Active Brownian particles and run-and-tumble particles separate inside a maze

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Flocking birds, colonies of bacteria and schools of fish are only a few examples of active systems that display variety of fascinating collective patterns. Due to the continuous absorption of energy by their constituents, active systems are always out of equilibrium and their behavior are not able to be explained by ordinary statistical physics. Therefor studying their properties and thinking about their possible applications has attracted a lot of attention in many different areas of science and engineering. Active or self-propelled particles can be distinguished by their moving strategies. Accordingly, there are two main classes of these particles; Active Brownian particles and run-and-tumble particles. The former refers to active particles that move with constant speed and reorient gradually due to rotational diffusion. Synthetic Janus particles move with this strategy. The latter also moves with constant speed but reorient suddenly to a random direction. E. Coli bacteria and some other microorganisms move in this way. Despite of having different moving strategies, active Brownian particles and run-and-tumble particles behave very similarly in many situations which makes them difficult to be distinguished or separated well.

Here we have proposed an special kind of geometry analogous to a nested Matryoshka-like maze that is able to separate these two particles from each other excellently. By reporting their mean first passage times to start from the outer region of the nested maze, we show that persistent run-and-tumble particles reach the center very fast while persistent active Brownian particles does not reach the center at all. In addition, by measuring their long time steady state densities, we show that active Brownian particles accumulate in the inner regions of the maze while run-and-tumble particles are found almost everywhere. Therefor by using appropriate boundaries or tools, different types of active particles are separable from each other, without need to any chemical or biological agents.

[l] T. Vicsek, A. Zafeiris, Phys. Rep. **517**, 71 (2012).

[2] M.E. Cates, J. Tailleur, EPL **101**, 20010 (2013).

[3] A. Zöttl, H. Stark, J. Phys. Condens. Ma **28**, 31 (2016).

[4] A.P. Solon, M. E. Cates, EPJ Special Topics **224**, 1231 (2015).