observe spontaneous edge guidance and corner accumulation of self-propelled particles [1].

This emergent behaviour is guaranteed by a second-order non-Hermitian skin effect [2], a so far unobserved topologically robust non-equilibrium phenomenon, that we use to dynamically break detailed balance. Our stochastic circuit model predicts, without fitting parameters, how guidance and accumulation can be controlled and enhanced by design: a device guides particles more efficiently if the topological invariant characterizing it is non-zero.

Our work establishes a fruitful bridge between active and topological matter, and our design principles offer a broad blueprint to design devices that display spontaneous, robust and predictable guided motion and accumulation, guaranteed by out-of-equilibrium topology.

REFERENCES

[1] Lucas S. Palacios, Serguei Tchoumakov, Maria Guix, Ignasio Pagonabarraga, Samuel Sánchez and Adolfo G. Grushin, arXiv: 2012.14496 (2020)
[2] Kohei Kawabata, Masatoshi Sato, and Ken Shiozaki, Phys. Rev. B 102, 205118 (2020)

FIGURES

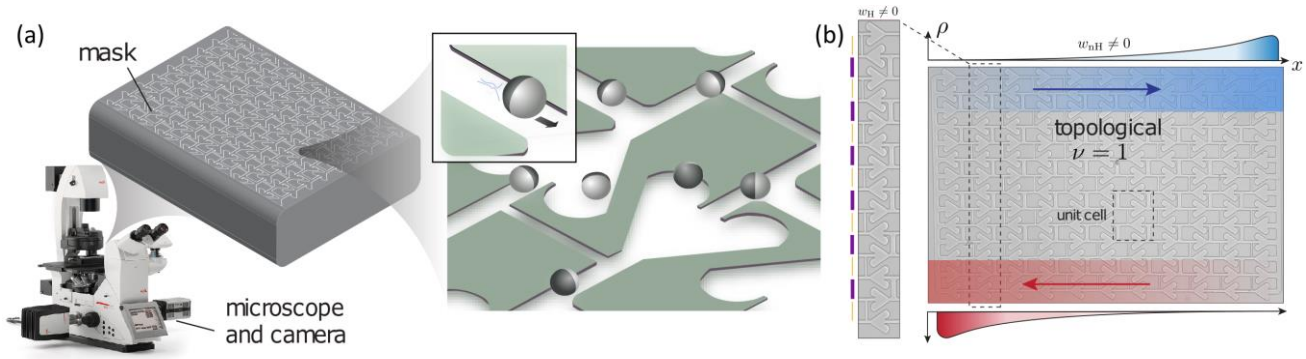

Figure 1: Illustration (a) and photography (b) of the fabricated device within which the active particles propagate. The channels are periodically arranged and particles propagate more easily on the edges because of topological edge motion.